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Determine the Tomatoes Volume

AL-Badri S.B.S[1]

[1]*Department of Agricultural Machines and Equipment, College of Agricultural Engineering Sciences, University of Baghdad, Iraq,* *samir.albadri@coagri.uobaghdad.edu.iq*

DETERMINE THE TOMATOES VOLUME

Abstract: The aim of this research is to obtain a quick and low-cost method for measuring the volume of tomatoes for small farmers, which have limited access to new technology. This measurement will help in grading, packaging size, and transportation costs. Weight loss of the tomatoes relates to their shelf life, which is between 5-7%; within this range, the tomatoes are still edible. This research attempted to find a relationship based on the volume of tomatoes in an elliptical spheroid using the water displacement method. The samples included 15 tomatoes chosen randomly and weighed, and then the height and width were measured. Tomatoes weight in water and water high with tomatoes were measured and then the different calculated, which represented the volume. The results illustrated that the linear regression model explained 80% of the data. The tomato shapes may help in the weight loss and firmness of tomatoes during storage for further studies.

Keywords: Tomatoes, weight loss, shapes, sizes

Introduction

Tomato ranks first among fruit crops in terms of the planted area, production, and consumption in Iraq. The COVID-19 pandemic represents a massive impact on human health. Moreover, each 100 g of the red tomatoes continued at13.7 mg Vitamin C, which is very important to human health. For adults, the recommended daily amount of vitamin C is 65–90 mg.

Tomatoes size measurements are important for monitoring the growth curve, observing each plant's growth individually, and estimating yield (Kilic & M. Kadri, 2010). The temperature was an important factor that impacts the shelf life of tomatoes which has affected the rate of biological processes (AL-Badri, 2019). This includes changes in tomato softening and weight loss, which are reflected in the tomato shape.

Tomato volume is useful for harvesting and forecasting applications (Fukui, Schneider, Nishioka, Warisawa, & Yamada, 2017). Critically review the literature to identify the different methods used to determine the volume of tomatoes.

There are many techniques used to measure tomato volume, such as OmiSurface software (Aníbal, Eifert, Wang, & Sanglay, 2018), Tomato Analyzer software (Rodriguez *et al*., 2010), and Morphology Attributes software (Gonzalo *et al*., 2009). Fruit sizes were estimated based on weight and volume (Lino, Sanches, & Dal Fabbro, 2008). Tomatoes weight loss was 1.9% for the samples stored at 10.01±0.0°C and average relative humidity 90.20±0.0%RH for the tomatoes storage for 26 days, while the maximum weight loss was 5.47% for the tomatoes stored at 21.78±0.04°C and average relative humidity was 75.12 ±0.20 %RH for 18 days, and the tomatoes within this range still were edible (AL-Badri, 2019). Tomatoes volumes are considered the best method for determining size, which is the most common method for grading tomatoes because most consumers prefer tomatoes that are large in size, which also gives an accurate packaging size (Peleg, 1985). Tomatoes grading is important in reducing transportation costs and packaging (Taheri-Garavand, Rafiee, & Keyhani, 2011). The volume of tomatoes was estimated using the method of water displacement considered slow in some studies. Therefore, researchers have used imaging processes and thermal images to obtain fast results. However, imaging processes give two dimensions of the objects (Fukui, Schneider, Nishioka, Warisawa, & Yamada, 2017), which means that some of the shapes will be missing, which means that the results do not accurately describe the shape. Tomato's shape index was 0.93±0.05 (Rodrı´guez, Kim, & Knaap, 2013). The machine vision system was used to measure the tomatoes, strawberry, and mushroom volumes and compared with the water displacement/buoyant force method (Aníbal, Eifert, Wang, & Sanglay, 2018), which was more accurate than other methods, but it is costly too much (Lino, Sanches, & Dal Fabbro, 2008). This procedure takes time because it takes 30 images for each rotated sample of tomatoes. The software was developed to analyze the shapes of tomatoes and used 100 images (Brewer *et al*., 2006). Other methods by Fukui, Schneider, Nishioka, Warisawa, & Yamada (2017) used a clustering technique for images through a sub-image. All these methods cost money and time, while Aníbal, Eifert, Wang, & Sanglay (2018) confirmed that there was a high correlation between water displacement and imaging processing. The water displacement method was used in this research to obtain quick and low-cost results for the volume of tomatoes in tomatoes.

Material and Methods

The tomatoes were brought from the market and weighed. The sample included 15 tomatoes randomly chosen with elliptical spheroids. The measurements were taken, which included weight, height, and width (Mutschler, Yasamura, & Sethna, 1986). A digital scale was used to measure sample weight. A digital Vernier caliper was used to measure the width and height of the tomatoes. The weight of the empty jug was 86 g. The measuring jug was scaled, which was filled with water to 0.80 liters. Each tomato was put in the water jag, which was filled with water until 0.80 litter, and the amount of the water height was recorded. The water height of tomatoes represents the volume of the tomato. Then, the weight jug was subtracted from the tomatoes in the water from the jug weight filled with 0.80 liters.

The following equations were used: -

Tomato shape index = Tomato height/ Tomato width …………… (1)

This equation is used to calculate the tomatoes shape index.

ETV = (1/6) × (height) × (diameter)^2 ..…………………… (2)

This equation is used to calculate the Estimated Tomatoes Volume (ETV)

Results and Discussion

The results in table-1- illustrate that the overall model was highly significant, df (3, 14), F=136.6271. The coefficient of weight was more important, which means that the weight impacted the results, and the coefficient of the diameter was more important than the length. R2= 0.9868, indicating that this model explains most of the data.

Table 1: illustrated the results of ANOVA with regression

Regression Statistics

Multiple R	0.986846				
R Square	0.973868				
Adjusted R Square	0.878203				
Standard Error	20.47672				
Observation	14				
ANOVA					
	Df	*SS*	*MS*	*F*	*Significance F*
Regression	3	171861,7	57287.25	136.6271	2.05E-08
Residual	11	4612.259	419.2963		
Total	14	176474			

The results in Table 2 illustrate that the standard deviation was smaller than the mean for all the parameters, which included weight in grams, height, and width in cm, W in gram water sample, actual tomato volume, tomato shape index, and estimated tomato volume, which indicated that most of the data were clustered about the mean.

Table 2: illustrates the mean, max, min, SD, and CV% of the measurements

Parameter	Mean	Max	Min	SD	CV%
Weight in gram	134.7	194.0	89.0	33.3	24.7
Height in cm	5.6	6.9	4.6	0.7	11.6
Width in cm	6.3	7.5	4.1	0.9	13.6
W in gram water sample	136.1	195.0	90.0	33.6	24.7
Actual Tomato Volume ATV cm^3	110.8	190.0	65.0	43.5	39.3
Tomato Shape Index	0.9	1.2	0.8	0.1	12.7
Estimated Tomato Volume	46.4	75.5	15.7	15.3	32.9

The results in Figure 1 illustrate that there was a strong relationship between weight in grams vs. estimated weight in grams, and regression was equal to 1, which means that this model explained all the data.

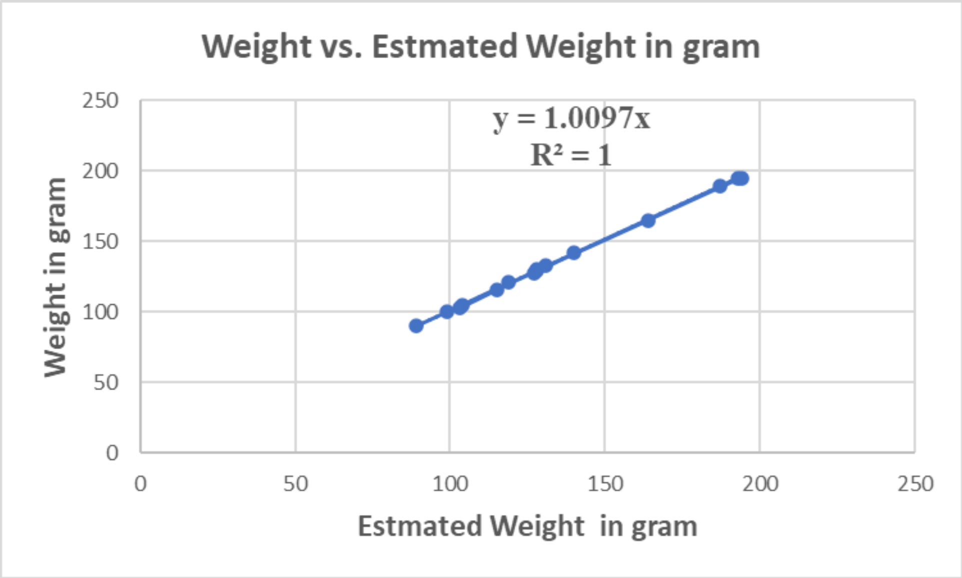

Figure 1 illustrated the relationship between weights in gram vs. estimated weight in gram.

The results in Figure 2 illustrate that there was a strong relationship between weight in grams and ATV, and regression explained 80% of the data.

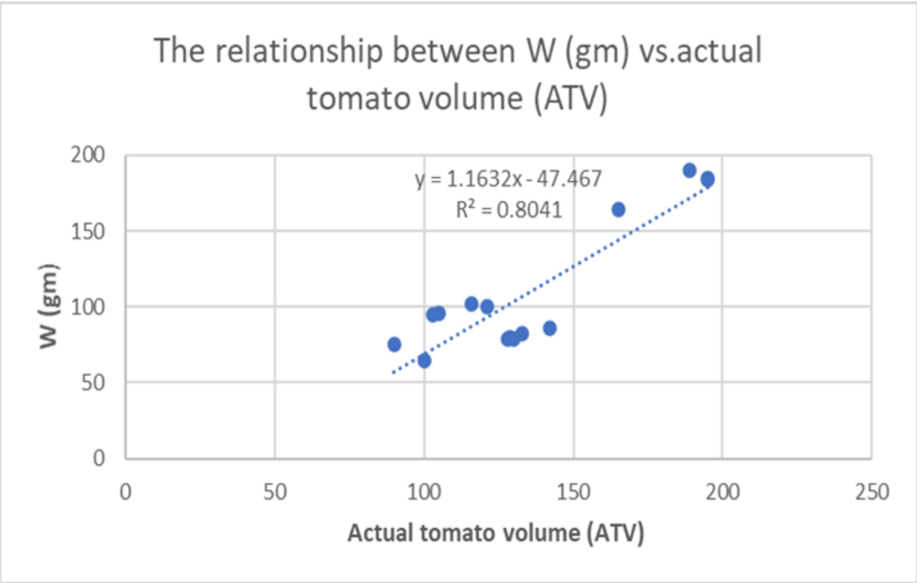

Figure 2 illustrates the relationship between W (g) and the actual tomato volume (ATV).

The results in figure 3 illustrate that the regression model explains 57% of the data, and the slope coefficient is low, which means that the lake of fit can provide a better model.

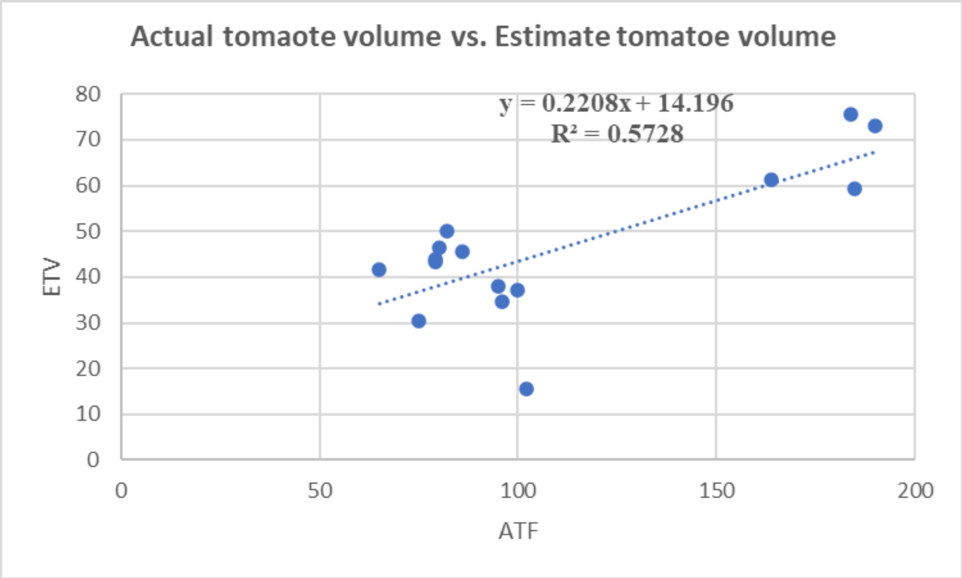

Figure 3 illustrated the Actual tomato volume vs. Estimate tomato volume.

Conclusion and Recommendation

This study estimated that the volume depends on the height and width of tomatoes: -

- Weight loss was the most significant factor that impacts tomatoes' volume.
- Width and length are less important than weight.
- This method can be used at small farms and for education students because it is cheapest in price, short in times, and does not need technology compared to the imaging process or any other methods which were mentioned in the introduction.
- The model can be developed by integrating temperature and relative humidity during storage and transpiration.
- Iraqi farmers need to be educated, harvest green tomatoes, and store them, especially during the summer, because the prices go down. This will help extend the shelf life and reduce weight loss and volume loss.

Future work is needed to establish datasets containing a comprehensive elemental analysis of the volume of more fruits and vegetables. These include different tomato varieties, green bell peppers, cucumbers, and carrots with a big sample size.

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