Tarım Makinaları Bilimi Dergisi (Journal of Agricultural Machinery Science)
2009, 5 (1), 103 - 108

Volume Determination of Kahramanmaras Red Pepper (*Capsicum annuum* L.) by Using Image Analysis Technique

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Abstract: The size of an agricultural product is an important parameter to determine fruit growth and quality. It can be used to determine the optimum harvest time as a maturity index. In this study, the image analysis method was tested on Kahramanmaras red pepper (*Capsicum annuum* L.) which may have a non uniform shape. For this purpose; the front, top and left side of each pepper was taken into account for evaluations and projection areas. The effect of each image and image combination has been used to determine the volume of peppers. The regression coefficients between the projection areas and volume values have also been assessed for volume estimation. The most appropriate estimation formula has been calculated from the top and the left projection area. The regression coefficient has been found 89.7% for estimation of volume.
Key words: Physicomechanic properties, Kahramanmaras red pepper, Image analysis, the volume of an agricultural product, Grading.

INTRODUCTION

Peppers have been mostly cultivated in the Mediterranean, Aegean, Marmara and Southeastern Anatolia regions of Turkey. They are consumed as a fresh material and used as an industrial raw material in canned food, tomato paste, pickles, sausage, hot dogs, salami etc.

According to recent statistics, world production of pepper has reached 18.5 million tons (Bastaban & Sayıncı, 2007). Pepper production has increased for the last ten years in Turkey who is the third largest producer in the world. In our country, 80% of red pepper is produced in Kahramanmaras (especially in the center of the city, also in Pazarcık, Turkoglu and Narli districts) also Gaziantep (Duman et. al. 2002).

Determination of physicomechanical properties of agricultural products are important for many applications such as surface area, volume and density measurements, weight measurements, water loss, heat transfer and quality of pesticides (Lee et. al. 2002).

Harvesting on time is important for packing, grading and sorting. It is necessary to do this process easily and economically. In this regard, the image analysis method is seen as an important tool. The image analysis method has a high accuracy rate and is also economical and practical. The image analysis technique used in this study is quicker and easier than previous methods. It has pixel-based techniques.

All fruit and vegetables sold in modern markets have been sorted. In general, automatic machines are used for economic classification (Wulfsohn et. al. 2004). The grading standard is needed for each product in the modern market system.

It can be sorted according to diameter when the degree of sphericity of fruit is at a high level (Sessiz & Pekitkan 2007, Öztürk 1988). Kahramanmaras red pepper can be sorted due to the weight or the maximum diameter for the variety features (Sessiz ve Pekitkan, 2007).

In this study, determination of product volume has been investigated by using image analysis method. The image analysis method can be used as a maturity index for the harvest time of Kahramanmaras red pepper.

MATERIALS AND METHODS

40 Kahramanmaras red peppers were chosen amongs the fresh fruit for the determination of their volume. 20 of them were used to check the equation and the rest were used as a control.

A Nikon 10.1 megapixel D40X model SLR digital camera has been used for taking digital photographs.

Digital photographs of Kahramanmaras red peppers have been taken by using a calibration plate (Figure 1). The calibration plate provides descriptive information about the size of the object for Myriad image analysis program.

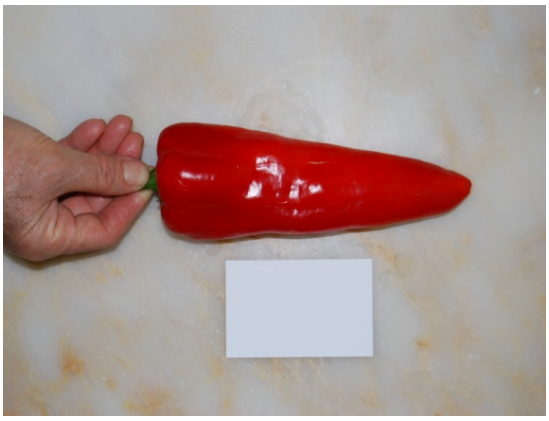


Figure 1. An example of digital photographs of Kahramanmaras red pepper

Then, three view projection areas have been determined from front, top and left views of the peppers (Figure 2).

Front view

Top view

Left view

Figure 2. Pepper projection areas

Digital images can be evaluated by using some package programs or software. Wulfsohn et al. (2004) expressed that Mathematica programme can also be used for this purpose.

In this study, the images have been analyzed by using Myriad v8.0 (Figure 3).

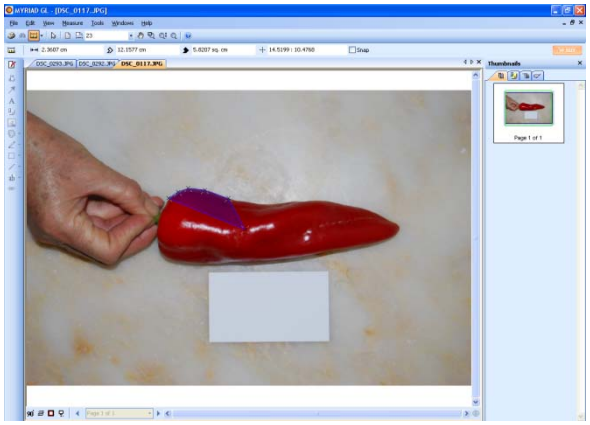
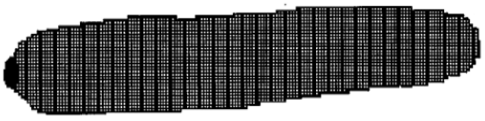


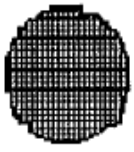
Figure 3. Myriad v8.0 interface

This program is working as two-steps; these are calibration process and selection process. In this program the images have to choose correctly (Beyaz, 2008). The program offers different choices at the selection process. In that research, polygon selection method was used for surface area determination. A digital image of the graph paper has been used for the calibration of the program.

Hahn and Sanchez (2000) evaluated a mathematical model by using front and left image (A_F and A_L) obtained from the carrot images (Figure 4). In this way, they used their mathematical model to find the real volume values quickly and without any damage of the material.



0° view



90° view

Figure 4. The front and left images obtained from the sum of carrot slices

The model which determines actual volume of carrot slices is that;

$$V = 308.22*10^{-6} \sum_{i=0}^{n} [V_{Fi} + V_{Li}] \quad (1)$$

Where;
V: The real value of the volume (cm^3),
V_F: Total front volume slices (px),
V_L: Total left volume slices (px)
n: The number of parallel pixel discs.

Wen Jin and Sun (2006) estimated the volume of the products from sliced images. The researchers used the following formula to estimate of the volume of ellipsoidal shaped ham:

$$V=\sum_{i=1}^{n/2} V_i \quad (2)$$

Where;
V_i: Disk volume (cm^3).

Hofstee and Molema (2003) developed a model by using image processing method for volume estimation of the potatoes:

$$\ln V=C_i+\beta_1.\ln(PW)+\beta_2.\ln(PA) \quad (3)$$

Where;
C_i : Coefficient (dependent on potato varieties)
$\beta_{1,\ 2:}$ The regression coefficients
PW: Potato width
PA: Potato area

Demirsoy and Demirsoy (2007) developed the following mathematical model for estimation weight and volume of peach during the development period:

$$F_V=46,575-10,392*W+7,479*L-0,055*W^2-0,111*L^2+0,216*W*L \quad (4)$$

Where;
F_V : Product volume (cm^3),
L : Length (cm),
W : Width (cm).

Estrada et al. (2009) evaluated the following formula for mango fruits to estimate of volume and determine the growth dynamics at products:

$$V_t= V_1 + V_2 + V_3 + V_4 \quad (5)$$

Where;
V_T : Total volume (cm^3),
$V_{1,\ 2,\ 3,\ 4:}$ Based on middle ellipse, quarter ellipsoid, half cone and half-cylinder the volume (cm^3), respectively

Hall et al. (1996) developed the following model for estimation of the volume of kiwi fruit before the harvest:

$$V_h= A_p + B_p\ V_p + C_p\ (D_H-155) \quad (6)$$

Where;
V_h : Total volume (cm^3),
A_P, B_P, C_p : The prediction coefficients depend on the day,
V_p : Average volume (cm^3),
D_H : Harvest day.

The image analyze method's main aim is to process the size and quality of the produce quickly. In this research, projection area method has been preferred for calculating of pixels method. The most suitable equation for the volume estimation from projection areas selected among the following regression equations:

$$V_1=\pm a\pm b(A_F) \quad (7)$$

$$V_2=\pm a\pm b(A_T) \quad (8)$$

$$V_3=\pm a\pm b(A_L) \quad (9)$$

$$V_4=\pm a\pm b(A_F+A_L) \quad (10)$$

$$V_5=\pm a\pm b(A_L+A_T) \quad (11)$$

$$V_6=\pm a\pm b(A_F+A_T) \quad (12)$$

$$V_7=\pm a\pm b(A_F+A_L+A_T) \quad (13)$$

Where;
$V_{1,2,3,4,5,6,7}$: Estimated volumes from projection areas of pepper (cm^3),
A_F : Front projection area (cm^2),
A_T : Top projection area (cm^2),
A_L : Left projection area (cm^2) .

After the determination of the most appropriate regression equation, the result obtained from 20 peppers by using estimation compared statistically with real volume values. For determining the real volumes, a measuring cylinder which has 5 ml measurement precision with 5 cm diameter and 500 ml the total

volume has been used. The volume of each pepper was calculated from the amount of water increase at the cylinder.

The real volume values and estimated volumes which were achieved from mathematical models were compared. The obtained data has been analyzed statistically with the Minitab.

RESULTS AND DISCUSSION

The fronts, top and left view projection areas of the peppers were examined. One by one and together effects for determining of volume of these views were expressed. The regression coefficient between the real volumes and estimated volumes were determined by using these values. Similarly Dursun et al. (1996) was describing the relationship between the physical properties and surface areas of cereals and legumes. The results have been evaluated statistically.

The relationship between the real volumes of Kahramanmaras red peppers and the front projection area values (A_F) was pointed as a graph at Figure 5. Similarly top projection area values were presented at Figure 6. However left projection areas values and the estimation equation can be seen in Figure 7.

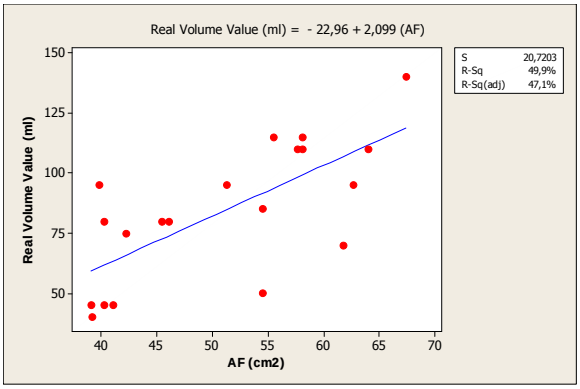


Figure 5. The regression equation and graph obtained by using A_F projection area

According to this assessment, the real volume value which was obtained from the front projection area shows the regression coefficient has reached 49.9%.

The regression coefficient obtained from estimation equations by using of the top projection area was 66.6%.

The regression coefficient obtained by using left projection area was 63.6%.

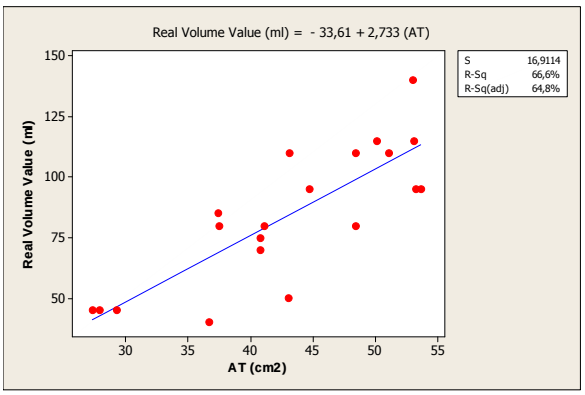


Figure 6. The regression equation and graph obtained by using A_T projection area

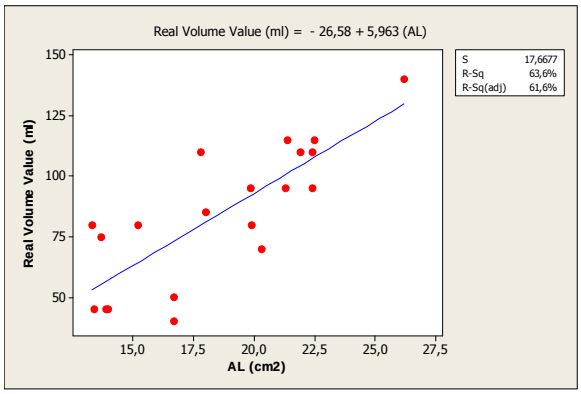


Figure 7. The regression equation and graph obtained by using A_L projection area

When the volume estimation obtained from one projection area, top projection area values has the highest regression coefficient (66.6%). The volume estimation has been examined by making double groups from these three projection areas.

Figure 8 represents the regression graph which is obtained from the sum of top and left projection areas.

Estimation equation has reached a regression coefficient 74.7% depending on this assessment.

The following equation presented as the most appropriate equation:

Real Volume Value (ml) =-47,29+2,132 (A_T+A_L) (14)

Figure 9 shows the regression equation graph which was determined from total value of the front and left projection areas.

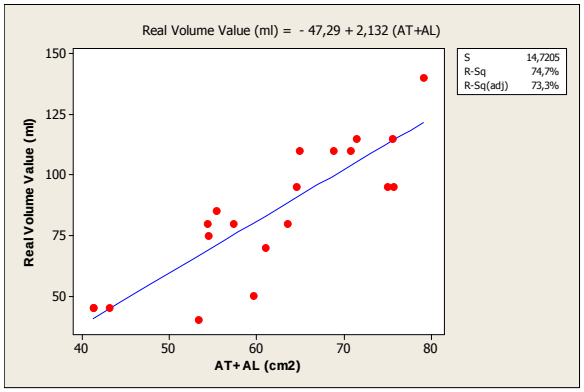


Figure 8. The regression equation and graph obtained by using A_T + A_L projection areas

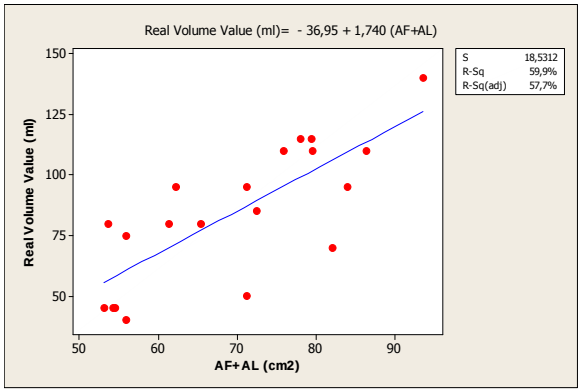


Figure 9. The regression equation and graph obtained by using A_F + A_L projection areas

It can be seen in Figure 9, the regression coefficient was 59.9%. Figure 10 shows the sum of the regression graph. Estimation coefficient was obtained as 71.1% depending on the regression equation.

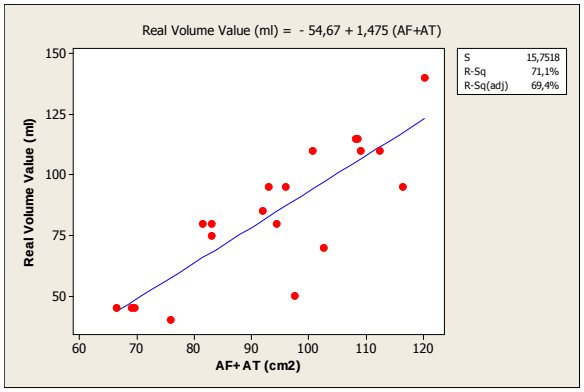


Figure 10. The regression equation and graph obtained by using A_F + A_T projection areas

Figure 11 shows estimated regression graph obtained from sum of three (front, left and top) projections area values.

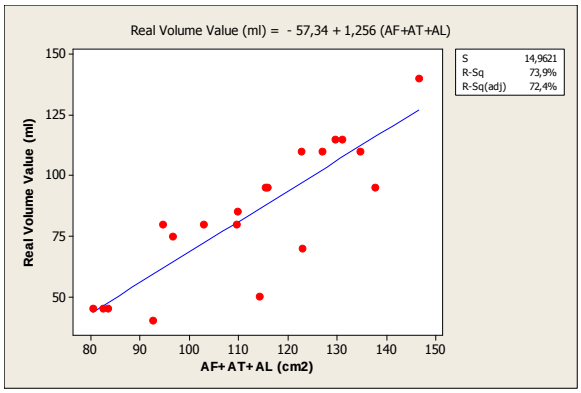


Figure 11. The regression equation and graph obtained by using A_F + A_T + A_L projection areas

Figure 11 describes the regression coefficient 73.9% which was determined from front, left and tops of the projection areas. This value for the regression gave the second highest value. The volume estimation with two projection areas, the highest rate of regression estimation value was 74.7% which obtained from the sum of the top and left projection areas. It can be explained by the front view of Kahramanmaras red peppers is more non uniform than top view.

Sum of left-top projection area equation which gave the highest regression coefficient was used for estimate volume values. Then relationship between the real volume of peppers and estimated volume values has been compared. The results have been showed in figure 12.

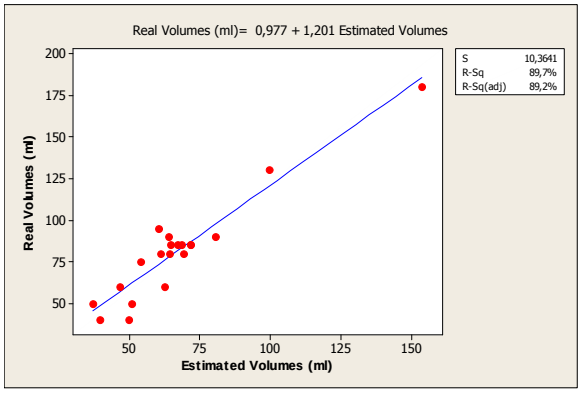


Figure 12. Comparison of the actual volume and regression equation estimation results by using sum of A_T + A_L projection areas

It has been pointed that Figure 12 the regression coefficient values between the real peppers volume value and the estimated volume values had been found as 89.7%.

This volume estimation rate can be used as, before the harvest as a maturity index, after the harvest as a classification and packaging parameter.

Overall, at irregular shape products such as pepper is expected to be high regression coefficient relationship between volume and weight. However, classification and packaging system by using image analysis techniques according to the quality of the product is also possible. In this regard research has router features.

According to the results of image processing method volume of Kahramanmaras red pepper seems to be appropriate for volume estimation.

REFERENCES

Bastaban, S. ve Sayıncı, B. 2007. Kırmızı Biberin Kurutulmasında Gelişmeler. 24. Ulusal Tarımsal Mekanizasyon Kongresi, p: 390-393, Kahramanmaras

Beyaz, A 2008. Elmalarda Mekanik Zedelenmenin Görüntü Analiz Tekniği İle Belirlenmesi. Ankara University, Graduate School of Natural and Applied Sciences Department of Agricultural Machinery Master Thesis

Demirsoy, H. and Demirsoy, L. 2007 Prediction Model for Estimating Peach Fruit Weight and Volume on the Basis of Fruit Linear Measurements During Growth. Journal of Fruit and Ornamental Plant Research 15: 65-69.

Duman, A. D., Zorlugenç, B. ve Evliya, B. 2002 Kahramanmaras'ta Kırmızı Biberin Önemi ve Sorunları. KSU Nature and Engineering Journal 5(1): 111-117.

Dursun, E, Güner, M. ve Öztürk, R. 1996. Tarımsal Ürünlerin Fiziksel Özelliklerinin ve Kaplama Yöntemiyle Yüzey Alanlarının Belirlenmesi. 6.International Agricultural Mechanization Congress, p: 70-76, Ankara.

Estrada, G.C., Blanco, A.S. and Vasquez, M.R. 2009. Equation to Estimate Volume and Growth Dynamics of Mango 'Manila' Fruit. *www.actahort.org/members/*

Hahn, F. and Sanchez, S., 2000. Carrot Volume Evaluation Using Imaging Algorithms. J. Agric. Engng Res. 75, 243-249.

Hall, A.J., Mc Pherson, H.G., Crawford, R.A. and Seager, N.G. 1996. Using Early-Season Measurements to Estimate Fruit Volume. Journal of Crop and Horticultural Science, 24: 379-391.

Hofstee, J.W. and Molema, G.J., 2003. Volume Estimation of Potatoes Partly Covered with Dirt Tare. AnASAE Meeting Presentation Paper Number: 031001.

Jin, C. and Wen Sun, D., 2006. Estimating the Surface Area and Volume of Ellipsoidal Ham Using Computer Vision. Journal of Food Engineering 73: 260-268.

Lee, D. J., Eifert, J. and Westover, B., 2002. Surface Area and Volume Measurement Using Radial Projections. The Cooperative State Research, Education, and Extension Service of the U.S. Department of Agriculture, Special Research Grants Program, Food Safety (Project Number 99-34382-8463)

Öztürk, R., 1988. Bazı Meyve Ve Sebzelere Uygun Tip Boylama Makinelerinin Yapısal Karakteristikleri. Ankara University, Graduate School of Natural and Applied Sciences Department of Agricultural Machinery PhD Thesis

Sessiz, A. ve Pekitkan, G. F., 2007. Biberin Hasat Sonrası Teknolojisi. 24. Ulusal Tarımsal Mekanizasyon Kongresi, p: 212-221, Kahramanmaras

Wulfsohn, D., Gunderson, H. J. G. and Vedel Jensen, E. B., 2004. Volume Estimation From Projections. Journal of Microscopy 215: 111-220.