

Determining the orange volume using image processing

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Abstract. Orange (*Citrus Aurantium*) is one of the much in demand winter fruits in Iran; therefore it is important to sort its quality for marketing. The first superficial property of fruit that makes attraction is its volume and size. In recent researches it was shown that its volume would be correspond to other properties such as taste and amount of glucose. Current methods for determining volume are often slow and harmful, and aren't usable collectively. In this research, volume of other 23 oranges has obtained by image processing method (IPM) and compare with volumes that measured by water displacement method (WMD). Then the T-test examination of paired samples doesn't show meaningful difference in 95% level among obtained volumes from these two methods. In addition, the one by one graph shows data more closely.

Keywords: orange volume, fruits grouping, image processing.

1. Introduction

Iran produces about 2.3 Million tons of citrus in world and has rested in 8th grade in the world. But produced oranges are exported more little because of variability of sizes and packaging ways .So that Iran is in 55th grade in export domain [1]. The most important parameter in calibration, transportation, producing and packaging systems is physical properties of agriculture products. Among these physical properties, volumes, mass, surface area, and centre of gravity are their most important in sizing systems [2]. Volume is tri-dimensional space occupied by one thing that is shown in different systems by unit. In some measuring ways, volume is shown by test method such as water displacement. Volume is indicated by amount of displaced water. The size of fruits is one of the most important parameters in validating quality by costumers. Costumers prefer uniform shapes and weight [3]. Estimating average size of fruits in standard organization, rise of market price (cost price), presentation of fruit growing stage, prediction of garden fruitage and grouping is important. Estimating the size of fruits, also, for packaging, transporting and shop keeping will be useful [4]. Usually, the size of agricultural products is indicated by mass because its measuring is relative simple .Anyway, sorting by volume would give high yield to mass. Meanwhile, the mass of agricultural products are determinable by volume provide that products density be clear. Two general methods of measuring volume includes follow; measuring by volume of gas and volume of water displacement. The first method (gas) doesn't make harm but it is time consuming. The latter is not time consuming but would be harmful on product [5]. However both serve are well in lab conditions but are not usable in real conditions [6]. Researchers used image processing to obtain volume of kiwi, cantaloupe, supposed kiwi and cantaloupe as an ellipsoid in 2- dimensional space by inventory method. Then they divided ellipsoid by rectangular and after by circulating them simulated tri-dimensional ellipsoid- like body then obtained the volume of simulation body as the volume of kiwi and cantaloupe by mathematic relation [7,8]. By comparing this volume for volume obtained by replacing volume using t-test examination there is no meaningful difference in meaningful level 95%. In other study, Rashidi et, Al (2007) used the same method to obtain volume of egg but there was no meaningful difference in level 95% too [9]. Also obtained the volumes of

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watermelons by estimating ellipsoid-like with (IPM) and compared to data obtained by WDM [10]. By obtaining small and large diameters of watermelons he estimated ellipsoid-like of each of them and obtained their volume based on this .In addition images was made of watermelons and their volumes was obtained by image processing. Finally, resultant volumes of these two methods with volume obtained from water replacing method was compared by T–test examination and concluded that Ellipsoid-like estimating method had meaningful difference with water displacement in meaningful level 95%. But image-processing method in same level had no meaningful difference with volume replacing method. According to indicated cases, also, determining the volume of fruit can be helpful in stages post harvesting in better marketing and in high yielding in stages per harvesting by recognizing the weakness of tree. But current methods of determining the volume is confront with more limitations such as being harmful and useful less in all conditions. The image processing method eliminates these limitations at high level.

2. Material and Methods

Orange samples; about 30 oranges were used of bloody variety during test period. Oranges were provided in different sizes. Of these samples, 7 oranges were used for calibration of image processing method with replacing volume method. 23 others were used for image processing method test.

2.1. Water Displacement Method (scaled cylinder)

To calibrate and compare the volumes obtained from image processing method it was used of current method of measuring water displacement. This method was done in several ways that is one of the most current uses of scaled cylinder which causes carelessness of measuring due to capillary action of water. Due to this to decrease in this error, it was used of scaled cylinder, which its orifice diameter was large. Capillary action of water is not more tangible in this scaled cylinder and the care of reading numbers was relatively high. Schematic image of scaled cylinder has obtained in fig 1.

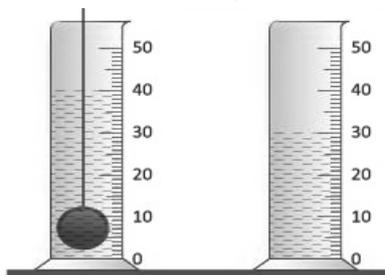


Fig. 1: Schematic image of the cylindrical measurement volume graduated.

2.2. Taking image

To take better images it must be used of lightening system, thus it was used of special box which was prepared to this (Fig.2). In this special box, the lamps were in locations that high the resolution of 3CCD camera (SONY CYBERSHOT) for imaging be obtained. Images were recall by software MATLAB version 7.8. Images were taken immediately after determining volume displacement method orange and number of each image were also recorded. Note that dimensional images of the property, was used in imaging The lens distance must exist in all the same pictures, so order a special place in the box for the camera embedded therein were considered . Also, dimensions of image were by pixel and metric dimensions were extracted from these pixels, so all images were taken in equal size (1632 ×1224).

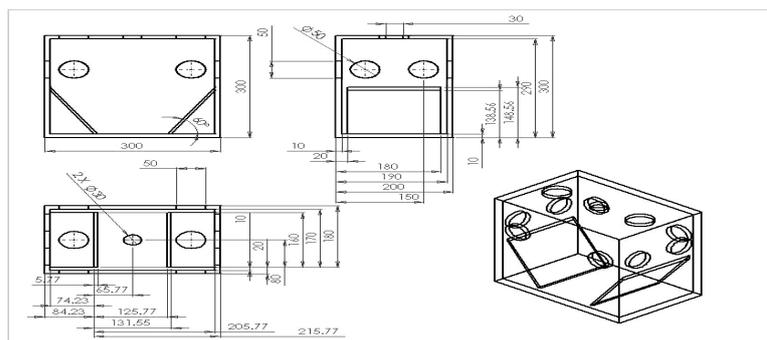


Fig. 2: Three-dimensional image and three-view boxes used for taking images of samples.

Every picture includes image of fruit itself and two other images that positioned in two flat mirrors aside. These mirrors, meanwhile, provide image of two other side of oranges, help in better lightening too. Regards that images had changed their dimensions in flat mirrors, these two images were not used and only middle image was separated in software by using *Imcrop* command in MATLAB.

2.3. Functions used in image processing process

In this stage the aim was to obtain an image to extract volume relations i.e. to extract an index of image that can estimate the volume. Therefore, this stage can be divided in two processes; pre-processing and extracting relations.

In first one, image was converted to binary by making threshold which components of orange sample and ground were 1 and 0 respectively (Fig.3). As images were provided in colure space RGB by profile R, G, B that one of them has found in (Fig.3), it is clear that difference between bands R was in high and this difference is useful in separating them. Along with, by making threshold between two peak of histogram (R-B) which has shown in (Fig.4), and after conducting dominating filter to delete noise, binary image was obtained. As shown in (Fig 4), there is one main peak of image which the numbers of its pixels are higher in zero value and the second is about 0.7. By making threshold about 0.3 we can separate background and orange simply. The result will be binary image that there was noise (Fig.3 part C). Noises were demolished by combining filter with matrix 5*5 and finally in (Fig.5 part D) will be the result.

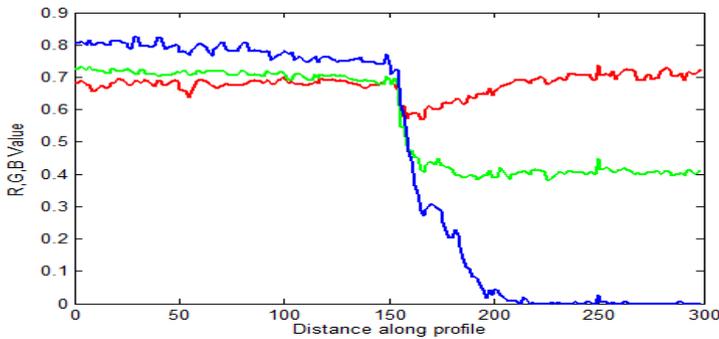


Fig. 3: Profile of part of the original Fig 5 (Part A) to the 150 related to the field and after 150 related to the orange.

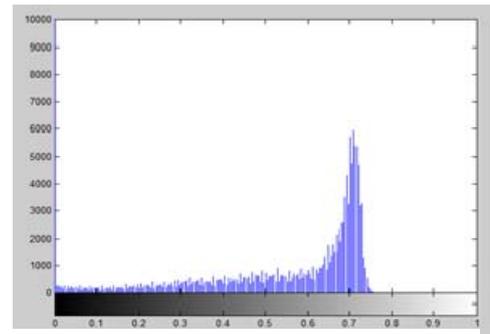


Fig. 4. Histogram chart component(R-B).

2.4. Obtaining an index for measuring volume and calibrating of image processing method

To obtain an index of measuring image-processing method, two images of 23 were chosen and after doing pre-processing section, the binary image was obtained. Then, the area of section that was separated as orange was obtained by pixel from this image. Regards that the superficial shape of orange was similar to spherical body, samples were regarded as sphere .As clear, the volume of sphere is given by $V=4/3 \pi r^3$, by obtaining the area of Fig.5(part D) and that two-dimensional image of sphere is the biggest of its circumferential circle and its radius is the same as radius of sphere. Therefore by using obtained area of circle from image processing method, we can calculate r (radius) by pixel from relation $A = \pi r^2$. As indicated, in order to calibrate, it was used of two images of orange samples obtained from mean samples chosen randomly. Calibrating was that the ratio of the real volume from water displacement method by cm^3 and the volume by pixel from image processing method was calculated. This ratio was used to convert the volume by pixel of other samples of orange and their volume was obtained by cm^3 .

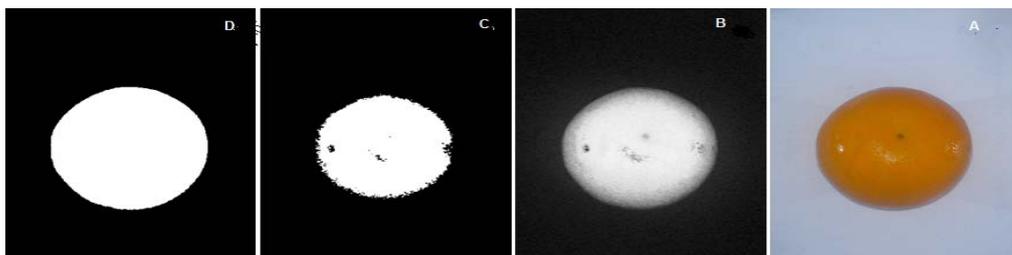


Fig. 5: Sample images. A) Original image, B) Image Roller Component (RB), C) image after the investment threshold, and D) Image after applying filters.

2.5. Statistical analyze

Calculated volumes from image processing method and resultant volumes of WDM were compared for paired samples by t-test examination. In addition to; one by one diagram of data of both methods was drawn to show closeness of obtained data from IPM to WDM.

3. Results and discussion

In general, obtained results in this study include 3 parts. The first is results for calibrating and obtaining the ratio of pixel to cm. The second, the volumes obtained from proposed method which has considered in part 3 by t-test examination, variance analyses, and one by one diagram with volume obtained from WDM.

3.1. Calibration results

The volume of two being used samples were calculated by WDM and every one were obtained by relation sphere volume r . Also, r was calculated in IPM using obtained area. Finally, ratio r calculated from WDM volume to r calculated from IPM was cleared for every sample. Then mean of both ratios was considered for all samples as calibration ratio. This ratio was equal to 3.19×10^{-6} . Results from image processing method that converted to sample volumes using ratio in calibration, have obtained along volume data calculated from base WDM in table 1.

3.2. Comparing WDM and IPM

The results of t-test examination of paired samples, doesn't show meaningful differences in meaning level %95 ($P > 0.05$) for volumes obtained from IPM to volumes calculated from WDM (table 2). Mean differences of series of volumes obtained by two methods in this test was 1.078 and Standard deviation between these methods was 3.744. Confidence interval %95 has evaluated between -2.698 and 0.541 cm^2 (table2).

(1.0: 1.0) diagram is another index to indicate closeness of calculated data from both methods. As clear from Fig. 6, the volumes resulted from IPM in samples that volumes of samples are little, is little than real volume and resulted volume from IPM is bigger than real volume by increasing sample volumes. One of the reasons for increasing volumes trend to real volume is approaching samples to camera lens. This trend is indicating to being bigger and massive of sample. But this trend, the linear relation of converting pixel to cm is deviated from linear mood. Regards to that, two samples chosen for this ratio were average samples, the average samples were positioned nearly on (1.0: 1.0) line of Fig 6. One of the simple solution for this problem is that camera should be positioned in far distance from samples so with approaching sample to lens it make little impact. Anyway, in addition IPM to calculate volume of orange is not only fast, no harmful, and care ness way, but can obtain the volume of many samples simultaneous. Also, this way can be employed in systems after harvesting such as ones which make grouping by quality and can add separating by volume to this systems to be economic. Other than this, image processing method to measure volume, can be even useful before –harvesting processes and by using it we can consider growing stages fruit.

Table 1: Area obtained by IPM and volumes obtained from both methods for all samples studied.

Number of samples	Volume of WDM	Area of IPM technique (Pixel)	Volume of IPM
1	125	142045	127.984
2	124	139750	124.895
3	112	131400	113.87
4	99	122750	102.813
5	10	124470	104.982
6	123	142730	128.911
7	91	113900	91.897
8	86	109920	87.123
9	64	86470	60.788
10	103	126020	106.949
11	119	140080	125.338
12	86	108990	86.02

13	109	126720	118.213
14	61	825779	56.731
15	84	109838	87.026
16	70	90785	65.394
17	76	96193	71.324
18	103	126210	107.191
19	105	123930	104.3
20	65	88082	62.495
21	85	111600	89.128
22	89	110660	88.004
23	63	86128	60.427

Fig. 6: Chart volumes calculated from two volumes of WDM and IPM with equity lines or Peer to Peer.

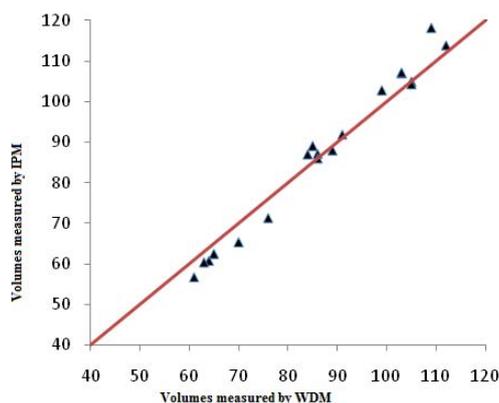


Table 2: Test results of paired t-test to compare of calculating volume WDM and IPM.

samples	df	Differences of paired samples				Probability (P)
		Standard deviation	mean	95% Confidence Interval of the Difference		
				upper	lower	
Volumes coupled WMD and IPM	22	3.744	1.0784	0.541	-2.697	0.181

4. References

- [1] Anonymous. 2008, FaoSTAT, www.Fao.org.
- [2] M. A. Safwat. Theoretical Prediction of Volume, Surface area, and Center of Gravity for Agricultural Products. *TRANS. A.S.A.E.* 1971, **5**: 549-553.
- [3] H. Sadrnia, A. Rajabipour, A. Jafary, A. Javadi and Y. Mostofi. Classification and analysis of fruit shapes in long type watermelon using image processing. *Int. J. Agric. Biol.* 2007, **1**: 68-70.
- [4] K. Waseem, A. Ghaffoor and SU. Rehman. Effect of fruit orientation on the quality of litchi (*Litchi chinensis* Sonn) under the agro-climatic conditions of Dera Ismail Khan-Pakistan. *Int. J. Agric. Biol.* 2002, **4**: 503-505.
- [5] S. Sahin, and S.Gülüm Sumnu. *Physical Properties of Foods*. Springer Science and Business Media (LLC). 2006.
- [6] M. Ngouajio, W. Kirk, and R. Goldy. A simple model for rapid and nondestructive estimation of bell pepper fruit volume. *J. Crop Hortic. Sci.* 2003, **38**: 509-511.
- [7] M. Rashidi, K. Seyfi, and M. Gholami. Determination of kiwifruit volume using image processing. *Asian Research Publishing Network*, 2007, **2** (6): 646-651.
- [8] M. Rashidi and K. Seyfi. Classification of Fruit Shape in Cantaloupe Using the Analysis of Geometrical Attributes. *World Journal of Agricultural Sciences*. 2007, **3** (6): 735-740.
- [9] M. Rashidi, M. Malekiyan, and M. Gholami. Egg Volume Determination by spheroid approximation and image processing. *World Applied Science Journal*. 2007, **4** (3): 590-596.
- [10] AB. Koc. Determination of watermelon volume using ellipsoid approximation and image processing. *Postharvest Biology and Technology*. 2007, **45**: 366-371.