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# Using geometrical characteristics to grading pomegranate fruit (var. Malas)

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**Abstract**

Size and fruit shape are of the most important quality parameters for evaluation by consumer performance. Also misshapen fruits are usually rejected according to grading standards of fruit. This research was conducted to determine quantitative grading algorithm for pomegranate shape and size. To reach objective and reproducible results, some Physical characteristics of pomegranate such as mass and outer dimensions (length and width) were measured and an evaluation based on mass and outer dimensions was proposed. Results of the study showed that mass and aspect ratio (length to width ratio) of apple can be used successfully to grade apple shape and size.

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## Introduction

Pomegranate *(Punica granatum* L.) belongs to *Punicacea* family. It is one of the important and commercial horticultural fruit which is generally very well adapted to the Southern coastal countries of the Mediterranean Sea climate (Biale and Young, 1981; Harde *et al.,* 1970). It has been cultivated extensively in Iran, India and some parts in the U.S.A (California), China, Japan, Spain and Russia. Pomegranate fruits are consumed fresh or processed as juice, jellies and syrup for industrial production (Hodgson, 1917; Nagy *et al.,* 1990). Different parts of its tree (leaves, fruits and bark skin) have been used traditionally for their medicinal properties and for other purposes such as in tanning. It is proved to have high antioxidant activity and good potency for cancer prevention (Afaq *et al.,* 2005; Gil *et al.,* 1995; Rania *et al.,* 2007).

Fruit packaging installations have been founded in five northern cities of Ramsar, Shahsavar, Noshahr, Chaloos and Amol to process and pack citrus in advanced modern ways, but packaging is not yet done in the most suitable and proper way. Grading and sizing of fruit is a prerequisite to proper packaging, but not much importance has been attached to its study (ICRI, 2005). There does not exist any suitable set of standards for grading and sorting of the fruit. There only exists a rough grading manual of not much scientific value, as reported through some publications of Iran Standard and Industrial Research Institute (SWFV, 2002; WSFV., 1999).

Physical and geometrical properties specifications of agricultural products constitute the most important parameters needed in the design of grading, transferring, processing, and packaging systems. Physical specifications, mechanical, electrical, thermal, visual, acoustic and chemical properties are among attributes of useful engineering application (Owolarafe *et al.*, 2007; Mohsenin, 1980; Topuz, 2005).

The official quality definitions for sorting fruits are hardly more than a measure on size and shape. Most sorting standards specify size and shape based on visual comparison of size and shape relative to reference drawings. These drawings serve as references in classifying size and shape (Sadrnia *et al.*, 2007; Beyer *et al.*, 2002). Although ratings based on visual comparison do not require any equipment, the method is subjective and may depend on person executing the rating. Moreover, rating scores may be biased by confusing variables such as shape or size (Gerhard *et al.*, 2001). Substitute approaches describe size and shape using indices calculated from physical and geometrical properties of fruits. Since such approaches are based on direct measurement, they are objective and reproducible. In addition, necessary measurements can be performed easily and no complicated equipment is needed (Owolarafe *et al.*, 2007; Mohsenin, 1980). Shape and size are the most important quality parameters of fruits. This quality attributes of Fruit are affected by inheritance in addition to environmental growing conditions. Similar to other fruits and vegetable, pomegranate shape and size are the most important quality parameters. Consumers prefer fruits of equal size and shape. Sorting can increase uniformity in size and shape, reduce packaging and transportation costs and also may provide an optimum packaging configuration (Sadrnia *et al.*, 2007). Moreover, sorting is important in meeting quality standards, increasing market value and marketing operations (Wilhelm *et al.*, 2005). Sorting manually is associated with high labor costs in addition to subjectivity, tediousness and inconsistency which lower the quality of sorting (Wen and Tao, 1999). However, replacing human with a machine may still be questionable where the labor cost is comparable with the sorting equipment (Kavdir and Guyer, 2004). Studies on sorting in recent years have focused on automated sorting strategies and eliminating human efforts to provide more efficient and accurate sorting systems which improve the classification success or speed up the classification process (Kleynen *et al.*, 2003; Polder *et al.*, 2003).

The main objective of this research is to develop a fast procedure that allows an un-biased and reproducible quantitative description of fruit shape and size in pomegranate (cv. Malas) that is based on mass and outer dimensions.

## Materials and methods

*Sample preparation*

Mature fresh pomegranate fruits (cv. Malas) were collected from Tehran province of Iran, in 2013 autumn season (Figure 1). The fruits were cleaned manually to remove all foreign material and defective fruits. Then 120 randomly fruits were selected for defects by careful visual inspection, transferred to the laboratory and held at 4±1 °C and 87±5% relative humidity until experimental procedure. Before each test, the required quantity of samples was taken out of refrigerator and allowed to warm up to room temperature (25˚C).

In order to obtain required parameters for pomegranate shape and size detection algorithm, the mass of each pomegranate was measured to 0.1 g accuracy on a digital balance. By assuming the general shape of pomegranate as an oblate spheroid, the outer dimensions of each pomegranate, i.e. length (a) and width (b) (Figure 2) was measured to 0.1 cm accuracy by a digital caliper (AND GF-600, JAPON). Moisture content of the samples was determined according to AOAC approved vacuum oven (Memmert-ULE500, Germany) method (AOAC, 2005). All the physical properties were determined at the moisture contents of 69.3 % (w.b.). All the experiments were replicated at least of five times and the average values were reported. Table 1 shows some physical and geometrical properties of the 120 randomly selected pomegranate fruits.

*Shape and Size Detection*

Primary investigation indicated that three pomegranate sizes, i.e. small (misshapen), medium (normal) and large (normal) were detectable and separable in the samples. An easy technique of judging based on analysis of outer dimensions of pomegranate was used for detecting shape of pomegranate. Aspect ratio was used to detect oblate spheroid (misshapen), spheroid (normal) and oblong spheroid (misshapen) pomegranate fruits. Aspect ratio is defined by equation 1. (Mohsenin, 1980; Sadrnia *et al.*, 2007).

$$A.R. = \frac{a}{b} \qquad (1)$$

Where, A.R. = Aspect ratio (dimensionless), a = Length of fruit (cm), b = Width of fruit (cm).

For mathematical describing of pomegranate shape and size, mass and aspect ratio of pomegranate fruits were subjected to statistical analysis using the Microsoft Office Excel 2007.

## Results and discussion

Mass of medium size pomegranate fruits ranged from 200 to 240 g, while mass of small size pomegranate fruits were less than or equal to 200 g and mass of large size pomegranate fruits were more than or equal to 240 g. Therefore, the mass lines 200 g and 240 g can separate medium size pomegranate fruits from small size and large size pomegranate as shown in Figure 3.

**Table 1.** Physical and geometrical properties of pomegranate.

| Parameter | Minimum | Maximum | Mean±SD | C.V. (%) |
|---|---|---|---|---|
| Length, mm | 68.21 | 106.73 | 86.32±7.52 | 7.62 |
| Width, mm | 65.38 | 93.17 | 80.56±6.93 | 5.41 |
| Mass, g | 237.73 | 335.5 | 290.4±31.14 | 10.28 |
| Aspect ratio | 0.85 | 1.13 | 1.01±0.05 | 5.31 |

Aspect ratio of spheroid shape pomegranate ranged from 0.95 to 1.05, while aspect ratio of oblong spheroid shape pomegranate were more than or equal to 1.05 and aspect ratio of oblate shape pomegranate fruits were less than or equal to 0.95. As a result, the aspect ratio lines 0.95 and 1.05 can separate spheroid shape pomegranate from oblate spheroid shape and oblong spheroid shape pomegranate as indicated in Figure 3.

Among nine "size and shape" combinations (three sizes × three shapes); samples with "normal size" × "normal shape" (two combinations) were considered as normal pomegranate fruits. Pomegranate fruits with other combinations (seven combinations) were considered as misshapen pomegranate. Fig. 3 shows the mass lines 200 g and 240 g in association with the aspect ratio lines 0.95 and 1.05 can separate normal pomegranate (two green regions) from misshapen pomegranate (seven white regions).

**Table 2.** Shape and size of pomegranate.

| Size | Mass range (g) | shape | Aspect ratio | description | Frequency (%) |
|---|---|---|---|---|---|
| | | Oblate spheroid | ≤ 0.95 | Misshapen | 2.52 |
| Small | ≤260 | Spheroid | 0.95 – 1.05 | Misshapen | 5.04 |
| | | Oblong spheroid | ≥ 1.05 | Misshapen | 3.36 |
| | | Oblate spheroid | ≤ 0.95 | Misshapen | 11.76 |
| Medium | 260-320 | Spheroid | 0.95 – 1.05 | Normal | 53.78 |
| | | Oblong spheroid | ≥ 1.05 | Misshapen | 10.92 |
| | | Oblate spheroid | ≤ 0.95 | Misshapen | 2.52 |
| Large | ≥ 320 | Spheroid | 0.95 – 1.05 | Normal | 7.56 |
| | | Oblong spheroid | ≥ 1.05 | Misshapen | 2.52 |

**Fig. 1.** Pomegranate (Malas variety).

Results of study indicated that three shapes, three sizes, and consequently nine "shape and size" combinations were detectable and separable in the pomegranate. Results of study also showed that among three shapes, frequency of spheroid pomegranate was the highest (66.38%), while frequency of oblate spheroid pomegranate was the lowest (16.8%). Frequency of oblong spheroid pomegranate was 16.82%. Moreover, among three sizes, frequency of small pomegranate was the lowest (10.92%), while frequency of medium pomegranate was the highest (76.46%). Frequency of large pomegranate was 12.62%. Besides, frequencies of normal and misshapen pomegranate were 61.34% and 38.66%, respectively (Table 2). These results are in line with those of Sadrnia *et al.* who reported that aspect ratio can be used effectively to determine normal and misshapen fruit, and quite in agreement with those of Ku *et al.* and White *et al.* who concluded that classification of fruit shape using indices calculated from outer dimensions of fruit can increase uniformity in shape and size (Sadrnia *et al.*, 2007; Ku *et al.*, 1999; White *et al.*, 2000).

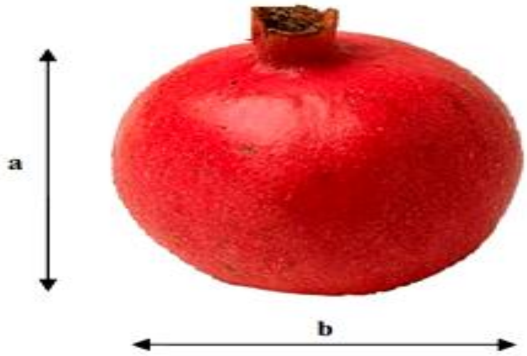


**Fig. 2.** Dimensions of pomegranate fruit; a and b are the length and width.

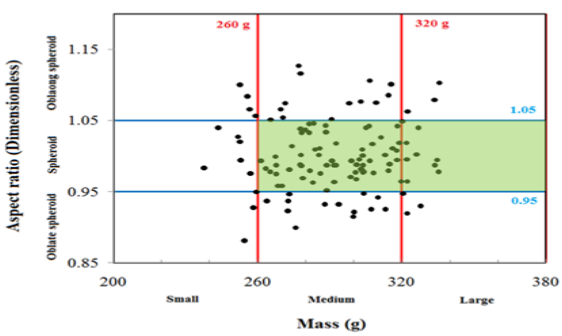


**Fig. 3.** Grading of pomegranate fruits; normal (green area) and misshapen (white area).

## Conclusions

Grading and quality rating is normally done by experts. To achieve objective and reproducible results, a simple evaluation based on measured geometric characteristics is proposed. Significantly differences in shape and size were detected between normal and misshapen fruits. This method can be adapted and applied to other product too. It can be concluded that mass and aspect ratio of pomegranate can be used effectively to determine normal and misshapen pomegranate.

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