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Classification of Tangerine Size and Shape Based on Mass and Outer Dimensions

Majid Rashidi and Fereydoun Keshavarzpour

Department of Agriculture, Shahre-Rey Branch,
Islamic Azad University, Tehran, Iran

Abstract: Fruit size and shape are the most important quality parameters for evaluation by customer performance. In addition, misshapen fruits are generally rejected according to sorting standards. This study was conducted to determine quantitative classification algorithm for tangerine size and shape. To reach objective and reproducible results, mass and outer dimensions (height and diameter) of tangerine were measured and an assessment based on mass and outer dimensions was proposed. Results of the study indicated that mass and aspect ratio (height to diameter ratio) of tangerine can be used effectively to classify tangerine size and shape.

Key words: Tangerine · Sorting · Grading · Shape · Mass · Geometrical properties

INTRODUCTION

The tangerine (*Citrus tangerina*) is an orange-colored citrus fruit (Fig. 1). Tangerines are smaller than most oranges and are usually much easier to peel and to split into segments. They have been found in many shapes and sizes. The number of seeds in each segment varies greatly. The taste is often less sour, or tart, than that of an orange. While less tart, tangerines are also sweeter than oranges. Tangerines are a good source of vitamin C, folate and beta-carotene. They also contain potassium, magnesium and vitamins B_1, B_2 and B_3 [1].

Iran products 3.5 million tones of citrus and is ranked 22nd in the world. But, Iranian tangerines are not exported because of variability in size and shape and lack of suitable packaging [2]. Similar to other fruits, tangerine size and shape are the most important quality parameters. Consumers prefer fruits of equal size and shape [3, 4]. Sorting can increase uniformity in size and shape, reduce packaging and transportation costs and also may provide an optimum packaging configuration [5]. Moreover, sorting is important in meeting quality standards, increasing market value and marketing operations [6]. Sorting manually is associated with high labor costs in addition to subjectivity, tediousness and inconsistency which lower the quality of sorting [7].

Fig. 1: Tangerine (*Citrus tangerina*)

However, replacing human with a machine may still be questionable where the labor cost is comparable with the sorting equipment [8]. 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 [9, 10].

Physical and geometrical properties of frits are the most important parameters in design of sorting systems. Among these properties, mass and outer dimensions are the most important ones [11]. The official quality definitions for sorting fruits are hardly more than a

Corresponding Author: Dr. Majid Rashidi, Ph.D., Department of Agriculture, Shahre-rey Branch, Islamic Azad University, Tehran, Iran.

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. 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 size or shape. 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 [3-5]. Accordingly, the present study was conducted to develop a fast procedure that permits an un-biased and reproducible quantitative description of tangerine size and shape based on mass and outer dimensions.

MATERIALS AND METHODS

Experimental Procedure: One of the most common commercial cultivars of tangerine in Iran, i.e. Clementine was considered for this study. One hundred and twenty randomly selected tangerines of various sizes were purchased from a local market. Tangerines were selected for freedom from defects by careful visual inspection, transferred to the laboratory and held at 5±1°C and 90±5% relative humidity until experimental procedure. In order to obtain required parameters for tangerine size and shape detection algorithm, the mass of each tangerine was measured to 1.0 g accuracy on a digital balance. By assuming the general shape of tangerine as an oblate spheroid, the outer dimensions of each tangerine, i.e. height (H) and diameter (D) was measured to 0.1 cm accuracy by a digital caliper. Table 1 shows some physical and geometrical properties of the 120 randomly selected tangerines.

Size Detection: Primary investigation indicated that three tangerine sizes, i.e. small (misshapen), medium (normal) and large (normal) were detectable and separable in samples.

Shape Detection: An easy technique of judging based on analysis of outer dimensions of tangerine was used for detecting shape of tangerine. Aspect ratio was used to detect oblate (misshapen), oblate spheroid (normal) and spheroid (normal) tangerines. Aspect ratio is defined by equation 1 [3-5, 11].

Table 1: The mean value, standard deviation (S.D.) and coefficient of variation (C.V.) of some physical and geometrical properties of the 120 randomly selected tangerines

Parameter	Minimum	Maximum	Mean	S.D.	C.V. (%)
Mass, g	39.0	194.0	101.5	34.2	33.7
Height, cm	3.30	6.90	5.02	0.67	13.4
Diameter, cm	4.30	8.20	6.12	0.79	13.0
Aspect ratio	0.70	0.98	0.82	0.06	7.20

Table 2: Size, mass range, shape, aspect ratio range, description and frequency of the 120 randomly selected tangerines

Size	Mass range (g)	Shape	Aspect ratio range	Description	Frequency(%)
Small	≤ 90	Oblate	0.8	Misshapen	11.4
		Oblate spheroid	0.8-0.9	Misshapen	20.2
		Spheroid	0.9	Misshapen	0.90
Medium	90-150	Oblate	0.8	Misshapen	15.8
		Oblate spheroid	0.8-0.9	Normal	30.7
		Spheroid	0.9	Normal	6.10
Large	≥ 150	Oblate	0.8	Misshapen	7.00
		Oblate spheroid	0.8-0.9	Normal	6.10
		Spheroid	0.9	Normal	1.80

$$A.R. = H / D, (A.R. = 1.0) \tag{1}$$

Where:
A.R. = aspect ratio, dimensionless
H = height of tangerine, cm
D = diameter of tangerine, cm

For mathematical describing of tangerine size and shape, mass and aspect ratio of tangerines were subjected to statistical analysis using the Microsoft Office Excel (Version 7.0-2003).

RESULTS

Small, Medium and Large Tangerine Sizes: Mass of medium size tangerines ranged from 90 g to 150 g, while mass of small size tangerines were less than or equal to 90 g and mass of large size tangerines were more than or equal to 150 g. Therefore, the mass lines 90 g and 150 g can separate medium size tangerines from small size and large size tangerines as shown in Fig. 2.

Oblate, Oblate Spheroid and Spheroid Tangerine Shapes: Aspect ratio of oblate-spheroid shape tangerines ranged from 0.8 to 0.9, while aspect ratio of spheroid shape tangerines were more than 0.9 and aspect ratio of oblate shape tangerines were less than 0.8. As a result, the aspect ratio lines 0.8 and 0.9 can separate oblate-spheroid shape tangerines from spheroid shape and oblate shape tangerines as indicated in Fig. 2.

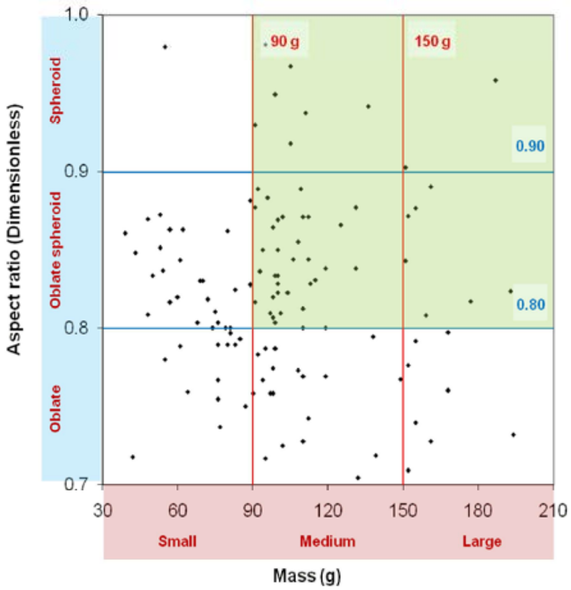

Fig. 2: Aspect ratio versus mass; green and white regions show normal and misshapen tangerines, respectively

Normal and Misshapen Tangerines: Among nine "size and shape" combinations (three sizes × three shapes); samples with "normal size" × "normal shape" (four combinations) were considered as normal tangerines. Tangerines with other combinations (five combinations) were considered as misshapen tangerines. Fig. 2 shows the mass lines 90 g and 150 g in association with the aspect ratio lines 0.8 and 0.9 can separate normal tangerines (four green regions) from misshapen ones (five white regions).

DISCUSSION

In this study, mass and outer dimensions (height and diameter) of tangerines were analyzed to classify tangerines size and shape. Results of study indicated that three sizes, three shapes and consequently nine "size and shape" combinations were detectable and separable in the tangerines. Results of study also showed that among three sizes, frequency of medium tangerines was the highest (52.6%), while frequency of large tangerines was the lowest (14.9%). Frequency of small tangerines was 32.5%. Besides, among three shapes, frequency of oblate-spheroid tangerines was the highest (57.0%), while frequency of spheroid tangerines was the lowest (8.8%). Frequency of oblate tangerines was 34.2%. Moreover, frequencies of normal and misshapen tangerines were 44.7% and 55.3%, respectively (Table 2). These results are in line with those of Rashidi and Seyfi [3], Rashidi and Gholami [4] and Sadrnia *et al.* [5] who concluded that some physical and geometrical properties of fruit can be used effectively to determine normal and misshapen fruit.

CONCLUSION

It can be concluded that mass and aspect ratio of tangerine can be used effectively to classify normal and misshapen tangerine.

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