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Shape and size grading of apple fruit (cv. Fuji) based on geometrical properties

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Abstract

Fruit shape and size are 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 assortment and grading algorithm for apple shape and size. To reach objective and reproducible results, some Physical characteristics of apple (Fuji variety) 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

Fruits are attractive and nutritional foods, because of their color, shape, unique taste and smell, and rich in minerals, vitamins and other beneficial components (Cassano *et al.*, 2003). Apple is a tree and its pomaceous fruit, of species *Malusdomestica* Borkh in the rose family *Rosaceae*, is one of the most widely cultivated tree fruits. There are more than 7500 known cultivars of apples (Dobrzanski *et al.*, 2006). Iran, with 190000 ha of cultivation area (2.8% of the world production area) is among the world's top apple producers. In spite of 2.66 million tons of annual Iranian apple production, exportation of that is low (FAO, 2011).

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, 1986; Topuz *et al.*, 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 (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, 1986). 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, apple 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 (Hazbavi, 2014; 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 apple (cv. Fuji) that is based on mass and outer dimensions.

Materials and methods

Sample Preparation

Mature fresh apple fruit (cv. Fuji) were collected from Tehran province of Iran, in 2012 summer 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 90±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 apple shape and size detection algorithm, the mass of each apple was measured to 0.1 g accuracy on a digital balance. By assuming the general shape of apple as an oblate spheroid, the outer dimensions of each apple, i.e. length (L) and width (W) (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 85.3 % (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 apples.

Shape and Size Detection

Primary investigation indicated that three apple 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 apple was used for detecting shape of apple. Aspect ratio was used to detect oblate spheroid (misshapen), spheroid (normal) and oblong spheroid (misshapen) apples. Aspect ratio is defined by equation 1. (Sadrnia *et al.*, 2007; Mohsenin, 1986).

$$A.R. = \frac{L}{W} \quad (1)$$

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

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

Results and discussion

Small, Medium and Large Sizes

Mass of medium size apples ranged from 45 to 85 g, while mass of small size apples were less than or equal to 45 g and mass of large size apples were more than or equal to 85 g. Therefore, the mass lines 45 g and 85 g can separate medium size apples from small size and large size apples as shown in Figure 3.

Table 1. Physical and geometrical properties of apple.

Parameter	Minimum	Maximum	Mean±SD	C.V. (%)
Length, mm	45.45	61.32	52.46±5.82	6.81
Width, mm	49.87	65.28	55.76±6.83	6.11
Mass, g	19.62	103.33	65.31±11.4	16.64
Aspect ratio	0.79	1.07	0.94±0.05	5.38

Table 2. Shape and size of apple.

Size	Mass range (g)	shape	Aspect ratio	description	Frequency (%)
		Oblate spheroid	≤ 0.9	Misshapen	4.2
Small	≤45	Spheroid	0.9 - 1	Misshapen	12.6
		Oblong spheroid	≥ 1	Misshapen	4.2
		Oblate spheroid	≤ 0.9	Misshapen	11.8
Medium	45-85	Spheroid	0.9 - 1	Normal	42.9
		Oblong spheroid	≥ 1	Misshapen	5.9
		Oblate spheroid	≤ 0.9	Misshapen	3.4
Large	≥ 85	Spheroid	0.9 - 1	Normal	11.8
		Oblong spheroid	≥ 1	Misshapen	3.4

Oblate Spheroid, Spheroid and Oblong Spheroid Shapes

Aspect ratio of spheroid shape apples ranged from 0.9 to1, while aspect ratio of oblong spheroid shape apples were more than or equal to 1 and aspect ratio of oblate shape apples were less than or equal to 0.9.

As a result, the aspect ratio lines 0.9 and 1 can separate spheroid shape apples from oblate spheroid shape and oblong spheroid shape apples as indicated in Figure 3.

Fig. 1. Apple (Fuji variety).

Normal and Misshapen Apples

Among nine "size and shape" combinations (three sizes × three shapes);samples with "normal size" × "normal shape" (two combinations) were considered as normal apples. Apples with other combinations (seven combinations) were considered as misshapen apples. Figure 3 shows the mass lines 45 g and 85 g in association with the aspect ratio lines 0.9 and 1 can separate normal apples (two green regions) from misshapen apples (seven white regions).

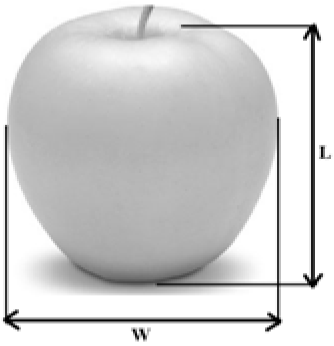

Fig. 2. Dimensions of apple fruit; L and W are the length and width.

In this research, mass and outer dimesions (Length and width) of apple fruits were analyzed to Assort apples shape and size. Results of study indicated that three shapes, three sizes, and consequently nine "shape and size" combinations were detectable and separable in the apples. Results of study also showed that among three shapes, frequency of spheroid apple was the highest (66.6%), while frequency of oblong spheroid apple was the lowest (13.7%). Frequency of oblate spheroid apple was 19.7%. Moreover, among three sizes, frequency of small apple was the lowest (21%), while frequency of medium apple was the highest (60.6%).Frequency of large apple was 18.4%. Besides, frequencies of normal and misshapen apple were 54.7% and 45.3%, respectively (Table 2). These results are in line with those of Sadrnia *et al.* (2007) 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.* (1999) and White *et al.* (2000) who concluded that classification of fruit shape using indices calculated from outer dimensions of fruit can increase uniformity in shape and size (White *et al.*, 2000; Ku *et al.*, 1999; Sadrnia *et al.*, 2007).

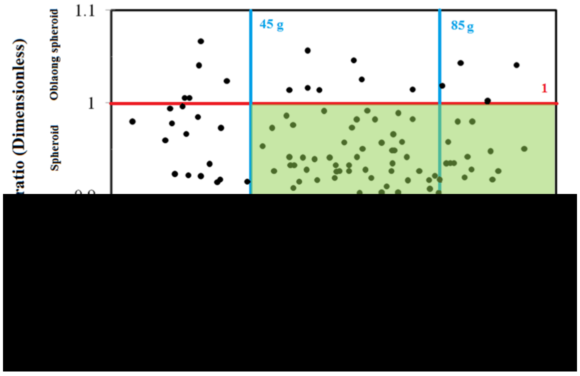

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Fig. 3. Grading of apple fruits; normal (green area) and misshapen (white area).

Conclusion

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 apple can be used effectively to determine normal and misshapen apple.

References

AOAC. 2005. Official Methods of Analysis, 18th Ed. Association of Official Analytical Chemists, Washington DC, U.S.A.

Beyer M, Hahn R, Peschel S, Harz M, Knoche M. 2002. Analysing fruit shape in sweet cherry. Scientia Horticulturae **1(4),** 139–50. http://dx.doi.org/101016/S0304-4238(02)00123-1

Cassano A, Drioli E, Galaverna G, Marchelli R, Di-Silvestra G, Agnasso P. 2003. Clarification and concentration of citrus and carrot juices by integrated membrane processes. Journal of Food Engineering **57(2),** 153-163. http://dx.doi.org/101016/S0260-8774(02)00293-5

Dobrzanski B, Rabcewicz J, Rybczynski R. 2006. Handling of Apple: Transport Techniques and Efficiency Vibration, Damage and Bruising Texture, Firmness and Quality. Institute of Agrophysics of Polish of Sciences, Lublin, Poland.

Food Agriculture Organization. 2011. Available at: http://www.fao.org/statisticshtm.

Gerhard J, Nielsen HM, Wolfgang P. 2001. Measuring image analysis attributes and modeling fuzzy consumer aspects for tomato quality. Computers and Electronics in Agriculture **31(1),** 17–29. http://dx.doi.org/101016/S0168-1699(00)00171-X

Kavdir I, Guyer DE. 2004. Comparison of artificial neural networks and statistical classifiers in apple sorting using textural features. Biosystems Engineering **89(3),** 331-344. http://dx.doi.org/101016

Hazbavi I. 2014. Using geometrical characteristics to grading pomegranate fruit (var. Malas). International Journal of Biosciences **4(7),** 100-105 http://dx.doi.org/10.12692/ijb/4.7100-105

Ku HM, Doganlar S, Chen KY, Tankley SD. 1999. The genetic basis of pear-shaped tomato fruit. Theoretical and Applied Genetics **9,** 844–50.

Mohsenin NN. 1980. Physical properties of plants and animal materials. Gordon Breach Sci. Press, New York, USA.

Owolarafe OK, Olabige TM, Faborode MO. 2007. Macro-structural characterisation of palm fruit at different processing conditions. Journal of Food Engineering **79(1),** 31-36. http://dx.doi.org/10.1016/j.jfoodeng2006.01.024

Polder G, Van Der Heijden GWAM, Young IT. 2003. Tomato sorting using independent component analysis on spectral images. Real-Time Imaging **9(4),** 253-259. http://dx.doi.org/10.1016/j.rti.2003.09008

Sadrnia H, Rajabipour A, Jafary A, Javadi A, Mostofi Y. 2007.Classification and analysis of fruit shapes in long type watermelon using image processing. International Journal of Agriculture and Biology **9,** 68-70.

Topuz A, Topakci M, Canakci M, Akinci I,Ozdemir F. 2005. Physical and nutritional properties of four orange varieties. Journal of Food Engineering **66(4),** 519-523. http://dx.doi.org/10.1016/jjfoodeng.2004.04.024

Wen Z, Tao Y. 1999. Building a rule-based machine-vision system for defect inspection on apple sorting and packing lines. Expert Systems with Applications **16(3),** 307-313. http://dx.doi.org/101016/S0957-4174(98)00079-7

White AG, Alspach PA, Weskett RH, Brewer LR. 2000. Heritability of fruit shape in pear. Euphytica **112,** 1–7.

Wilhelm LR, Suterand DA, Brusewitz GH. 2005. Physical Properties of Food Materials. Food and Process Engineering Technology. ASAE, St. Joseph, Michigan, USA.