Agricultural Engineering Research Journal 6(3): 26-30, 2016
ISSN 2218-3906

DOI: 10.5829/idosi.aerj.2016.26.30

Fruit Shape Classification in Cantaloupe (cv. Samsouri) Using the Analysis of Geometrical Attributes

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Abstract: Classification of fruit shape is vital in evaluating agricultural produce, meeting quality standards and increasing market value. It is also helpful in planning packaging, transportation and marketing operations. Misshapen fruits are generally rejected according to sorting standards of fruit. Therefore, this study was carried out to establish quantitative algorithm for classification of fruit shape in cantaloupe (*Cucumis melo*) and to determine detection algorithm for misshapen cantaloupes. Geometrical attributes and some physical characteristics of cantaloupe such as length, major diameter, minor diameter, mass, volume and density were measured. To achieve objective and reproducible results, an assessment based on geometrical attributes analysis was proposed. Significant differences in fruit shape parameters i.e. length to lateral geometric mean diameter ratio (roundness ratio) and major diameter to minor diameter ratio (ellipsoid ratio) were detected between fruit shapes. The results of the study indicated that roundness ratio and ellipsoid ratio can be used successfully to classify fruit shape and determine normal and misshapen fruit.

Key words: Grading · Sorting · Geometrical attributes · Cantaloupe

INTRODUCTION

Cantaloupe (*Cucumis melo*) is a subtropical fruit and belongs to the family Cucurbitaceae. Its spread from Italy to other parts of the world was rapid due to its ordinary climatic requirements. Cantaloupe is considered as one of the best fruits due to its high nutritive value. Besides a rich source of vitamin A and C, it contains a fair amount of nutrients (Calcium, Magnesium, Phosphorus, Potassium and Iron) and vitamins (B_1, B_3, B_5 and B_6). Cantaloupe contains 55-59% edible portion, 87-92% moisture, 0.1-0.2% oil, 0.60-1.0% protein and 6.3-10.3% total soluble solids [1]. Iran produces 750, 000 tons of cantaloupes, but Iranian cantaloupe is not exported because of variability in size and shape and lack of proper packaging. Fruit shape is one of the most important physical properties and quality parameters of all agricultural produce [2]. Consumers prefer fruits of equal weight and uniform shape. Misshapen fruits are generally rejected according to sorting standards of fruit [3]. Classification of fruit can increase uniformity in size and shape, reduce packaging and transportation costs and also may provide an optimum packaging configuration [4]. Moreover, classification of fruit shape is vital in evaluating agricultural produce, meeting quality standards and increasing market value. It is also helpful in planning packaging, transportation and marketing operations [5].

Fruit shape is affected by inheritance in addition to environmental growing conditions [6]. Description of fruit shape is often necessary in horticultural research for a range of different purposes such as cultivar descriptions in applications for plant variety rights or cultivar registers [7, 8], evaluation of consumer preference [9], investigating heritability of fruit shape traits [6, 10], stress distribution analysis in the fruit skin [11], determining misshapen fruit in a cultivar [12], effect of orientation on the fruit size [13] and estimation of fruit volume and weight [5]. On the other hand, the official quality definitions for fruit or vegetable are scarcely more than a measure on size and color. The USDA grade standard specifies shapes based on visual comparison of fruit shape relative to reference drawing. These drawing serve as a reference in classifying fruit shape. Ratings based on visual comparison don't require any equipment. However, the method is subjective

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and may depend on person who executes the rating. Moreover, rating scores may be biased by confusing variables such as fruit size or color [12]. As a result, this process runs very slowly and seems not satisfactory for fruit classification in distribution terminals. Substitute approaches describe fruit shape using indices calculated from geometrical attribute of fruit e.g. watermelon [5], pear [6] and tomato [14]. Since such approaches are based on direct measurement, they are objective and reproducible. In addition, necessary measurements can be performed by a caliper and no complicated equipment is needed.

The present study was thus planned to develop a rapid procedure that permits an un-biased and reproducible quantitative classification of fruit shape and to determine normal and misshapen fruit in cantaloupe.

MATERIALS AND METHODS

Plant Material: The most common commercial variety of cantaloupe cv. Samsouri was considered for this study and about 120 samples of mature cantaloupe were picked up at random (without consideration fruit shape) from their storage piles. Fruits 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 use. Primary investigation based on longitudinal and lateral cross section shapes indicated that five shapes were detectable and separable in samples. Fig. 1 shows five fruit shapes in cantaloupe such as: (I) oblate, (II) regular, (III) oblong, (IV) round and (V) elliptical.

Experimental Procedure: In order to obtain required parameters for fruit shape detection algorithm, three mutually perpendicular axes, length (L), major diameter (D_1; longest intercept normal to L) and minor diameter (D_2; longest intercept normal to L and D_1) as shown in Fig. 2 were measured using a digital caliper with ± 1.0 mm accuracy. In addition, some physical properties of fruit i.e. mass and volume were measured. The mass of each cantaloupe was measured using a three-digit precision scale with ± 5.0 g accuracy (E-130T model from Spain). The volume of each cantaloupe was measured using the water displacement method. Each cantaloupe was submerged in a container full of water. The volume of the displaced water was directly measured using a 1000 ml capacity graduated cylinder. Water temperature was kept at 25°C. The bulk density of each cantaloupe was then calculated from the mass divided by the measured volume. Table 1 shows geometrical attributes and some physical properties of cantaloupe in Samsouri variety.

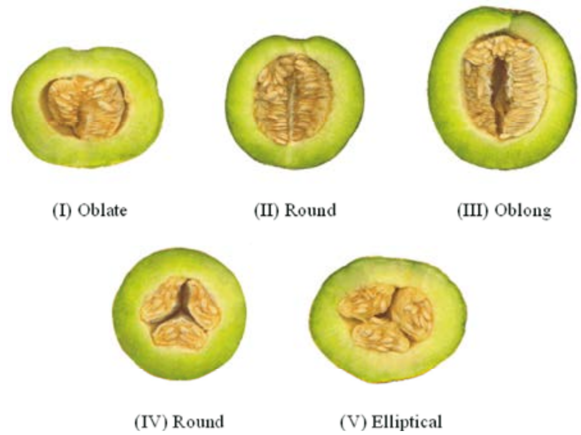

Fig. 1: Five fruit shapes in cantaloupe based on longitudinal and lateral cross section of fruits

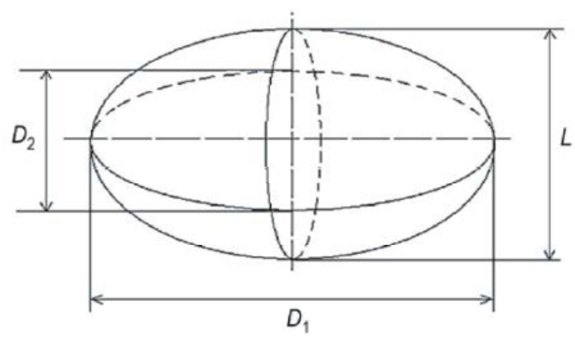

Fig. 2: The dimensions of a cantaloupe

Table 1: The mean values, S.D. and C.V. of the geometric attributes, mass, volume and density of cantaloupe cv. Samsouri

Parameter	Mean	Minimum	Maximum	S.D.	C.V.
Longitudinal diameter (mm)	134	95	185	18.8	14.0
Major lateral diameter (mm)	147	106	205	21.3	14.4
Minor lateral diameter (mm)	140	101	190	20.5	14.7
Mass (g)	1397	510	3380	549	39.32
Volume (cm^3)	1528	538	3654	640	41.86
Density ($g\ cm^{-3}$)	0.924	0.776	1.070	0.06	6.34

Fruit Shape Detection: An easy technique of judging based on analysis of geometrical attributes of cantaloupe was used for detecting shape of fruit. Roundness ratio was used to detect oblate, regular and oblong fruits. Roundness ratio is defined by equation 1 [15, 16]:

$$R.R. = \frac{L}{\sqrt{D_1 D_2}} \quad (1)$$

where:

R.R. = Roundness ratio, non-dimensional

L = length, mm

$\sqrt{D_1 D_2}$ = lateral geometric mean diameter, mm

Another parameter, ellipsoid ratio, was used to detect round and elliptical fruits. Ellipsoid ratio is defined by equation 2 [15, 16]:

$$E.R. = \frac{D_1}{D_2} \quad (2)$$

where:

E.R. = ellipsoid ratio, non-dimensional

D_1 = major diameter, mm

D_2 = minor diameter, mm

For mathematical describing of fruit shape and to determine detection algorithm for normal shape and misshapen cantaloupe, geometrical attributes of fruits, roundness ratio values and ellipsoid ratio values were subjected to statistical analysis using the Microsoft EXCEL (Microsoft Corporation, Redmond, WA).

RESULTS

Oblate, Regular and Oblong Fruits: Statistical results show that the mean roundness ratio value of regular fruits is 0.97, while the mean roundness ratio values of oblate and oblong fruits are 0.86 and 1.14, respectively. Results also show that roundness ratio value for regular fruits ranged from 0.90 to 1.10, while roundness ratio value for oblate fruits ranged from 0.74 to 0.89 and for oblong fruits from 1.13 to 1.18 (Table 2). Therefore, the roundness ratio lines 1: 0.90 and 1: 1.10 can be used as separating indicators. Fig. 3 demonstrates the roundness ratio lines 1: 0.90 and 1: 1.10 can separate regular fruits from oblate and oblong fruits.

Round and Elliptical Fruits: Statistical results of the study also indicate that the mean ellipsoid ratio value of round fruits is 1.04, while the mean ellipsoid ratio value of elliptical fruits is 1.15. Results also indicate that ellipsoid ratio value for round fruits ranged from 1.0 to 1.09, while ellipsoid ratio value for elliptical fruits ranged from 1.10 to 1.26 (Table 3). Therefore, the ellipsoid ratio line 1: 1.10 can be employed as separating indicator. Fig. 4 demonstrates the ellipsoid line 1: 1.10 can separate round fruits from elliptical fruits.

Normal and Misshapen Fruits: Results of the study show that roundness ratio value for normal fruit shapes ranged from 0.90 to 1.10 and ellipsoid ratio value for them ranged from 1.0 to 1.10 (Table 4). Therefore, roundness ratio lines 1: 0.90 and 1: 1.10, together with the ellipsoid ratio lines 1: 1.0 and 1: 1.10 can be used as separator of normal fruits

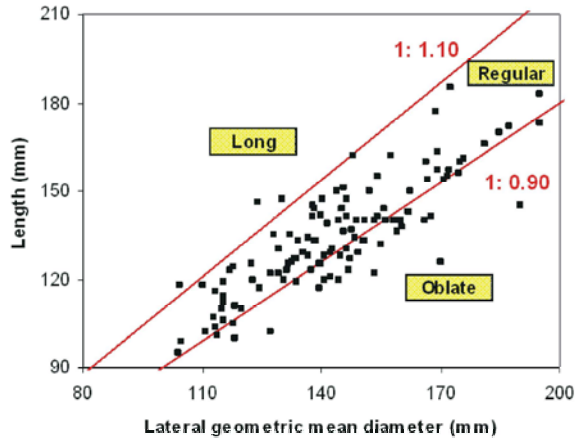

Fig. 3: Length versus lateral geometric mean diameter and separator lines of regular fruits from oblate and oblong fruits

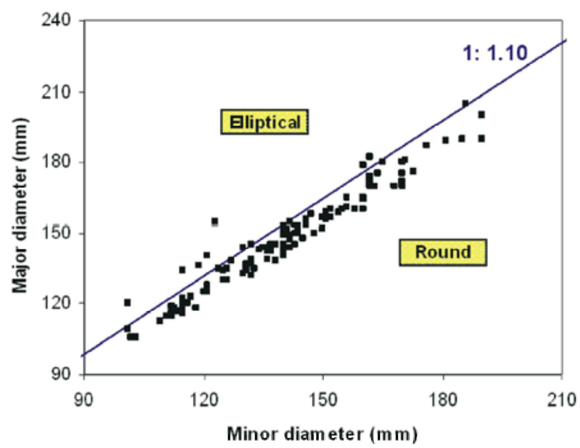

Fig. 4: Major diameter versus minor diameter and separator line of round fruits from elliptical fruits

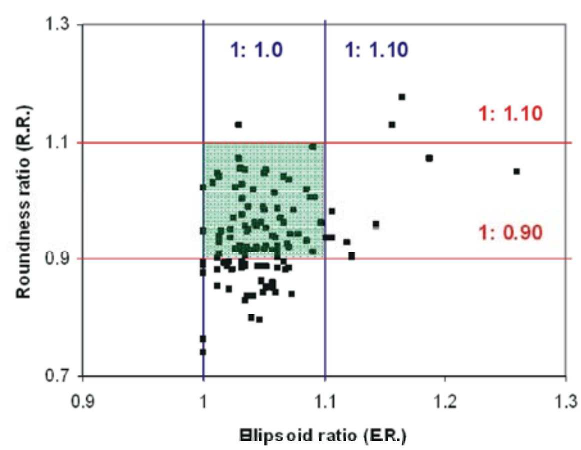

Fig. 5: Roundness ratio versus ellipsoid ratio and separator lines of normal fruits from misshapen fruits

Table 2: The mean values, S.D. and C.V. of roundness ratio of oblong, regular and oblate shapes of cantaloupe cv. Samsouri (shapes based on longitudinal cross section of fruits)

Shape	Mean	Minimum	Maximum	S.D.	C.V.
Oblate	0.86	0.74	0.89	0.04	4.35
Regular	0.97	0.90	1.10	0.05	5.29
Oblong	1.14	1.13	1.18	0.03	2.36

Table 3: The mean values, S.D. and C.V. of ellipsoid ratio of round and elliptical shapes of cantaloupe cv. Samsouri (shapes based on lateral cross section of fruits)

Shape	Mean	Minimum	Maximum	S.D.	C.V.
Round	1.04	1.0	1.09	0.02	2.27
Elliptical	1.15	1.10	1.26	0.05	3.53

Table 4: Description, roundness ratio range and ellipsoid ratio range of normal shape and misshapen cantaloupe

Shape	Description	Roundness ratio range	Ellipsoid ratio range
Normal	Round and round	0.90 – 1.10	1.0 – 1.10
Misshapen	Oblate	< 0.90	-----
Misshapen	Oblong	> 1.10	-----
Misshapen	Elliptical	-----	> 1.10

from misshapen fruits. Fig. 5 shows the roundness ratio lines 1: 0.90 and 1: 1.10 in conjunction with the ellipsoid ratio lines 1: 1.0 and 1: 1.10 can separate normal fruits from misshapen fruits. Results of the study also indicated that roundness ratio value for oblate kind of misshapen fruits is less than 0.90 (R.R. < 0.90) and for oblong kind of misshapen fruits is more than 1.10 (R.R. > 1.10). Moreover, ellipsoid ratio value for ellipsoid kind of misshapen fruits is more than 1.10 (E.R. > 1.10).

DISCUSSION

In this study, the geometrical attributes of cantaloupe, i.e. length, major diameter and minor diameter, were analyzed to classify fruit shape. The study indicated that five shapes, i.e. oblate (misshapen), round (normal), oblong (misshapen), round (normal) and elliptical (misshapen), were detectable and separable in fruits. The results of the study also indicated that among all kinds of misshapen fruits, number of oblate kind was the highest, while number of oblong kind was the lowest. In addition, amount of normal shape fruits and all kinds of misshapen fruits were in the order of normal (60.0%) > oblate (31.0%) > elliptical (7.0%) > oblong (2.0%). These results are in line with those of Sadrnia *et al.* (2007) who reported that fruit shape parameters can be used effectively to determine normal and misshapen fruit and quite in agreement with those of Ku *et al.*, (1999), White *et al.*, (2000), Koc (2007) and Kavdir & Guyer (2007) who concluded that classification of fruit shape using indices calculated from geometrical attributes of fruit, can increase uniformity in size and shape.

CONCLUSION

Primary investigation based on longitudinal and lateral cross section shapes indicated that five shapes were detectable and separable in samples. To achieve objective and reproducible results, a judgment based on geometrical attributes analysis was proposed and significant differences in fruit shape parameters i.e. roundness ratio and ellipsoid ratio were detected between five fruit shapes. Finally, roundness ratio and ellipsoid ratio were effectively used to classify fruit shape and determine normal and misshapen fruit. This method can also be adapted and applied to other products with the same physical features.

ACKNOWLEDGEMENT

The financial support provided by the Agricultural Research, Education and Extension Organization (AREEO) of Iran under research award number 2-109-1200000-05-0000-86083 is gratefully acknowledged.

REFERENCES

1. Arabsalmani, K., 1996. Evaluation of flowering, fruiting and effect of seed extraction time on seed quality characters of cantaloupe (*Cucumis melo*), M.Sc. Thesis, University of Tabriz, Iran.
2. Kavdir, I. and D.E. Guyer, 2004. Comparison of artificial neural networks and statistical classifiers in apple sorting using textural features. Biosystems Engineering, 89(3): 331-344.

3. Waseem, K., A. Ghaffoor and S.U. Rehman, 2002. Effect of fruit orientation on the quality of litchi (*Litchi chinenesis* Sonn) under the agro-climatic conditions of Dera Ismail Khan-Pakistan. Int. J. Agric. Biol., 4: 503-505.
4. Tabatabaeefar, A., A. Vefagh-Nematolahee and A. Rajabipour, 2000. Modeling of orange based on dimensions. J. Agr. Sci. Tech., 2: 299-305.
5. Koc, A.B., 2007. Determination of watermelon volume using ellipsoid approximation and image processing. Postharvest Biology and Technology, 45: 366-371.
6. White, A.G., P.A. Alspach, R.H. Weskett and L.R. Brewer, 2000. Heritability of fruit shape in pear. Euphytica, 111: 219-227.
7. Beyer, M., R. Hahn, S. Peschel, M. Harz and M. Knoche, 2002. Analaysing fruit shape in sweet cherry. Sceintia Horticulturae, 96: 139-150.
8. Hasnain, R., M.J. Jaskani, M. Mumtazkhun and T.A. Malik, 2003. In vitro Induction of polyploids in watermelon and estimation based on DNA content. Int. J. Agric. Biol., 3: 298-302.
9. Gerhard, J., H.M. Nielsen and P. Wolfgang, 2001. Measuring image analysis attributes and modeling fuzzy consumer aspects for tomato quality. Computers and Electronics in Agriculture, 31: 17-29.
10. Currie, A.J., S. Ganeshanandam, D.A. Noiton, D. Garrick, C.J.A. Shelbourne and N. Orgaguzie, 2000. Quantitative evaluation of apple (Malus_domestica Borkh) fruit shape by principal component analysis of Fourier descriptors. Euphytica, 111: 219-227.
11. Considine, J. and K. Brown, 1981. Physical aspects of fruit growth - theoretical analysis of distribution of surface growth forces in fruit in relation to cracking and splitting. Pl. Physiol., 68: 371-376.
12. Sadrnia, H., A. Rajabipour, A. Jafary, A. Javadi and Y. Mostofi, 2007. Classification and analysis of fruit shapes in long type watermelon using image processing. Int. J. Agric. Biol., 1: 68-70.
13. Moreda, G.P., J. Ortiz-Canavate, F.J. Garcia-Ramos and M. Ruiz-Altisent, 2007. Effect of orientation on-line size determination performed by an optical ring sensor. Journal of Food Engineering, 81: 388-398.
14. Ku, H.M., S. Doganlar, K.Y. Chen and S.D. Tankley, 1999. The genetic basis of pear-shaped tomato fruit. Theor. Appl. Genet., 9: 844-850.
15. Mohsenin, N.N., 1986. Physical Properties of Food and Agricultural Materials, pp: 79-127. 2nd Revised and Update Edition. Gordon and Branch Science Publishers. New York.
16. Wilhelm, L.R., D.A. Suter and G.H. Brusewitz, 2005. Physical Properties of Food Materials. Food and Process Engineering Technology, ASAE, St. Joseph, Michigan, USA.