Physical and nutritional properties of hawthorn fruit (Crataeguspontica L.)

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Abstract: Hawthorn, from Rosaceae family, is one of the important forest fruits of which there are different species in Iran. In this study, some characteristics of hawthorn fruit (Crataeguspontica), including physical properties (fruit length, width, thickness, geometric, arithmetic and equivalent mean diameter, surface area, sphericity, aspect ratio, thousand fruit mass and true density) and nutritional properties (total dry matter, total soluble solid, titratable acidity and moisture content) were considered. Results showed that average of fruit length, width and thickness were 1.53 mm, 1.95 mm and 1.78 mm, respectively. The geometric mean diameter was same to arithmetic mean diameter (1.75mm), while equivalent mean diameter was higher than both (1.76 mm). Some physical properties such as sphericity (1.13%), surface area (1.69mm) and aspect ratio (1.26) were determined. Average of 100 fruit weight in this species was 306.54 g and it is estimated 3.06 g for one fruit. Total soluble solid percent (TSS) and titratable acidity percent (TA) of fruit hawthorn were estimated 18.7% and 1.71%, respectively.

Keywords:hawthorn fruit, physical characteristics, nutritional properties

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1 Introduction

Physical properties of agricultural products are useful information respect formechanizing harvest and postharvest operations.One of these properties is physical characteristics including informationaboutdimension and mass. Nutritional properties are important to know how a fruit or vegetable can be considered as potential in food industry.

Numerous researches were conducted to collect physical information of differentfruits and vegetables such as: sunflower seeds (Perez et al., 2007), cowpea seed (Kabas et al., 2007), cucurbit seeds (Milani et al., 2007), watermelon seed (Koocheki et al., 2007), rice (GhasemiVarnamkhasti et al., 2008), apple (Kheiralipour, 2008; Ragni et al., 2011), pomegranate (Riyahi et al., 2011), almond nut and kernel (Mirzabe et al., 2013) andwild pistachio (Fadavi et al., 2013).

In this research, hawthorn fruit of Ilam, Iran was considered. Hawthorn includes more than 250 different species (Blumenthal et al., 2000).The varieties are from small shrubs to trees (Bahorun et al., 2003). In general, the forms of the varieties are not as large trees or canopy dominants. Some of them are decidedly shrubby, whereas others can grow largely to heights of 12 m (Kumar et al., 2012). Hawthorn is distributed well in western Asia, Europe and North America. It is widelyused horticultural as an ornamental.The colors of ripped hawthorn fruits are yellow, red, black and the combined colors (Donmez, 2004).

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Another use of hawthorn is pharmaceutical utility in the western world (Bahorun et al., 2003; Ercisli, 2004). It is considered as one of the oldest traditionalmedicinal plants in some countries(Blumenthal et al.,2000)due to numerous chemical constituents(Ozturk and Tuncel, 2011).The medicinal aspects of hawthorn have a long traditionaccording to records written inancientRoman period(Veverisetal.,2004). Somevaluable antioxidantsare predicted to find as some *Crataegus*components. The fruit and also the flowercomponents of hawthorn are responsibleforfreeradicalscavengingactivitysuch as epicatechinandchlorogenicacid. They can be well amongthebestantilipoperoxidants (Guven et al., 2006).

Iran is recognized as an important source of genetic diversity of different plant species including fruit crops. Also, the country is a rich source of genetic variability for *Crataegus* species germplasm, which have a high morphological diversity, particularly in leaf, flower, and fruit characteristics.The hawthorn fruits of Ilam province are yellow to yellowish red and black, and those of Kurdistan province are red.In the present study, the authors describe some fruit attributes of *Crataeguspontica* grown in the Ilamforests includingphysical and nutritional properties. These propertiescan be useful in designing the machines for harvest, post-harvest processing operations and further breeding efforts.

2 Materials and methods

Hawthorn fruit (*Crataeguspontica*) were randomly harvestedfrom forests of Ilam province in late Oct. 2012(Figure 1).Experiments were conducted in randomized block design with three repetitions and a total of 100 fruits for each repeat.Theresearch was carried out in Ilam University, Ilam, Iran.

Figure 1 Hawthorn, fruit and kernel

3 Physicalcharacteristics

Considered physical characteristics of hawthorn fruit were, length, width, thickness,geometric diameter, equivalent diameter,arithmetic diameter, sphericity, surface area, aspect ratio, volume, bulk density,true density and porosity.

To determine the average size of the fruits, three linear dimensions,namely length, *L*, width, *W*, and thickness, *T*,were measured by using a digital caliper with accuracyof 0.01 mm, and fruit mass was determined with an electronicbalance of 0.1 g accuracy. The diameters were calculatedby considering Equation 1，Equation 2 and Equation 3, respectively (Mohsenin, 1986):

$$D_g = (LWT)^{\frac{1}{3}} \quad (1)$$

$$D_p = \left[L\frac{(W+T)^2}{4}\right]^{\frac{1}{3}} \quad (2)$$

$$D_p = \frac{(L+W+T)}{3} \quad (3)$$

where:

L: Fruit length (mm)

W: Fruit width (mm)

T: Fruit thickness (mm)

D_g*:* Geometric diameter (mm)

D_p*:*Equivalent diameter (mm)

D_a*:*Arithmetic diameter (mm).

The sphericity, *Sp*(%), is the ratio of surfacearea of a sphere having the same volume as that of fruit to thesurface area of the fruit, was determined using the following Equation 4 (Mohsenin, 1986):

$$D_p = \frac{(LWT)^{\frac{1}{3}}}{L} \quad (4)$$

The surface area,*S* (mm^2), of the fruit was calculated by using thefollowing Equation 5 (Mohsenin, 1986):

$$S = \frac{\pi}{4} D_g^2 \quad (5)$$

The aspect ratio, *Ra* was calculated by Equation 6Omobuwajoet al. (1999):

$$R_a = \frac{W}{L} \quad (6)$$

To determine volume, bulk density, true density and porosity, a few fruits with specific masses were dropped on container with volume of 200 cm^3. The container was full ofwater to fill the porous spaces. The fruit volume was calculated by Equation 7:

$$V_f = V_c - V_w \quad (7)$$

Where:

V_f: Fruit volume (cm^3)

V_c: volume of container (cm^3)

V_w: water volume (cm^3).

Bulk densityand true density were calculated using Equation 8 and Equation9, respectively.

$$\rho_b = \frac{M_f}{V_c} \quad (8)$$

$$\rho_t = \frac{M_f}{V_f} \quad (9)$$

Where:

P_b: Bulk density (g/cm^3)

ρ_t: True density (g/cm^3)

M_f: Fruit mass (g).

The fruit porosity, ε (%), was determined by following Equation 10 (Mohsenin, 1986):

$$\varepsilon = \frac{V_w}{V_f} \quad (10)$$

4 Nutritionalproperties

Nutritional properties of the fruit were included, titratable acidity (TA), total soluble solids (TSS), TSS/TA ratio, dry matter and moisture content. Three samples of fruit texture (10 g) were kept in an oven in 70 ℃ for 48 h. Then, the moisture content and dry matter were calculated by Equation 11 and Equation12, respectively:

$$MC = \frac{M_w - M_d}{M_w} \times 100 \quad (11)$$

$$DM = \frac{M_d}{M_w} \times 100 \quad (12)$$

Where:

M_w: Initial mass of fruit (g)

M_d: Mass of dried fruit (g)

MC: Moisture content of fruit, wet base (%)

DM: fruit Dry matter (%).

Titratable acidity (TA) was determined by potentiometric titration with 0.1 N NaOH up to pH 8.2, using 5 ml of juice diluted to 50 ml with distilled H_2O. The results were expressed as gram of malic acid per 100 g fresh weight. Total soluble solids (TSS, ℃Brix) were determined using a hand-held refractometer, also on ten fruit. TSS/TA ratio was specified as following Equation 13:

$$T = \frac{TSS}{TA} \quad (13)$$

Where:

T: TSS/TA ratio

TSS: Total soluble solids (℃Brix)

TA: Titratable acidity (%).

5 Results and discussion

The values of all measured and calculated physical characteristics of Ilam hawthorn fruit were shown in Table 1.

Table 1Physical characteristics of hawthorn fruit

Parameter	Maximum	Mean	Minimum	Standard Deviation
Length, mm	18.20	15.47	13.00	1.23
Width, mm	22.5	19.50	15.53	1.64
Thickness, mm	20.40	17.78	14.30	1.58
Geometric mean diameter, mm	19.84	17.51	14.62	1.37
Equivalent diameter, mm	19.86	17.53	14.63	1.37
Arithmetic diameter, mm	19.93	17.60	14.63	1.38
Sphericity, %	1.24	1.13	1.04	0.04
Surface area, mm^2	1235.51	968.41	671.20	150.10
Aspect ratio	1.39	1.26	1.10	0.07
Thousand fruit weight, g	3104.86	3065.47	2988.55	66.62
True density, kg/m^3	0.93	0.89	0.83	0.05
Bulk density, kg/m^3	0.48	0.47	0.46	0.01
Porosity, %	48.50	47.50	46.50	0.01

The mean of fruit length (L), width (W), and thickness (T) were 15.47, 19.50, and 17.88 mm, respectively. Geometric mean diameter and equivalent diameter of the fruit were close (17.51 and 17.53, respectively) whereas the arithmetic diameter had lightly higher magnetite (17.60).The critical use of fruit dimensional properties is to determine the aperture size of machines, particularly in separation of materials (Mohsenin, 1978). In this research, the dimensions of the fruits are relatively uniform hence it will improve the process optimization in design and development harvesting machine for the fruit as well as in separation and cleaning.

Other dimensional properties were 1.13%, 968.41 mm^2 and 1.26 as sphericity, surface area and aspect ratio, respectively. Also, the tendency of the fruit shape towards a sphere can be well determined by the sphericity (Mohsenin, 1978).

Average of 100 fruit massfor the studied variety was 306.54 g. It was estimated 3.06g as average of the individual fruitmass.Turkoglu et al. (2005) reported the hawthorn genotypes fruit mass and flesh/seed ratio as between 4.82 and 9.69 g and 0.29 and 4.21. Higher fruit mass with higher flesh ratio is the most important desirable characteristics of the fruit for breeding programs (Ercisli, 2004).

True density and bulk density of the fruit were 0.89 and 0.47 kg/m^3, respectively, and porosity was 47.50 %.

A summary of thestudiednutritional properties of hawthorn fruit was shown in Table 2.

Table 2 Nutritional properties of hawthorn fruit

Parameter	Maximum	Mean	Minimum	Standard Deviation
Moisture content, %	73.10	71.83	69.80	1.78
Dry matter, %	26.10	25.73	25.40	0.35
Total soluble solid (TSS, °Brix)	19.00	18.70	18.3	0.36
Titratable acidity, %	1.87	1.71	1.62	0.14
TSS/TA ratio	11.60	10.97	9.78	1.03

The moisture content of the hawthorn was 71.83%, w.b.; consequently its dry mater was 25.73 %. The moisture content is very important when determining the physical properties such as bulk density, fruit density, porosity, pulp mass, statistic and dynamic coefficient of friction of fruits and vegetables (Ozcan et al., 2005).

The Total soluble solid (TSS, °Brix) value derived from hawthorn juicewas 18.70.Eventually,titratable acidity of the hawthorn fruit was calculated as 1.71%. Using these data, the TSS/TA ratio of the fruit was 10.97.

In a similar research, Ozcan et al. (2005) reported 14.39 mm as fruit length, 19.34 mm as fruit diameter, 3.03 g as fruit mass, 0.87 g as seed mass, 1.98% as acidity and 32.31% as soluble solids content for fresh wild hawthorn fruits collected from Turkey. Turkoglu et al. (2005) recorded fruit diameter between 15.15 and 18.60 mm and fruit mass between 2.24 and 2.44 g for different genotypes of *C. orientalis*. Sparks and Martin (1999) determined fruit mass of *C. monogyna* from 0.21 g to 0.34 g. In next work, Balta et al. (2006)found that among *Crataegus* species, *C. tanacetifolia* had the highest fruit mass (4.99 g) followed by *C. orientalis* (3.48 g), *C. pontica* (3.31 g), *C. aronia* (2.63 g) and *C. meyeri* (1.36 g), respectively. In other researches, conducted by Balta et al. (2006), Ozcan et al. (2005), and Turkoglu et al. (2005) in different regions of Turkey, the total soluble solids and pH values of hawthorn genotypes ranged from 11.66% to 24.00% and 3.12% to 4.09%, respectively.

The studied properties of hawthorn in the presented research can be compared with apple fruits. As Kheiralipour (2008)andRagni and Berardinelli (2001)reported,the TSS value ofhawthorn is muchhigherthan applefruit. The TSSs of apple fruits were12.54, 10.73, 14.3, 13.7, 14.3 and 12.9 °Brixfor TSS for Delbarstival and Redspar, Golden Delicious, Stark Delicious, Grani Smith and Rome Beauty variety, respectively.

Also value oftitratable acidity for the hawthorn is higher than that of apple. The reporteddata for TSS/TA ratio of apples were so higher values as 429.20 and 305.85 for Redspar and Delbarstival, respectively (Kheiralipour, 2008).

6 Conclusions

Hawthorn is a forest tree grown in different temperate regions of the world. Fresh fruits need to be harvested, transported, sorted, graded and packed. As a first step in design of specific equipment for these processes, physical properties of the fruit need to be known.Some engineering properties of hawthorn fruit harvested from Ilam forests including physical characteristics and nutritional properties were determined to introduce the fruit. Also, the corresponding datathose are important for the design of equipments for harvesting, processing, transportation, sorting, separation, packaging and further breeding efforts of hawthorn.

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