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Some Physical and Mechanical Properties of Hawthorn Fruit

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Abstract
The knowledge of physical properties of hawthorn (Crataegus spp.) fruit is necessary to design post harvesting equipment such as cleaning, sorting, grading, kernel removing, storage, packing and processing of fresh fruits. Also, the information supplied on the physical properties of the hawthorn fruit can be used in human nutrition. This study was done to analyze the physical and mechanical properties of the Iranian hawthorn fruit like (dimensions, geometric mean diameter, sphericity, fruit density, volume, surface area, friction coefficient and Hardness) at the moisture content of 71.23 percent. Other results showed that linear dimensions varied from 18.22 to 29.10 mm in length, 17.92 to 27.79 mm in width, and 13.82 to 21.40 mm in thickness. Mean mass and fruit volume was measured as 4.273g and 4657.8mm3, respectively. The geometric mean diameter, sphericity, fruit density and surface area were measured as 20.40mm, 87.74%, 1.04 (g/cm^3) and 1316.42(mm^2), respectively. The friction coefficient over the surface of wood, glass and galvanize sheet were 0.39, 0.54 and 0.45, respectively. The highest rupture force, deformation and toughness in this moisture content were obtained for hawthorn loaded along the X-axis. The mean values of cracking force and energy were measured 15.17 N and 579.35 MJ, respectively. Increasing in size of hawthom was found to increase on cracking force and energy.

***Keywords**: Hawthorn, Physical and Mechanical Properties, Friction Coefficient*

1.Introduction

Hawthorn species often have trees or shrub that has leaves that are cut and significant lobe. Hawthorn fruit like apples is very small. Some Crataegus constituents are predicted to be good antioxidants. The flower and fruit constituents responsible for free radical scavenging activity are epicatechin,hyperoside and chlorogenic acid. They are also among the best antilipoperoxidants (Bahorun & Greiser, 1996; Bahorun & Trotin, 1994; Rakotoarison & Greissier, 1997). However, only a few are used for medicinal purposes. Traditionally, the fruits or the berries are used for their astringent properties in heavy menstrual bleeding and in diarrhoea. Both the flowers and berries act as diuretic and can be used to treat kidney problems and dropsy.Apart from their delicious flavour, hawthorn fruits have been shown to have a tonic effect on the heart. Fruits of our native species are often used in the treatment of weak heart conditions, especially if this is accompanied by high blood pressure (Baytop, 1984; Grieve, 1982; Schussler & Holzl, 1995; Wichtl, 1996). Studies have confirmed the potential of hawthorn fruits as a good source of antioxidants constituents (Bahorun & Greiser,1996; Bahorun & Trotin, 1994; Kery & Verzarne, 1977; Rakotoarison & Greissier, 1997). Borghei et. al, 2000, studied the effect of direction of applied loading and walnut dimension on the cracking force and deformation of walnut using an Instron test machine. All the tests were carried out on dried walnuts in which the moisture content of the shell was 6%, w.b. The ranges of variation for cracking force and relative deformation1 were 110-800 N and 0.01-0.045 respectively. With increase in walnut dimension, the cracking force and deformation were increased. Several models for predicting mass of kiwi based on physical attributes were determined and reported by Lorestani and Tabatabaeefar (2006). The objective of this study was to investigate some physical properties of the Iranian hawthorn fruit namely linear dimensions, unit mass and volume, sphericity, fruit densities, surface area, rupture energy and coefficient of static friction against three structural surfaces.

2.Method

The ripe fruits were used for all the experiments in this study. After buying the Iranian hawthorn fruits from the market in Tehran city they were brought to the laboratory at Tehran University and the test started between healthy fruits. Then, were isolated 100 randomly samples. Before the experiment, The fruits were cleaned to remove all foreign matters such as dust, branches, leaves, immature and damaged fruits. To obtain the moisture level of products, three samples of healthy fruit were put into three containers and after measuring the mass of the fruit and container separately, we put them within 48 hours and temperature of 78 º C in the Oven. Weight loss on drying to a final constant weight was recorded as moisture content by (AOAC 1984) recommended method and using the following equation (1):

$$M_c = \frac{Mo - Md}{Mo} \times 100 \qquad (1)$$

$$D_a = \frac{L + W + T}{3} \qquad (2)$$

where M_C is moisture content (w.b.), M_o is initial mass and Md is the final mass of date fruit (g). The 100 unit mass was determined using precision electronic balance to an accuracy of 0.01 g. for measurement of length (L), width (W) and thickness (T) using a micrometer screw gauge with a reading of 0.01 mm. Fruit volumes were measured by water displacement method. Fruits were weighed in air and allowed to float in water. Fruits were lowered with a needle into a graduated beaker containing water and the mass of water displaced by the individual fruit was recorded. Finally, fruit densities (g/cm^3) were determined from mass and volume of 100 grains by using the following equation (2) (Mohsenin, 1986):

$$P_f = \frac{Ma}{Ma - Mw} \times \rho_w \qquad (2)$$

where ρ_f and ρ_w are fruit and water densities (g/m^3); Ma and Mw are mass of hawthorn in air and water, respectively.

The geometric average diameter of hawthorn was calculated according Galedar *et al*. (2008) and Mohsenin (1986).

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

The sphericity S_p (%) was calculated with use the relationship described by Koocheki et *al*. (2007) and Milani (2007).

$$S_p = \frac{Dg}{L} \times 100 \qquad (4)$$

The surface area (*S)* of hawthorn fruit was found by analogy with a sphere of the same geometric mean diameter using the expression cited by Sacilik et al. (2003).

$$S = \pi D_g^2 \qquad (5)$$

The coefficients of static friction were obtained with respect to three different surfaces namely galvanized steel, plywood and glass surfaces by using an inclined plane apparatus as described by Dutta *et al.* (1988). The inclined plane was gently raised and the angle of inclination at which the sample started sliding was read off the protractor with sensitivity of one degree. The tangent of the angle was reported as the coefficient of friction (Dutta et al., 1988):

$$\mu = \tan\varphi \qquad (6)$$

where, μ is the coefficient of friction and φ is the tilt angle of the friction device. All the friction experiments were conducted in three replications for each surface.

Determination of fruits hardness

Hardness values of hawthorn were measured by applying forces using a Test Instrument of Biological Materials and the procedure described by Aydın and O¨ gˇu¨ t (1991) (Fig. 1). The device has three main components, which are a stationary and moving platform, a drive unit (AC electric motor and electronic variator) and a data acquisition (Dynamometer, amplifier and XY recorder) system. Hardness force was measured by the data acquisition system. The fruit was placed on the moving lower platform and was pressed against the stationary platform. The probe used in the experiment had a 5mm diameter and was connected to the dynamometer. Each experiment was conducted at a loading velocity at 1mm/min.

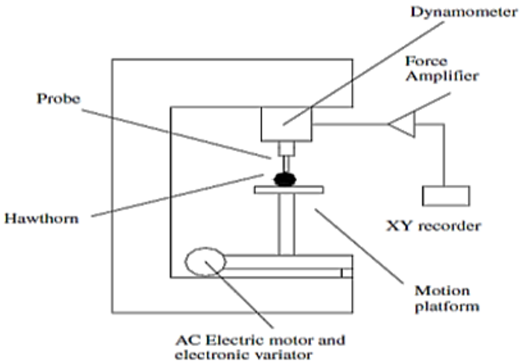

Fig. 1. Biological material test unit (B.M.T.U.).

In this study the effects of cracking force, absorbed energy were studied on fruit. All the tests were conducted using an Instron test machine. Fiftye replications were used for each treatment. From the compression speed and time, the hawthorn deformation was computed and force deformation curve was plotted. Rupture force and deformation were measured directly from the plotted force–deformation curve. Energy absorbed (Ea) by the sample at rupture was determined by calculating the area under the force– deformation curve from the following equation (Braga et al., 1999; Gupta & Das, 2000; Mohsenin, 1978).

$$E_a = \frac{1}{2} F_r D_r \qquad (7)$$

Where F_r is the rupture force and D_r is the deformation at rupture point.

3.Results and Discussion

Some physical and mechanical properties of the hawthorn in this research were studied, such as length (L), width (W) , thickness (T),mass, Geometric mean diameter, Sphericity, surface area, Fruit density, Volume and Hardness were measured as 23.01± 2.72 (mm), 21.90 ± 2.47(mm), 16.87±1.90 (mm), 4.27±1.20 (g),20.40± 2.27 (mm), 87.74± 2.91, 1316.42 ± 302.53 (mm2), 1.04± 0.19 (g/m3),4657.8± 1425 (mm3) and 1.6 ± 0.23 (N) respectively. The importance of dimensions is in determining the aperture size of machines, particularly in separation of materials as discussed by Mohsenin (1986). These dimensions can be used in designing machine components and parameters. For example, it may be useful in estimating the number of fruits to be engaged at a time. The major axis has been found to be useful by indicating the natural rest position of the fruit. The following general expression can be used to describe the relationship between the average dimensions of fruits at 71.23% (w.b.) moisture content. Physical properties such as weight, length and diameter of fruit, mass, volume of fruit, geometric mean diameter, sphericity, fruit density, projected area, terminal velocity, hardness and static coefficient of friction were established at the 71.23% moisture content level. The moisture content is very important when determining the physical properties such as bulk density, fruit density, porosity, pulp mass, static and dynamic coefficient of friction of hawthorn fruit (Ajisegiri, 1987; Baryeh, 2001; Demir, Dog˘an, O¨ zcan, & Hacıseferog˘ulları, 2002; Demir & O¨ zcan, 2001; Hacıseferog˘ulları, Gezer, Bahtiyarca, & Menges_, 2003). Similar investigations were conducted to determine the projected area, volume, bulk density, fruit density and terminal velocity by Demir and O¨ zcan (2001) for rose fruits. Eighty-eight percent of fruit were between 3 and 6 g at a moisture content of 71.23% in weight, 93% were between 17 and 23mm in Geometric mean diameter, 90% were between 19 and 25mm in length. The dimensions obtained from the equation are close to actual value. Grading fruit based on weight reduces packing and handling costs and also provides suitable packing patterns (Khoshnam et al., 2007). Also mean coefficient of static friction, on galvanized steel, plywood and glass surfaces, were obtained as 0.45, 0.39and 0.54, respectively. Result of analysis showed that the surface materials had a significant difference on the static coefficient of friction. The static coefficient of friction on galvanized steel was higher than that on plywood and lower than that of glass surface. This is due to the frictional properties between the fruits and surface materials. These properties may be useful in the separation process and the transportation of the fruits.

The average cracking force required to break the hawthorn N, respectively. The highest rupture force and energy in this moisture content were obtained for hawthorn loaded along the X-axis. The mean values of cracking force and energy were measured 15.17 N and 579.35 MJ, respectively. Increasing in size of hawthom was found to increase on cracking force and energy. Sharifian and Derafshi (2008) reported that the rupture energy to fracture walnut shell increased as the compression speed raised up to 200 mm/min.

4.Conclusion:

1- The average mass and volume for Hawthorn were found to be 4.273g and 4657.8mm^3,

respectively.

2- The fruit density was measured as 1.04± 0.19(g/m^3)

3- Linear dimensions ranged from 18.22 to 29.10 mm in length, 17.92 to 27.79 mm in width, and 13.82 to 21.40 mm in thickness.

4- The geometric mean diameter, sphericity and surface area were calculated as 20.40mm, 87.74% and 1316.42(mm^2), respectively.

5- The mean coefficients of static friction, on galvanized steel, plywood and glass surfaces, were obtained as 0.45, 0.39 and 0.54, respectively.

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