

The Investigation and Evaluation of Some Important Mechanical Tests for the Consumed Varieties of Persian Walnut

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Abstract

Removing the green husk and drying walnut are one of the most important steps in post-harvest processing of walnut. Therefore, it is need to precisely identify a walnut's shell. Physical and mechanical properties of shell in the four Persian walnut cultivars/genotypes were studied. This study investigated the mechanical properties of a walnut's husk and calculated the required energy in the process of shearing, penetrating and bruising for four walnut cultivars/genotypes (*K72*, *Z67*, *Pedro*, *Serr*). This was done by a texture analyzer instrument. Required energy to perform each of these tests were given in terms of the maximum and minimum values. The averaged results were so that the maximum amount of Krammer shear test belonged to *K72* variety and the minimum of that belonged to *Pedro* variety. Penetration's test data also indicated that the maximum amount in four available varieties was *Pedro* and the minimum value was suitable for *Z76*. Also, in the bruising test, *Serr* variety had the maximum value of required energy and *Z76* variety had the minimum energy requirement.

Keywords: De-husking, Green husk, Mechanical test, Persian walnut.

Introduction

One of the most yielding orchard fruits is walnut (*Juglans regia L.*). Persian walnut is one of the most important nutritive nut crops (Ebrahimi *et al.*, 2009). According to FAO statistics in 2011, the major producers in the world are China, Iran (Islamic republic of), United States of America and Turkey, respectively (FAO 2011). In recent years, the United States of America used to be the biggest producer of walnuts (Dena M. Camarena and Ana Sanjuán, 2006). The walnut industry of California produces approximately 450 to 550 thousand tons per year (Dasso, 2012). The outermost surface of a walnut is covered by a green layer that is called the husk, and

it has a variety of usage in industrial, pharmaceutical and cosmetics fields. The harvested walnut has a relatively high moisture content of 30%, compared to the safe storage moisture content of 8% (Rajabpour *et al.*, 2001). Hence, this husk usually remains fresh and juicy for a long period of time. According to Sitkei (1986), the moisture content of agricultural materials affects their physical and mechanical properties. Moisture content also affects the handling, storability and processing of biomaterials. Some researchers have studied the physical and mechanical properties of biomaterials (Olaniyan and

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Oje, 2002; Khazaei *et al.*, 2002; Aydin, 2002; Kaleemullah and Gunasekar, 2002; Aydin, 2003; Koyuncu *et al.*, 2004; Aviara *et al.*, 2005; Pliestic *et al.*, 2006; Razavi *et al.*, 2007; Oluwole *et al.*, 2007; Dash *et al.*, 2008; Altuntas and Ozkan, 2008; Altuntas and Erkol, 2010; Altuntas *et al.*, 2010; Davies, 2010; Purseglove, 2001; Singh *et al.*, 2010). Congestion of walnuts may cause some problems such as mustiness and turning black of nuts. Post-harvest processing of agricultural products in addition to reducing the losses and costs related to transportation not only supplies value-added products, but it also provides a better export of them and increases the quality. In the case of walnuts, husking immediately after harvest and drying processing are important steps. Also, in order to achieve walnuts with a high quality, identifying the physical properties of them, particularly the husk of walnut, is an urgent need in this industry (Ghafari *et al.*, 2011; Ebrahimi *et al.*, 2009; Guzel *et al.*, 1999).

Materials and Methods

To determine the mechanical properties of the four walnut genotypes/cultivars (*K72*, *Z67*, *Pedro and Serr*), the stresses of green husk (Krammer shear test, penetration test and bruising test) was investigated. The gauge used for texture was the model HOUNFIELD-H5KS. All kinds of varieties were gained from the research center of agricultural issues in Tuseserkan, a town in Hamadan County. In the Krammer shear test, the required shear force was measured by a food testing machine that has an

electronic load cell. Also, these measurements were done in real time condition. The results were recorded on a computer. A penetration test was done by a piercing tool on the upper jaw. Walnuts (with its husk) was placed inside of its smaller diameter, between the fixed jaw and movable jaw. The penetrating force on the upper jaw was measured by an electric load cell under real time conditions. In the bruising test, walnuts (with its husk) was placed inside on its smaller diameter, between upper movable jaw and bottom fixed jaw. A resistant force was measured by an electric load cell. It is worth to mention that all tests were carried out five times for each variety. The required energies for each test were computed by MATLAB software. In order to calculate the consuming energy in along with these tests, the area under the displacement-force graphs were estimated by MATLAB software.

Krammer shear test

In this test, the husk was placed between two grooved jaws (with ten metal blades in 2 mm thickness, 82 mm length and 51 mm width), and the distance between the grooves was 3 mm. A schematic illustration of device's jaws has been shown. The upper jaw approached to the bottom jaw with 20 mm.min⁻¹ speed (Fig. 1). The shear forces of the husk were measured by an electric load cell (that has maximum capacity of 5 KN) and under Real time condition then this data are recorded on computer and finally are drawn automatically in form of the displacement-force graph.

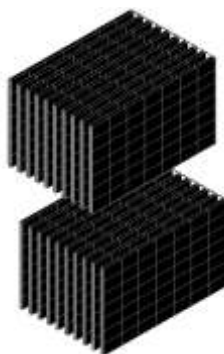


Fig.1. Schematic illustrated of used apparatus in Kerammer shear test

Penetration test

In this test, a piercing tool with 6.4 mm of diameter was used. The walnut (with green husk) was placed on its smaller diameter, between movable penetrating jaw and fixed jaw. A schematic illustration of the apparatus is shown in Fig. 2. The upper piercing jaw approached the underneath jaw with 50 mm per minute speed. The penetration force

of the upper movable jaw was measured by an electric “Load cell” and under Real time condition. The resulted data are recorded on computer and finally they are drawn automatically as a displacement-force curve. This test was performed five times for all genotypes/cultivars (Serr, Pedro, Z67 and K72).

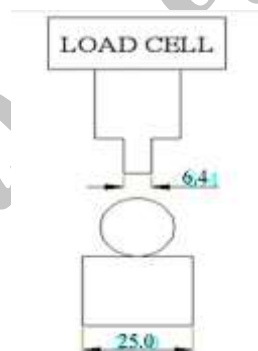


Fig. 2. Schematic illustration of used apparatus in penetration test.

Bruising test

For this test, the walnut with green husk was placed on its smaller diameter between upper movable jaw and bottom fixed jaw. A schematic illustration of related apparatus has been shown. The upper squeezer jaw came near the bottom fixed jaw

with 50 mm per minute speed (Fig. 3). The resistant force of the walnut’s husk was measured by an electric load cell (with maximum capacity of 5 kN), As mentioned earlier, this test was done five times for all varieties.

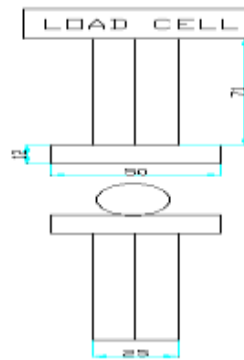


Fig.3. schematic illustrated of used apparatus in bruising test

Calculating of required energy for shear, penetration and bruising tests with MATLAB software aided

To compute the amount of consumed energy in addition to shearing, penetrating and bruising tests, the area underneath of displacement-force curve was

estimated by MATLAB software. All steps were performed on *Serr* variety's sample in the bruising test. The displacement-force curve of bruising test for *Serr* variety is shown Fig. 4.

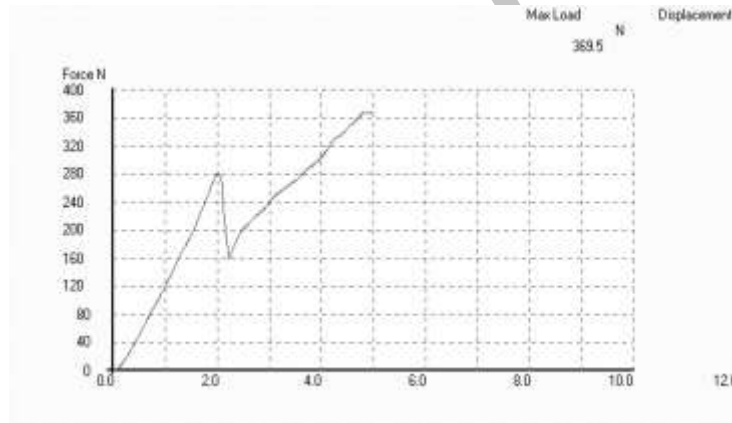


Fig.4. Displacement-force curve for *Serr* variety in bruising test

This graph shows that proportional limit's force is 280 N, whereas the displacement is two millimeters. To calculate energy, the area under the graph should be calculated till the proportional limit's point. MATLAB software can be used to convert this image (Fig. 4) into a binary image (black

and white) and count the number of white pixels. With the aid of Paint software this image was created. The colors of all pixels that are beneath the graph (till the proportional limit) are white and the remaining pixels are black in color. The resulting image can be seen in Fig. 5.



Fig.5. Displacement-force curve which is related to *Serr* variety in bruising test that is converted by Paint software

The counted white pixels for this sample are 6020. To calibrate the counted pixels (each pixel is equal to the amount of joules of work), one of used units in Fig. 5 can be chosen and counted by MATLAB software. This rectangular unit is shown as the dark gray color in Fig. 6. This unit was 40

Newtons in length and 1 millimeter in width and was is converted to binary mode with Paint software (Fig. 7). The number of pixels in this image was counted by MATLAB software and is equal to 990 pixels, which was equal to 40 Newtons per millimeter or 40 milli Jules.

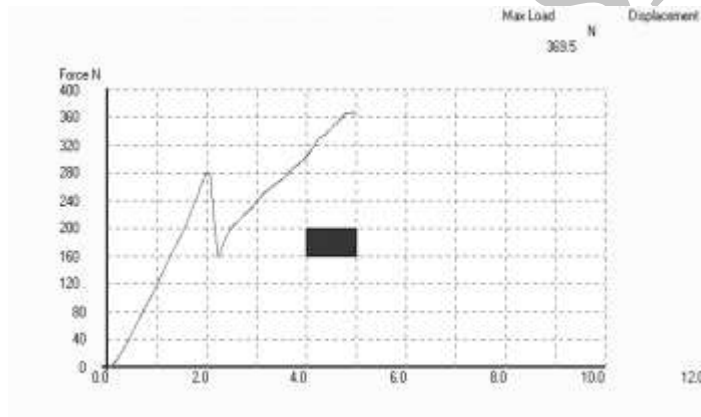


Fig.6. Rectangular unit that is used to calibrate the counted pixels. This unit is shown in dark gray color in Fig

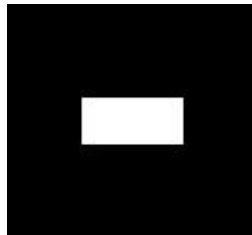


Fig.7. Rectangular unit that is used to calibrate the counted pixels. This unit is prepared for counting pixels in MATLAB, by Paint software

Results

The results for all the varieties and tests are shown in Fig. 8.

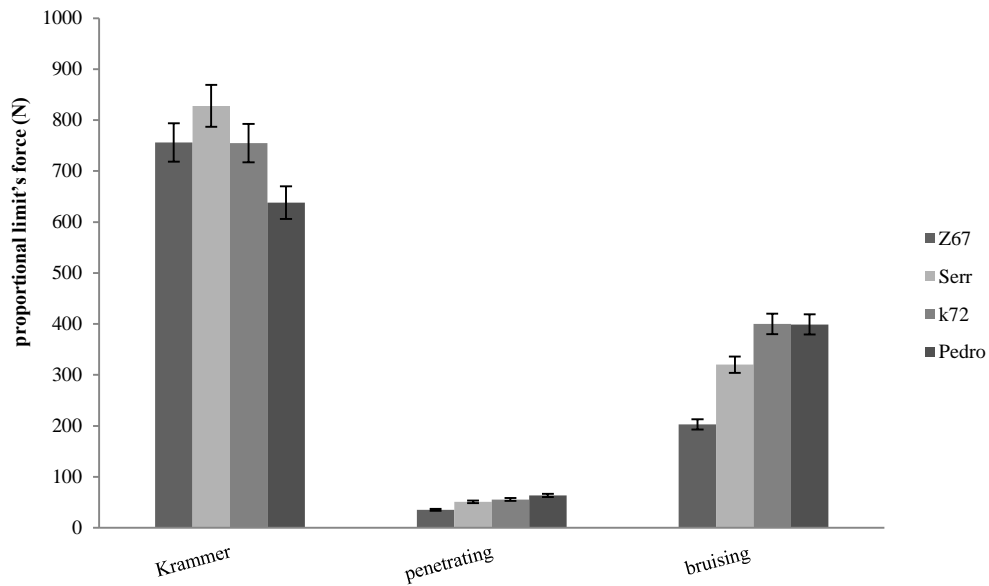


Fig. 8. Resulted data that are related to proportional limit's force (N) in all tests

Results of calculating the required energy in shear, bruising and penetration tests

The total quantities of pixels for the shear, bruising and penetration tests are shown in Fig. 9. The amount of work (m.J) per pixel that is related to the area under the curve (Fig. 10). In Fig. 11, the

final results of consumption of energy were presented. It should be mentioned that all data that are shown in Figs. 9, 10 and 11 are averaged results obtained from five replications of tests in all varieties.

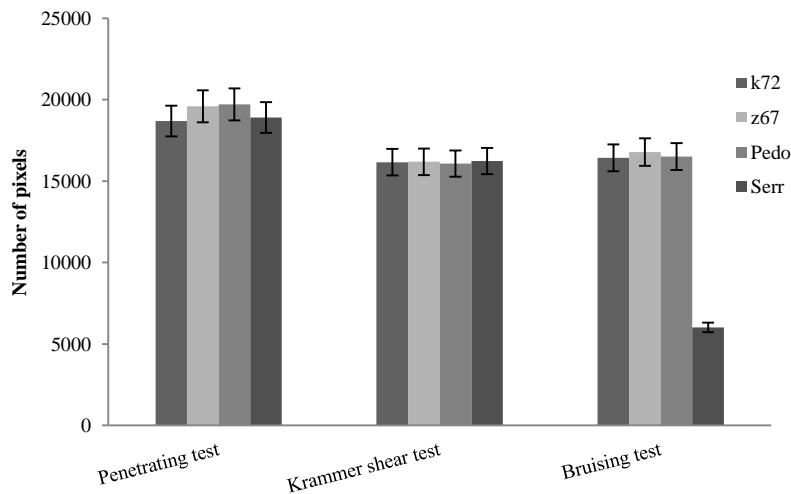


Fig. 9. Number of pixels related to the area of force-displacement diagram in Kramer shear, penetrating and bruising test

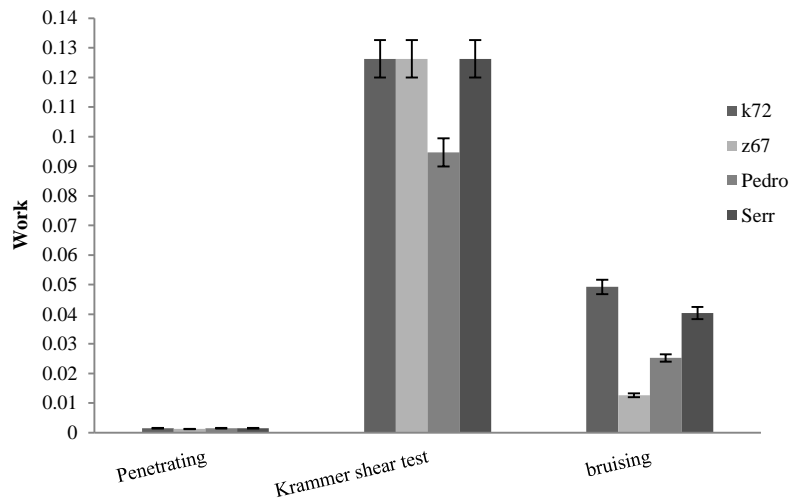


Fig. 10. Amount of work per one pixel in area of force-displacement diagram, related to all tests.

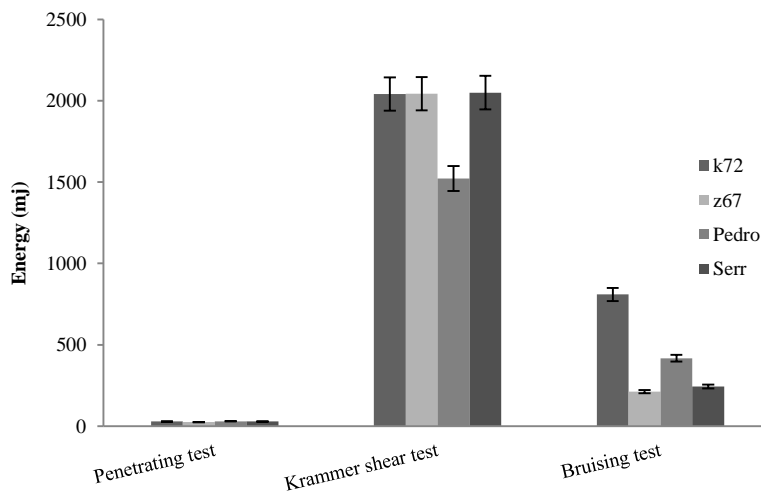


Fig. 11. Consumed energy (mj) in all kind of tests

Discussion

Because walnuts are one of the most important crops in the world, it is important that to have a proper knowledge of the nut and its properties for better processing the product. Therefore, in this study, the properties of four

varieties of walnuts were studied. Several experiments were performed, such as the Kramer shear test, penetration test and bruising test. In all the experiments, a food testing machine (texture analyzer) was used. Also, each test was repeated five times. In each trial, the data was obtained in a real-time condition. The averaged results of Kramer

shear test showed that the maximum value is were in the K72 variety and the minimum value was suited for the *Pedro* variety. The data from the penetration test indicated that the maximum and minimum values belonged to the *Pedro* and *Z67* varieties, respectively. In the bruising test, the highest value and the lowest value were for *serr* and *Z67*, respectively. The required energies for each trial were obtained by MATLAB software. In bruising test, the maximum and minimum values of consuming energies were for *K72* and *Z67* varieties, respectively (I thought previous sentence said *serr* and *Z67*). In the Krammer shear test, the highest consumed energy was for the *Serr* variety and the lowest value was for the *Pedro* variety.

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