Tarım Makinaları Bilimi Dergisi (Journal of Agricultural Machinery Science)
2008, 4 (4), 389 - 393

Parameters Involved in Walnut Peeling Process

Navid KARIMI[1], Saeed MINAEI[2], Darab HASANI[3], Afshin EYVANI[4]
[1]Science and Research Campus Islamic Azad University-Member of Young Researchers Club, Faculty of Agriculture, Department of Agriculture Mechanization, Tehran , Islamic Republic of Iran
for_navid@yahoo.com
[2]Tarbiat Modarres University, Faculty of Agriculture, Department of Agricultural Machinery, Tehran, Islamic Republic of Iran
[3] Seed and Plant Improvement Institute, Department of Horticulture, Karaj, Islamic Republic of Iran
[4] Iranian Agricultural Engineering Research Institute, Department of Hoticulture, Karaj, Islamic Republic of Iran

Abstract: Different procedures and equipment are used for walnut processing which include peeling and shelling. Mechanization of the peeling process can accelerate the process and prevent walnut discoloration. Knowledge of walnut behavior under loading is important for mechanizing the peeling process. Two tests were designed for this purpose; Static and Dynamic loading of whole walnuts. In the static test, walnuts are subjected to an increasing force until first the husk is broken (yield point1) and then the shell is broken (yield point2). Walnuts were sorted into 3 sizes (small, medium and large) and the tests were conducted as a complete random plots design. A similar experiment was conducted for dynamic loading. The test results showed that there is no significant difference between the peeling and shelling force for different sizes of walnuts except the shelling of large walnuts in the static test.These tests were followed by the peeling machine tests. The effect of residual time, at 2 levels (3 and 6 min) and beater rotational speed at 3 levels (200, 300, 400 rpm) on peeling quality were studied in these tests. Peeling quality was defined by 2 parameters: Damage percentage and peeling percentage. Walnut size and residual time didn't have a significant effect on these variables while the beater speed did. Results indicated that the 3 min-300 rpm combination is the best treatment and maybe recommended for walnut peeling using the peeling machine.

Key words: Walnut, peeling, physical properties, static and dynamic loading tests, post harvest

INTRODUCTION and LITERATURE REVIEW

Walnut peeling is one of the most difficult operations in walnut processing and is usually performed manually.

Walnut behavior under loading needs to be studied to obtain information regarding the effect of different types of forces on walnut, the range of necessary force for peeling and shelling or the effect of walnut size in this process.

Walnut was planted 10'000 years ago and developed after the Ice age. Some scientists stress that walnut was created before human according to what fossils indicate (Mitra et al., 1991). Perhaps Iran was the first place for walnut growth but some wild types of these trees had grown in Greece according to Radina (1997). Iranian walnut is called "English" in some references because they handled Iranian walnut to Europe for the first time (Zabolestani, 1997).

China and U.S.A are the first walnut producers in the world and they are followed by Iran and Turkish (FAO, 2006)

Many factors affect on walnut quality, quantity, processing and marketing. These include genotypes, temperature, moisture, nutrient content, diseases and pastes (Mosavi et al., 2005), harvest and post harvest operations delay (Qahremanian and Rezayi, 2005) and drying methods (Martin et al., 1975), (Olson and Sibbett, 1978), (Mate et al., 1996), (Ramos, 1998) and (Labavitch, 2001). Information on the effect of these factors are need for development and enhancement of mechanized operation.

MATERIALS and METHODS

Materials

Materials, instruments and tools used in this research can be listed as follow,: Walnuts, instruments for static and dynamic load tests, sorting tool, peeling machine and the necessary tools to measure size, revolution speed, force, etc.

Walnuts

Walnuts were provided by the research station garden of the Seed and Plant Improvement Institute located in Karaj, Iran. In this research station, there are different types of wild, conventional and improved walnuts. Because of the high variation in a normal walnut society, all of them were selected for our samples randomly. These walnuts were harvested manually because it's more commonly practiced in Iran.

Instrument for static loading test

This instrument was developed for loading walnuts. In gradually increasing manner the force is applied by two iron plates and is measured using a force gage. The schematic figure of this instrument is shown in figure 1.

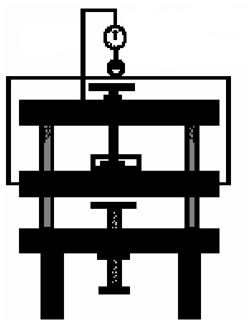

Figure 1. Schematic of the static loading test instrument

Instrument for dynamic loading test

This instrument simulates an impacting load which was used to test the walnut's behavior when a force is applied against them in a short time. The dynamic load tester in fact is a pendulum, so the force is calculated using equation (1) easily.

$$F = m.g.\sin\alpha \qquad (1)$$

Where F is the applied force (N), m is the pendulum weight (Kg), g is the gravitational acceleration (m/s^2) and α is the pendulum angel with vertical surface by (degree).

According to the equation (1), the force can be adjusted using the weight or angle of pendulum adjustment. Different weights of pendulum are provided by additional loads. This instrument is shown in figure 2 schematically.

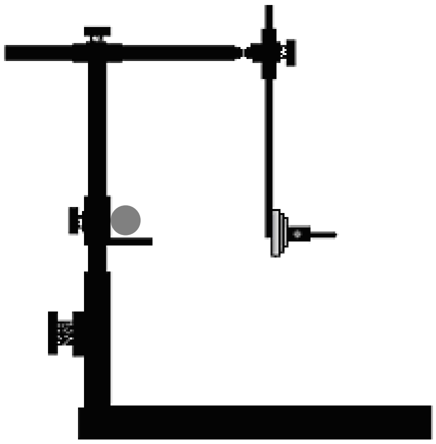

Figure 2. Schematic of the dynamic loading test instrument

Sorter tool

This tool was used to sort the walnuts by size before tests.

Peeling machine

This machine consists of two separated parts: First part is a 4 stroke gasoline engine as the machine power source and second part or peeling part is driven by the engine and it plays the main role in the peeling process. This part includes a walnut hopper, feeder, cage cylinder, rotor with blades, and entrance-exit trap doors.

The walnuts are loaded in the hopper and the feeder delivers them to the cage cylinder continuously. In the middle of this cylinder a rotor is rotating such that walnuts collide with the blades of rotor and cage grid. Walnut's husk is removed by this method. Removed husk downloaded from the grids and peeled walnuts exit of the trap door. Figure 3 shows this machine schematically.

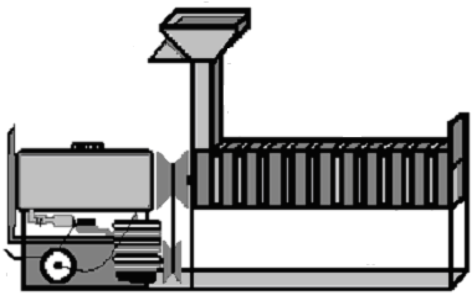

Figure 3. Schematic of the walnut peeling machine

Terms

It is necessary to define some terms used in this paper before the methods are explained.

Yield point 1: Minimum force to necessary break the husk without breaking the shell (N).

Yield point 2: Minimum force to needed shell (N).

Large diameter: Largest diameter of walnut (mm). Notice that walnuts aren't usually a complete sphere.

Small diameter: Smallest diameter of walnut (mm).

Husk thickness: Distance between the outer side of husk and outer side of shell (mm).

Small walnut: walnuts with large diameter less than 40^{mm}.

Medium walnut: Walnuts with large diameter between $40\text{-}50^{mm}$.

Large walnut: Walnuts with large diameter more than 50^{mm}.

Peeling percentage: Ratio of peeled husk weight removed by the machine to the whole husk weight

Damage percentage: Percentage of walnuts shelling by machine as an error index.

Methodes

The objectives of laboratory tests were to determine yield points including yield point1 and yield point2 under static and dynamic loading.

Because it was supposed that walnuts size can affect the results of tests, walnuts were separated into large, medium and small categorize using a sorter tool before the conducting tests.

Static load test to find yield point 1 was done as completely randomized design (CRD) with 5 observations according to table1.

Table 1. CRD to find yield point 1 for static load test

I	B	A	C
II	A	A	B
III	C	B	C

Where A, B and C refer to small, medium and large walnuts respectively.

Table 2 shows the CRD for yield point 2 of static load test.

Table 2. CRD to find yield point 2 for static load test

I	B	B	A
II	C	A	C
III	B	C	A

Dynamic load tests were conducted as per table 3 and table 4.

Table 3. CRD to find yield point 1 for dynamic load test

I	A	A	B
II	B	C	C
III	C	B	A

Table 4. CRD to find yield point 2 for dynamic load test

I	A	B	C
II	C	A	C
III	A	B	B

Some parts of the peeling machine were modified and some parts for example a gage to determine the blade's rpm were added to that because it wasn't a laboratory instrument and these changes were necessary to facilitate making measurements.

To use of same volume of walnuts in each test, an index level was determined on the walnuts hopper and each time hopper was loaded to index level. The revolution speed of rotor depends on engine speed and the engine speed is controlled by the accelerator knock itself. An iron plate was installed behind the accelerator knock. Then revolution speed of the rotor was measured by a tachometer[1] for different positions of the accelerator's knock and this position with the measured rpm was noted on the iron plate. The machine was calibrated by this method for tests.

Determining the effect of rotor rpm and walnut residence time, on the quality of peeling were the objectives of tests. for these purpose an experiment which was based on a block-factorial design was conducted according to table5.

Table 5. Experimental design for peeling machine's tests

S_W	$Block_1$	a_1b_1	a_2b_2	a_3b_1	a_2b_1	a_1b_2	a_3b_2
M_W	$Block_2$	a_2b_1	a_3b_1	a_1b_2	a_2b_2	a_3b_2	a_1b_1
L_W	$Block_3$	a_3b_1	a_1b_2	a_1b_1	a_3b_2	a_2b_2	a_2b_1

Where S_W, M_W and L_W refer to small, medium and large walnuts respectively. Levels of rotor speed (a) were: a_1=200, a_2=300 and a_3=400 rpm. And (b) refer to walnut residence time: b_1=3 and b_2=6 minutes.

Two indexes, peeling percentage and damage percentage were used to determine the walnut's

[1] Lutron (DT-2236)

peeling quality. Peeling percentage was calculated using the equation (2).

$$\%P_P = (\frac{W_{RH}}{W_{TH}}) \cdot 100 \quad (2)$$

Where $\%P_p$ is peeling percentage, W_{TH} is dry weight of total husk and W_{RH} is dry weight of removed husk by machine. Peelings were directed at 110°C for 48 hours and after this time they were weighed. This action is repeated for 1 hour again and this measured weight is called the dry weight if there is no difference between these two measured data.

Determination of W_{RH} and W_{TH} was difficult because the some husks were missing after the machine operation. So it was estimated as follows. As a guideline for each test, two similar samples were used. These samples were weighed and one of them "first sample", was loaded on machine and the other "second sample", was peeled manually and it's husk was weighed after drying. Ratio of the two weights (first sample against second sample) was used as a correction coefficient. W_{RH} and W_{TH} are estimated using equations (3) and (4).

$$W_{TH1} = W_{TH2}.C_c \quad (3)$$

$$W_{RH1} = W_{RH2}.C_c \quad (4)$$

Where W_{TH1} is weight of total husks for sample 1, W_{TH2} is weight of total husks for sample 2, C_C is correction coefficient, W_{RH1} is weight of husks for sample1 removed by the machine and W_{RH2} is weight of husks for sample2 removed manually.

Equation (5) was used to determine the walnut damage percentages.

$$\%Dp = (\frac{N_{DW}}{N_{IW}}).100 \quad (5)$$

Where $\%D_P$ is damage percentage, N_{DW} is number of damaged walnuts and N_{IW} is the number of inserted walnuts.

RESEARCH RESULT

Results of the static loading test are shown in Figure4.

The size of walnuts couldn't affect on necessary force for peeling process and in better mean on yield point 1 in the static load test.

There is a significant difference with 99% certainty, between the walnut strength for large walnuts (yield point 2) and that of small and medium walnuts. "Walnut strength" refers to the force required for causing shell failure.

Figure5 shows the results of the dynamic loading test.

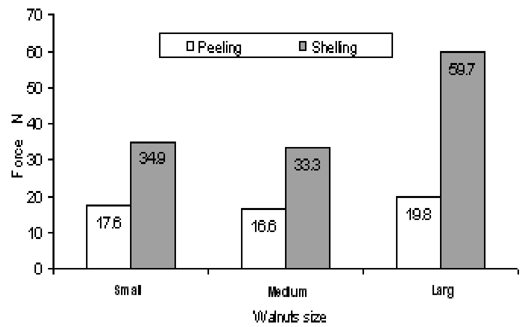

Figure 4. Result of static loading test

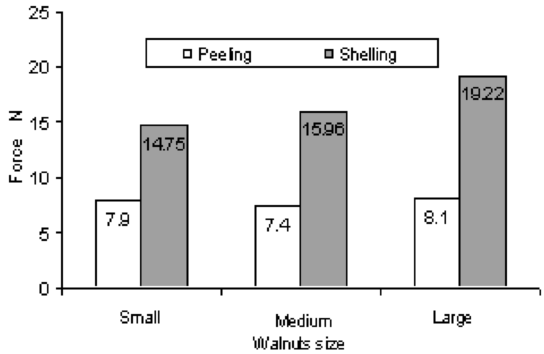

Figure 5. Result of dynamic loading test

According to statistical analyze; walnut size has no significant effect on both peeling and shelling in dynamic loading test.

The results of damage percentage according to the experimental design shown in table 5 are given in table 6.

Table 6. Percentage of damaged walnuts

S_W	$Block_1$	0.7%	1.5%	0.7%	0.7%	0.7%	2.0%
M_W	$Block_2$	0.7%	2.2%	1.0%	0.7%	2.4%	1.0%
L_W	$Block_3$	1.4%	0.7%	0.7%	2.4%	0.7%	0.7%

Because no significant difference was seen between the blocks, it's acceptable that the walnut damaging is not dependent on size. The residence time dose not affect this index since no significant difference was shown between the different levels of

(b) factor. Since there was a significant difference between a_3 and both a_1, a_2 it is concluded that rotor speed of 400 rpm increases significantly damage. The probable error in this case is equal to 1%. Also it's possible to study the effect of rotor speed and residence time separately since according to this statistic analysis there is no significant interaction between the (a) and (b) factors.

The results shown in table 7 demonstrate that there is no significant difference between the size of walnuts as block effect and peeling percentage.

Table 7. Result of peeling percentage

S_W	$Block_1$	91.0%	78.5%	87.7%	97.7%	83.4%	71.6%
M_W	$Block_2$	81.1%	96.6%	94.3%	79.2%	100.0%	79.2%
L_W	$Block_3$	91.3%	89.5%	98.4%	58.8%	81.0%	95.6%

Residence time has no significant effect on peeling percentage too because no significant difference was seen between the levels of (b) factor. Since there is a significant difference between (a_1) and both (a_2), (a_3), it's established that with 99% certainty, the rotor speed of 200 rpm significantly decreases peeling percentage.

DISCUSSION and CONCLUSION

Since in both static and dynamic tests, the effect of walnut size on peeling and shelling force was not significant (wxcept for shelling force of large walnuts), it may be concluded that the first hypothesis is rejected.

All data in load tests confirm that the force which is necessary for shelling is about twice that of force.

Maybe the most important result of this research is that the force which is needed for peeling or shelling in dynamic test is less than the force which is used in static test for each same process and size of walnuts as half, approximately. So it's clear that using impact force can be more effective for walnut peeling or shelling. This information can be used in design and development of walnut processing machinery.

Decreasing walnut damage and increasing the peeling performance are two objectives of the process. According to results of machine's test, the percent damage is dependent on rotor speed. At 400 rpm, it is significantly higher than 200 or 300 rpm but there is no significant difference between 200 and 300 rpm. Therefore, 400 rpm is not recommended for peeling operation.

Because at 300 and 400 rpm, the peeling percentage is higher than 200 rpm, using rotor speed of 200 rpm reduces the efficiency. Hence, to achieve high peeling performance and less damage percentage, rotor speed of 300 rpm is recommended.

Since the residence time had no significant effect on peeling and damage percentage, residence time of 3 minutes is preferable to 6 minutes because it results in higher machine capacity.

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