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The impact of vaporization on the crushing nuts *(Juglans regia L.)*

Utjecaj parenja na lomljenje oraha (*Juglans regia* L.)

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ABSTRACT

The influence of hot steam vaporization of the walnut (Juglans regia L.) cultivar 'Franquette' on the required force for deformation (breaking) and the energy required to fracture the shell with the centrifugal breaking machine was studied under the laboratory conditions. The maximum force (248.04 N) was used for breaking nuts, which were vaporized for 5 minutes and 171.35 N for 15 minutes vaporized samples of nuts. The shortest deformation (1.3 mm) was measured for breaking 0 minute vaporized nuts, and the maximum deformation (4.15 mm) for 15 minutes vaporization samples. The largest percent of the whole kernels (74.62 %), was measured on 15 minutes vaporized nuts and the lowest on 0 minutes vaporized sample (28.47 %).

Key words: nuts, hot steam vaporization, kernels, physical properties, centrifugal machine

SAŽETAK

U pokusu usporedbe morfoloških i fizikalnih svojstava ploda oraha (*Juglans regia* L.) sorte 'Franquette' proučavan je utjecaj parenja vručom parom na potrebnu silu za deformaciju (lomljenje) ploda te potrebnu energiju za lom ljuske ploda pomoću centrifugalnog stroja za lomljenja. Maksimalna sila (248,04 N) za lomljenje oraha izmjerena je kod 5 minuta parenih uzoraka, a najmanja kod 15 minuta parenja (171,35 N). Najmanja deformacija (1,3 mm) izmjerena je kod lomljenja suhih oraha, a najveća kod 15 minuta parenih (4,15 mm). Najveći dio celih jezgri (74,62 %), dobiven je kod lomljenja 15 minuta parenih oraha a najmanji kod 0 minuta parenja (28,47 %.).

Ključne riječi: orah, vruća para, jezgro, fizikalna svojstva, centrifugalna drobilica,

1.INTRODUCTION

Walnut crushers exist in many construction varieties, which are divided into two groups according to direction of the crushing force. The first group includes machines which enable a two–sided application of forces onto a hazelnut. The rigid crushing surfaces in the crusher have a constant tapered cylinder interspaces, allowing a constant shift of plates in translator motion, with an opening on the bottom, through which walnuts which have been crushed are passed. Because walnuts of the same variety are not of the same thickness or height, kernels can be severely damaged. To avoid losses of kernels a preliminary sorting of walnuts according to their thickness should be processed.

Since the cracking process is the most critical and delicate step for achieving high–quality kernels, mechanical properties of walnut cultivars is a pre–requisite for the design and development of a cracking machine (Pliestic et al., 2006). Özdemir & Özilgen, 1997, stated that the kernel extraction quality depend on shell moisture content, shell thickness, nut size, and loading positions in nuts. Dursun (1997) found that the compression position influenced the amount of force applied to crack walnuts and other nuts. In this study, the maximum force (244 N) required to crack walnuts occurred at right angles to the longitudinal axis while the minimum force (149 N) occurred when the force was applied along the suture line. Similarly, both Braga et al. (1999) and Aydın (2002) found that the maximum force required to crack nuts was measured when nuts were placed at right angles to the longitudinal axis whereas the minimum force required to crack nuts occurred when the force was applied along the longitudinal axis.

The objective of this work was to determine the effects of the vaporization time of walnuts on compression position, specific deformation and energy required to achieve: (1) crack of the nut shell and (2) optimum kernel extraction quality.

2. MATERIALS AND METHODS

2.1 Variety

We cracked the nuts of the ‘Franquette’ cultivar (Figure 1), one of the most common walnut varieties in the world, by using the centrifugal nutcracker (Bernik, 2000). It originates from the region of Grenoble in France. The tree grows slowly and it is not particularly vigorous. It is a late leafing variety, which is good for areas with late spring frosts. It is an early variety and its crop is quite abundant. The fruit is oblong, tapered, thick, and weighs between 9.5

and 12 grams (Ocepek, 1995). The shell is thin, firm, furrowed, and tightly shut. It is easily shelled, whereby the yield is 48 %.

The samples were taken from the selection plantation at the Maribor Biotechnical Faculty in 2007. Measurements were taken at the laboratory of the Chair of Agricultural Technology at the Biotechnical Faculty and at the laboratory of the Ljubljana Faculty of Mechanical Engineering.

Figure 1: Franquette (Ocepek, 1995)

2.2 Steaming walnuts with saturated steam

A boiler (Figure 2), equipped with a thermometer, was used for steaming. Attention was paid to the level of condensate in the boiler, so it did not rise to the walnuts on the mesh. Saturated steam at 106 °C was used for steaming. By raising the pressure above the value of atmospheric pressure, the steaming time is reduced, but this can alter the organoleptic characteristics of the kernel.

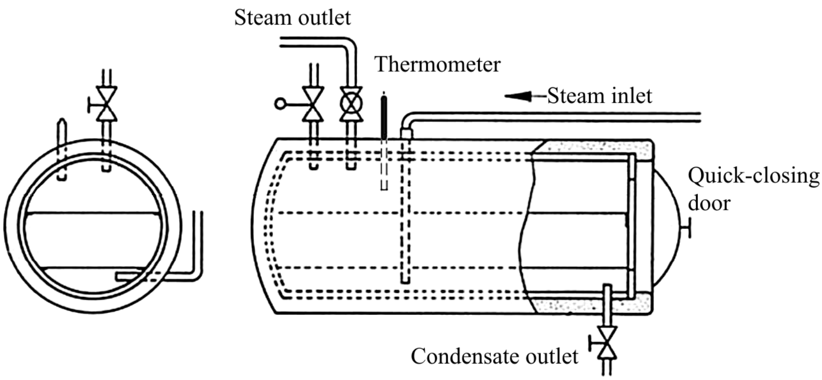

Figure 2: Steaming boiler

2.3. Centrifugal nutcracker

A centrifugal nutcracker (Figure 3), which operates on the principle of a centrifugal force created by the electric motor through the rotor, was used for cracking the walnuts. The rotor case consists of a cylinder with an opening at the top to allow the nuts to drop through, while at the bottom, the cylinder divides into two parts and widens in the direction of rotation. The nuts enter the rotor from the top and due to the centrifugal force exit at the bottom and hit the rotor case with a considerable force. For a better result, the rotor case can be replaced with different materials, or brackets can be fitted to crack nuts with stronger shells. The nutcracker's electric engine is equipped with a frequency regulator, with which prior to every cracking, the rotational frequency of the rotor was adapted according to the shell's moisture level.

After cracking, the cracked walnuts of each group were divided according to the position of the impact that caused the shell break. Then, in each group, the amounts of undamaged halves, partly damaged halves and residues were weighed.

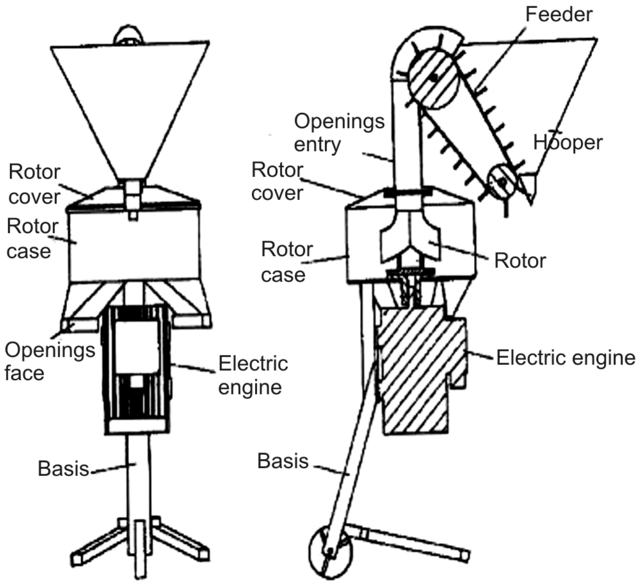

Figure 3: Centrifugal nutcracker (Bernik, 2000)

2.4. Nut size measurements

Measurements of the nuts regarding their height, width and thickness were carried out using a sliding caliper (Figure 4). A sliding caliper consists of a straight edge guide with a fixed jaw and a movable jaw. A locking lever was used for fixing the moving part. The measurements were taken so that the measured nuts were held between the moveable jaws and then the measurements were read. Thus, dimensions with a relative error of approximately one hundredth of a percent were measured.

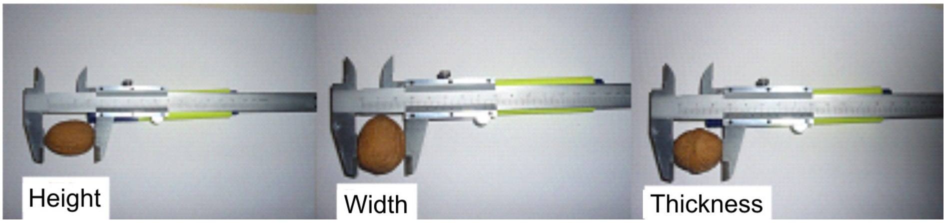

Figure 4: Nut measuring with a sliding caliper

2.5 Nut mass measurements

Mass measurement always began by steadying the scales. Then, each walnut was placed on it separately and the result was read. The scales used had an accuracy of 0.01 g and the capacity of weighing samples with a mass of up to one kilogram. Measurements were carried out in a tightly sealed area, since otherwise, deviations from the real mass due to draught and exhaled air might have occurred.

2.5 Nut volume measurements

The volumes of the entire nut, shell, and kernel were measured. Based on the obtained parameters, the air volume was calculated. Measurements were carried out by immersing the fruit, shell or kernel into water in the measuring cylinder. A measuring cylinder was used for immersion, the volume of which was calculated in advance. The difference in the height of the water column in the measuring cylinder was the basic parameter for the calculation of the total volume. The result — the actual volume of the fruit, shell or kernel — was obtained by deducting the volume of the instrument from the total volume.

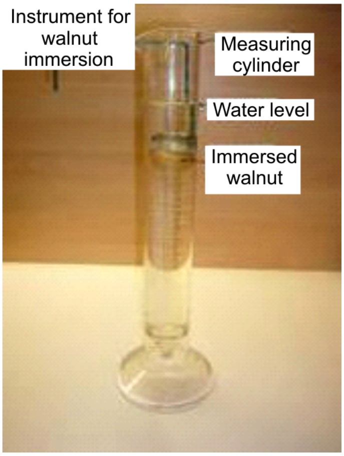

Figure 5: Nut volume measurement

2.6 Testing the strength of the shell

The test consisted of two parts. The first part was conducted with a special press (Bernik and Stajnko, 2008) at the laboratories of the Faculty of Mechanical Engineering — the measurement of the deformation and force needed to break the shell. For each measurement, the nut was held between jaws to ensure the sample was secure during measurement, and then the data was entered into the computer which is an integral part of the pressure tester. The force needed to crack the walnut shell was measured and observed.

3. RESULTS

3.1 Measurements of the physical property

Table 1 represents the physical properties of walnuts showing that the average volume of the entire nut was 18.42 ml, the average volume of the shell was 7.94 ml, the volume of the kernel was 6.03 ml, and the air volume was 4.44 ml. The most important characteristics to crack the nut were the volume of the kernel compared to the volume of the entire walnut, and the air volume (empty space). The air volume was determining as a distance between the kernel and the shell at particular points, as shown in Figure 6.

Table 1: Physical properties of walnuts of the 'Franquette' variety

Physical property	'Franquette'
Average walnut volume [ml]	18.42
Average shell volume [ml]	7.94
% of shell volume	43.13 %
Average kernel volume [ml]	6.03
% of kernel volume	32.75 %
Average air volume [ml]	4.44
% of air volume	24.12 %
% of kernel and % of air ratio	1 : 0.74
Mass [g]	11.67
Height [mm]	51.94
Width [mm]	31.98
Thickness [mm]	32.52

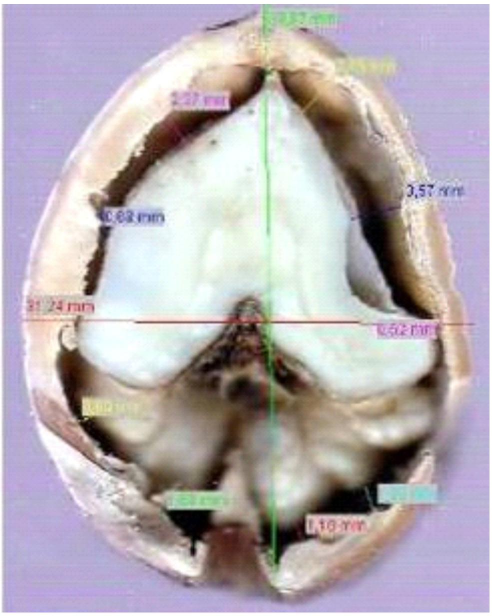

Figure 6: Distance between the kernel and shell in the 'Franquette' variety (Turk)

It was found out; the smaller was the space between the kernel and the shell, the higher was the probability of damaging the kernel when breaking the shell. Therefore, the larger was the empty space in a walnut, the higher was the probability of the kernel remaining intact while cracking the shell, since in the case of a larger distance from the shell, and the kernel has more space to avoid the broken shell.

3.2 Necessary work for cracking the steamed shell

Table 2 shows the measurement results of the work required on the ‘Franquette’ variety for cracking three types of samples: air dried, steamed for 5 minutes, and steamed for 15 minutes. A decrease in the amount of average work input may be seen according to the steaming time. There are significant differences in the average work input between the air dried sample and the samples steamed for 5 and 15 minutes. However, there is no statistically significant difference between the samples steamed for 5 and 15 minutes.

Table 2: Data on the necessary work (Nm) and basic statistical data obtained during pressing.

Walnut	Air dried	Steamed for 5 min	Steamed for 15 min
	Work (Nm)	Work (Nm)	Work (Nm)
Average	0.215	0.322	0.060
Standard deviation	0.162	0.104	0.024
Variation rate (VR %)	75.5 %	89.6 %	40.0 %
Median	0.159	0.093	0.055

3.3 Necessary cracking force

Figure 1 shows the necessary values of force for cracking the walnut shells steamed for different periods of time. It is clearly shown that the greatest force was necessary for cracking walnuts steamed for 5 minutes (248.04 N) at a deformation of 4.1 mm, followed by the air dried walnuts (202.31 N) at a deformation of 1.3 mm. The smallest force was needed for cracking walnuts steamed for 15 minutes: 171.35 N at a deformation of 4.15 mm.

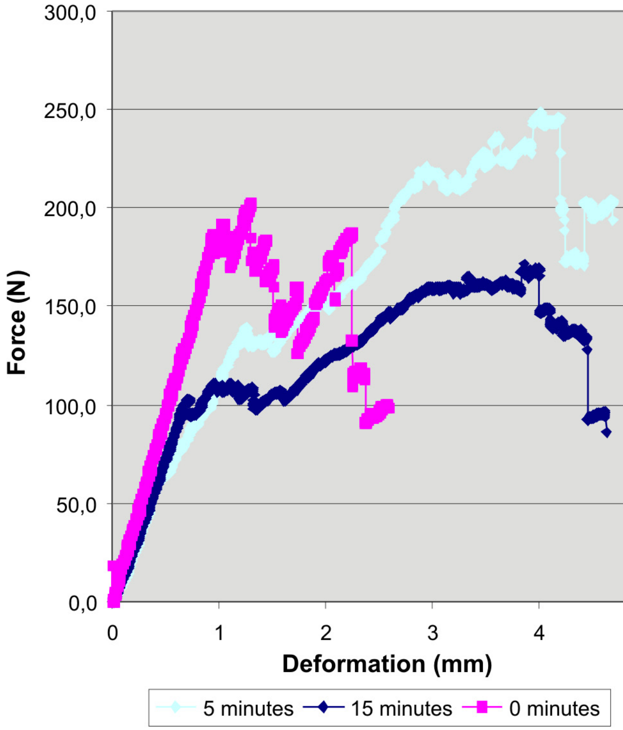

Figure 1: Force (N) in relation to deformation (mm) in cracking steamed walnuts

3.4 Point of breaking

The point of breaking critically influences the quality of cracking, since the manner of breaking directly influences the damage of the kernel and its quality. As shown in Figure 2, the distribution in the first walnut group (0 minutes) is relatively even, only the breaking from the side and those that cannot be identified deviate slightly.

In the group of walnuts steamed for 5 and 15 minutes, the greatest deviations were shown by the breaking from the side, 71.59 % or 49.52 % respectively, followed by those where the point of breaking could not be identified and the breaking on the top. In these groups, there were no middle breakings or undamaged categories.

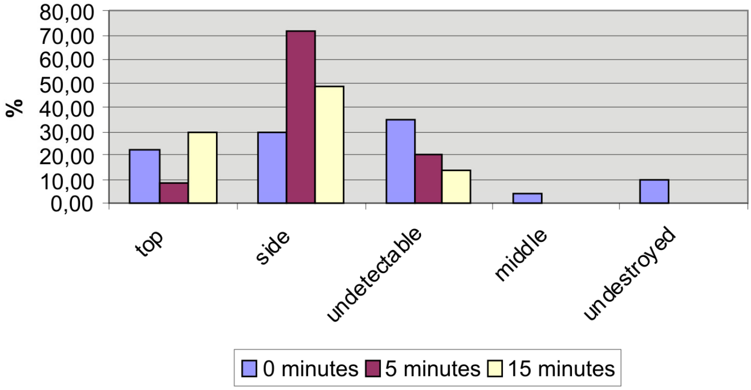

Figure 2: Point of breaking in percentage according to steaming time

3.5 Residue percentage

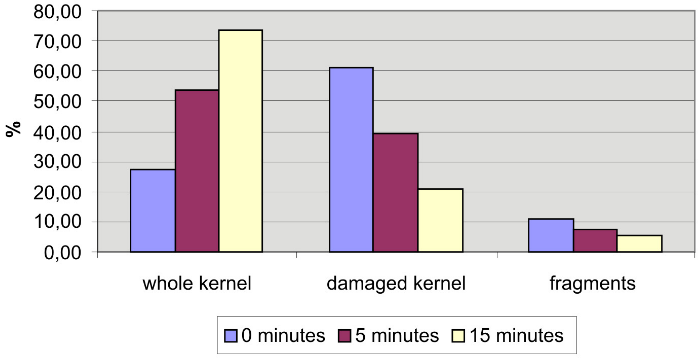

Figure 3: Residue percentage according to damage in different varieties

Based on the kernel damage after cracking with the centrifugal nutcracker, it was established that on average, cracking walnuts that have been steamed for 15 minutes was the most favourable, leaving 74.62 % of whole, undamaged halves. With steaming for 5 minutes, the proportion of whole kernels was reduced to 55.89 %, and in air dried samples to only 28.47 %, meaning that steaming significantly increased the proportion of whole kernels in both cases.

4. CONCLUSION

In the ‘Franquette’ walnut variety, the influence of steaming time on the necessary force for cracking the shell was determined. Simultaneously to deformation measurement, the necessary work (J) for nut deformation was also calculated. It was established that there are no significant differences between walnuts steamed for 5 and 15 minutes, while the values of the necessary force for cracking non–steamed walnuts are significantly higher.

Steaming the walnuts significantly influenced the physical properties of the nuts, because the shell became more elastic, needing only a force of 171.35 N instead of 202.31 N to crack it. On average the highest amount of the work needed for cracking, was for walnuts that had been steamed for 5 minutes (0.322 J), since the average deformation (4.1 mm) was larger than for air dried samples (1.3 mm). The least work needed for cracking was for walnuts steamed for 15 minutes (0.060 J).

A centrifugal nutcracker is an extremely handy device for cracking walnuts, because it saves a lot of physical work, and moreover, after steaming the walnuts for 15 minutes, more kernels remain undamaged (74.62 % of whole, undamaged kernels) than in manual cracking.

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