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THE EFFECT OF ROASTING ON THE TEXTURE OF WALNUTS

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Abstract. The objective of this study was to compare the mechanical properties of walnuts roasted in hot air and in oil at different technological parameters. It was found that the mechanical properties of walnuts were dependent on temperature and time of roasting. As roasting temperature increased nut hardness decreased. The time of roasting at lower temperatures also affected hardness alterations – the longer the roasting time, the lower the nut hardness values. There were recorded dependencies between the moisture of roasted nuts and their texture. Nuts of lower moisture featured less hard and more crispy texture, which was expressed by lower values of forces needed to destroy the nuts. The kind of heating medium used (air or oil) did not significantly affect the strength properties of walnuts.

Keywords: roasting, walnuts, moisture, texture

INTRODUCTION

Nuts are described as dried fruit in seeds, fruit with split hulls, or edible seed kernels of trees. Currently, over 1 mln t of nuts are commercially produced all over the world. The most common form used in food processing sector are shelled nuts which undergo the following processes: blanching, dicing, coating, roasting or grinding to meet product formulation needs or to add consumer appeal [3].

Roasting is one of the most important processes which provides useful features to the product. One of the several objectives of nut roasting is to alter and significantly enhance the flavour, texture, colour and appearance of the product. Roasting gives nuts a variety of textures and colours, increasing their crispness and making them more crunchy [1,2,4,5,7]. Roasted nuts are widely consumed as an appetizer and used as raw materials in sweets, confectionery, chocolate and biscuits.

As a result of roasting, moisture level in nuts decreases from the initial value in the range 4-6% down to 1-3%. Moisture reduction helps create a desirable crisp texture. Roasting improves the flavour of raw nutmeats from its green taste. If nuts are heavily roasted, the sugars in hazelnuts can decrease and, therefore, exposure to high temperatures for longer periods decreases the quality of nuts. The conditions of roasting generally used by processors are 100-180^{o}C and a residence time of 10-60 min [4,6]. There are two types of nut roasting: dry and oil. Dry roasting involves the heating of nuts using conventional or radiant microvave heat. In the oil method, raw nutmeats are immersed in boiling oil and then drained to remove oil excess [3]. Although there were analyses of the effect of dry roasting on nuts properties, it seems to be interesting to compare different methods of roasting.

The objective of this study was to compare the mechanical properties of walnuts roasted in hot air and in oil at different technological parameters.

MATERIALS AND METHODS

Preparation of roasted nuts

The subject of this investigation were shelled walnuts. 200 g samples of walnuts halves (initial moisture 4.5%) were roasted in hot air (laboratory dryer) and boiled in rapeseed oil (fryer). Roasting parameters were as follows: 9 min./112^{o}C, 26 min./112^{o}C, 17min./170^{o}C, 17min./180^{o}C, 9min./170^{o}C and 26 min./170^{o}C. In roasted nuts the following were analysed: moisture content – according to the gravimetric method, and texture parameters – by instrumental method. The data are mean results obtained in two technological replications.

Mechanical tests

Strength examinations of walnuts were carried out with the use of an Intsron Model 5544 Universal Texture Analyser outfitted with an extensometer head of the range up to 2 kN. Single walnut halves were bent in three point support system (Fig. 1a) and compressed between plates (Fig. 1b) at the speed of 5 mm min^{-1}. Both tests lasted until the examined sample was destroyed and they enabled determination of maximum bending force Fgmax value and the maximum compressive force Fcmax value. Each measurement was conducted on 10 nut halves.

Compressive strength examinations of walnuts in mass were performed using a piston moving at the speed of 5 mm min^{-1}. in a cylinder of 60 mm in diameter and the same height (Fig. 2). Stress value was calculated from the equation 1,

$$\sigma = \frac{4Fc}{\pi d^2} \qquad (1)$$

where: σ – stress (MPa), Fc – compressive force (N), d – cylinder diameter (mm).

While true strain value was determined on the basis of equation 2:

$$\varepsilon = \frac{\Delta h}{h} \tag{2}$$

where: ε – true strain (mm mm^{-1}), Δh – deformation (mm), h – cylinder height (mm).

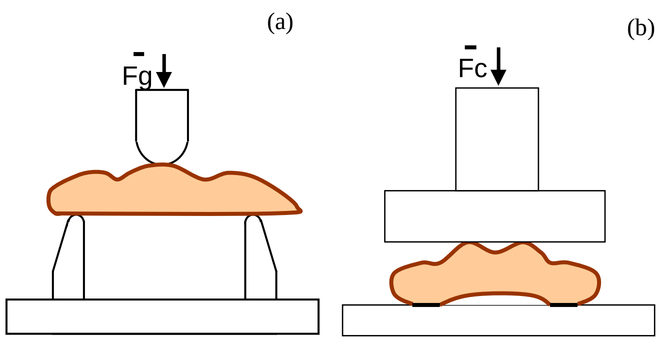

Fig. 1. Bending of a walnut half in three-point support system (a) and compression between plates (b)

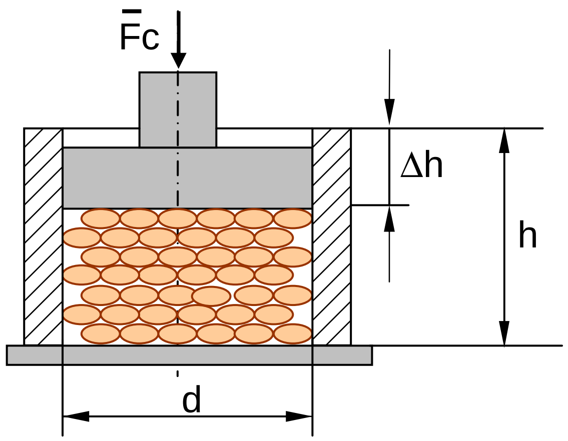

Fig. 2. Compression of walnuts in cylinder

Compression test lasted until *Fc* = 1 kN force was reached and thus stress amounted to σ = 0.35 MPa. Compression force corresponded to the area below the compression diagram in the stress-strain system (Fig. 3). This area was determined using the Excell programme, by summing up the areas of elementary trapezius determined by measuring points. Elasticity modulus was determined within the range from 0.3 to 0.35 MPa (Fig. 4). In this range increase in stress σ in relation to true strain ε could be described with the use of a linear function at a very high coefficient of determination. Tangent of the inclination angle of the straight line determined in this way corresponded to elasticity modulus.

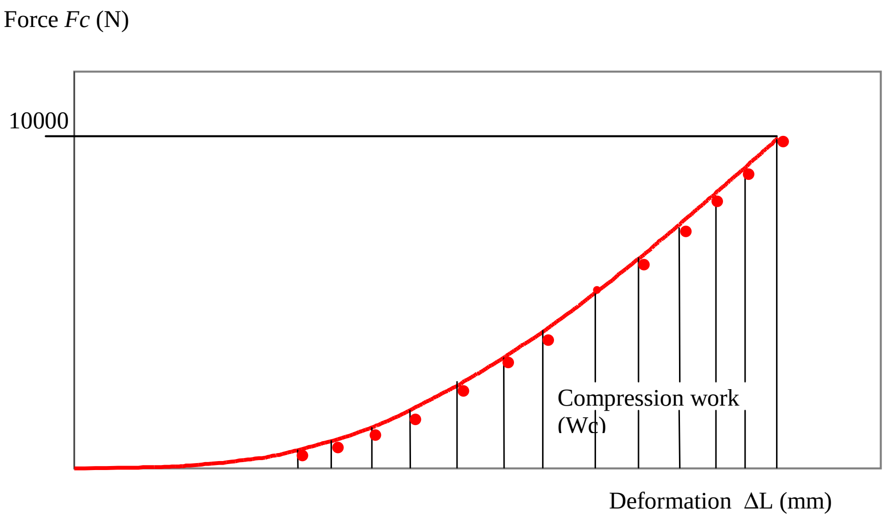

Fig. 3. Determination of compression work in cylinder

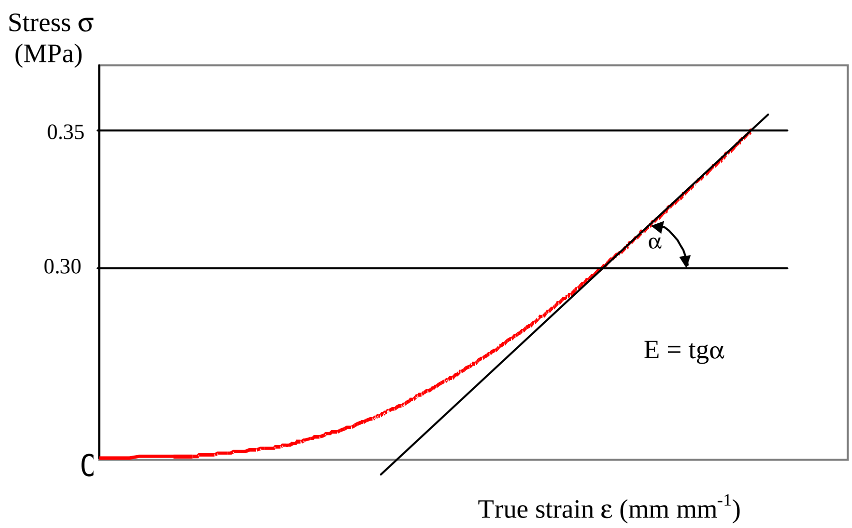

Fig. 4. Determination of elasticity modulus in cylinder

Statistical analysis

The results obtained in the experiment were subjected to statistical analysis by means of Excel and Table-curve programmes. In order to compare the hardness of roasted nuts with their moisture content vlaues obtained during roasting, as well as to determine the significance and the character of dependencies between these features, analysis of simple regression was performed. The chosen models were characterized by the lowest standard error.

RESULTS AND DISCUSSION

Moisture content values of walnuts roasted in hot air and in oil, at different temperatures and time, are presented in Table 1. Regardless of the kind of heating medium, walnuts roasted at higher temperatures featured lower moisture.

Table 1. Moisture content of roasted walnuts

Type of roasting	Roasting parameters					
	9 min.		17 min.		26 min.	
	112°C	170°C	100°C	180°C	112°C	170°C
Oil	2.40	0.91	2.88	0.80	2.27	1.05
Dry	3.21	1.5	2.22	0.84	2.03	0.95

The decrease in moisture directly affected the mechanical properties of walnuts. The results of the bending test are shown in Figure 5. Roasting at higher temperature for the same time decreased walnut hardness, regardless of the roasting method applied. The time of roasting, however, did not significantly affect walnut hardness.

Demir and Cronin [2], comparing hazelnut hardness dry-roasted at different temperatures and time, found that the temperature of roasting had a stronger effect on hazelnut texture, although both the parameters did significantly influence it. The authors explained the considerable differences between the samples with differences in the stage of nuts ripening, as well as with diverse nut shapes. Nut texture was getting uniform in the course of roasting process.

Mechanical properties, i.e. nut hardness is connected to a high degree with water content in the product. Relation between hardness, determined by the bending test, and nut moisture is presented in Figure 6. As the moisture of nuts decreased, their hardness also decreased.

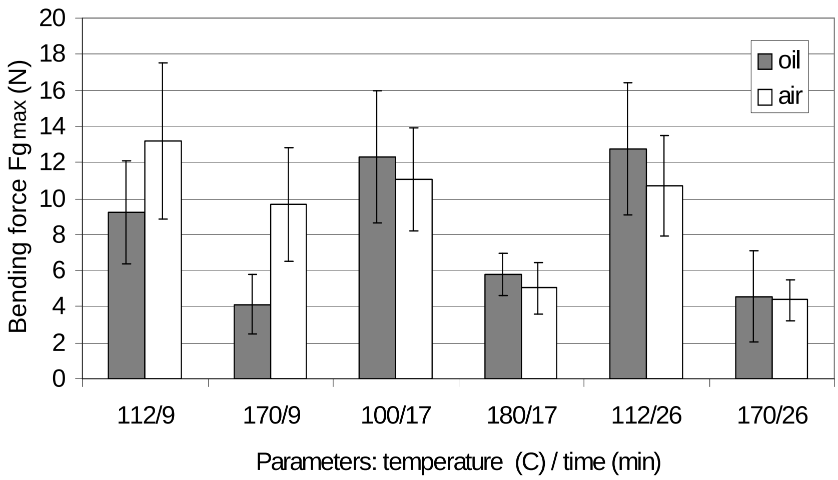

Fig. 5. Maximum bending force (*Fgmax*) of walnuts roasted at different technological parameters

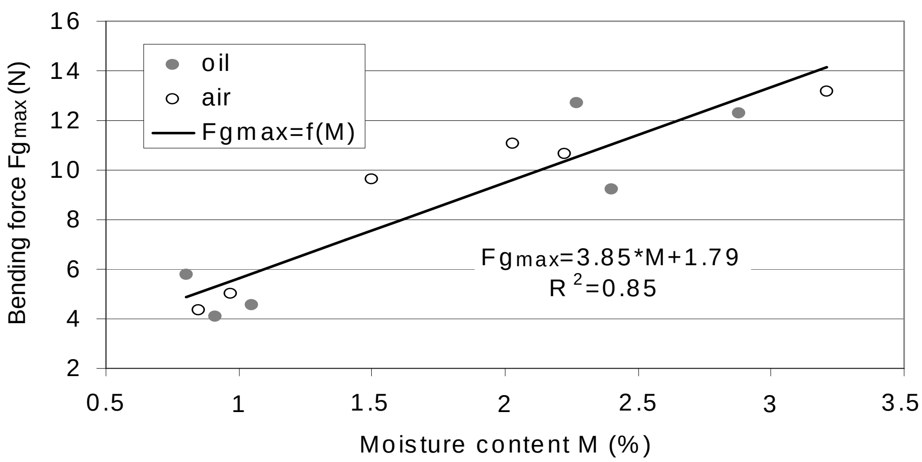

Fig. 6. Effect of moisture content on the bending force (*Fgmax*) of walnuts roasted at different conditions

Similar relations were recorded by Saklar *et al.* [7] when they compared the mechanical properties of hazelnuts dry-roasted at different temperatures. Nuts featuring lower moisture were of more crispy and crunchy texture.

The nuts also underwent the compression test determining the maximum force needed to destroy a sample (*Fcmax*). On the basis of temperature and roasting time analysis, there were observed similar dependences to the ones recorded during the bending test. The nuts roasted at lower temperatures for the same period exhibited higher hardness values (Fig. 7).

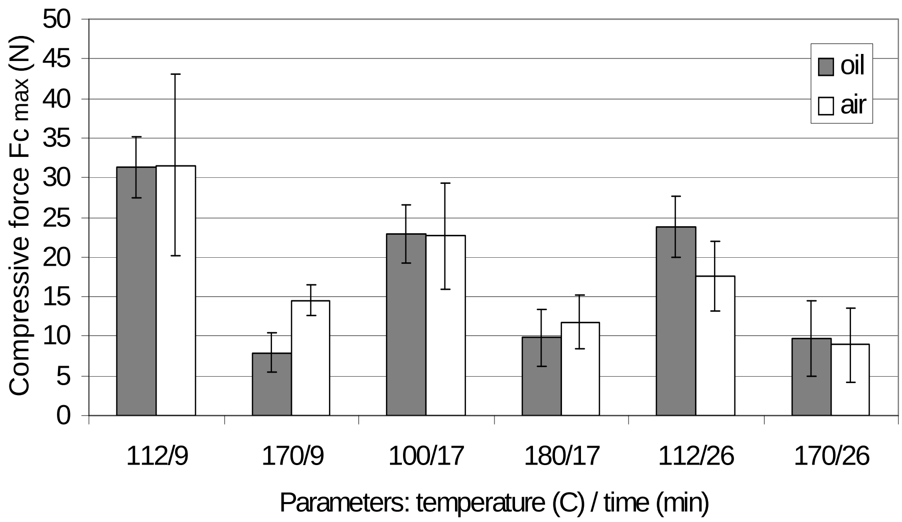

Fig. 7. Maximum compressive force (*Fcmax*) of walnuts roasted at different technological parameters

The longer the time of roasting at lower temperatures, the lower values of nut hardness were recorded, while no significant dependences in nut hardness were observed for roasting at higher temperatures. Figure 8 shows the determined relations between *Fcmax* and roasted nuts moisture. Similarly to the findings regarding the bending test, as nut moisture decreased in the course of roasting, the force needed to destroy a nut was also decreased.

The effect of the parameters related with roasting (air temperature, air velocity, roasting time) on the mechanical properties of hazelnuts was investigated by Saklar *et al.* [8]. They stated that crispness and nut crunch texture were dependent on alterations in nut microstructure that took place in the roasting process – as the roasting temperature increased, nut cell structure was getting loose. Due to the increase in volume of intracellular spaces and the decrease in elasticity of walls, nuts lose their elasticity (characteristic feature of raw nuts) when roasted and become more crispy and crunchy.

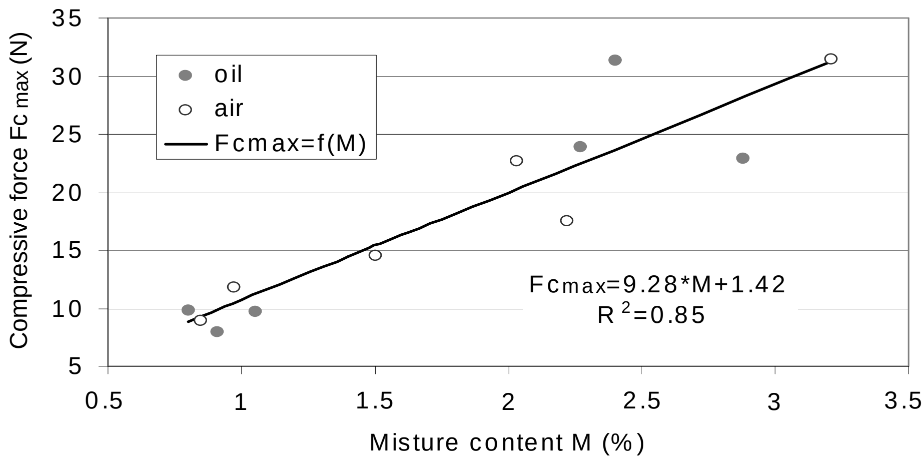

Fig. 8. Effect of moisture content on the compressive force (*Fcmax*) of walnuts roasted at different conditions

Although in the experiment carried out the cell structure of walnuts was not the subject to analysis, it is highly propable that they undergo the same alterations as hazelnuts. This can be proved by the results of analysed strength parameters. Regardless of the heating medium used – hot oil or air, the results of the investigated parameters resembled one another.

The results obtained after analysis of mechanical properties of single nuts, describing their texture, were proved by compression tests carried out in nut mass placed in a cylinder. Evaluated work needed to compress a determined nut volume showed similar relation to moisture of the analysed material as compression or bending forces (Fig. 9). As nut moisture decreased as a result of roasting, the work done when bending them also decreased, especially within moisture range from 1.5 to 1%. Since roasted nuts became more crispy and tender, slight alterations were also to be found in their elasticity modulus (Fig. 10). The higher the moisture of roasted nuts, the higher the modulus of elasticity.

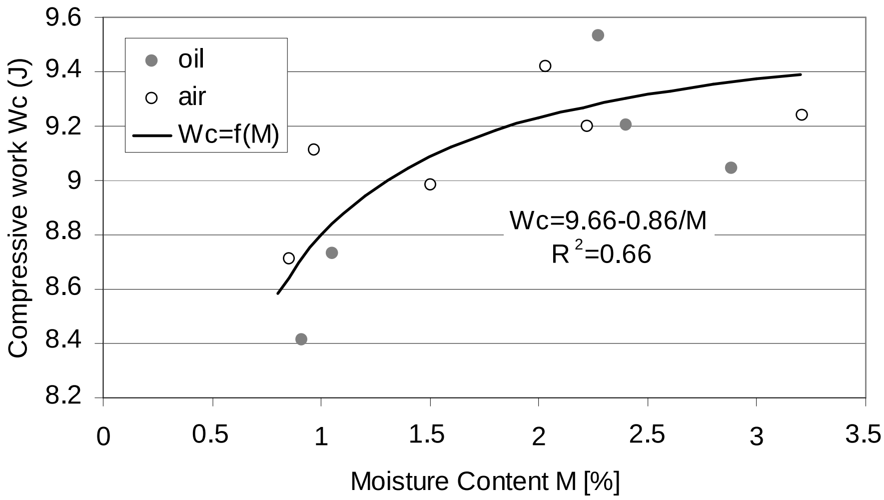

Fig. 9. Effect of moisture content on the compressive work (*Wc*) of walnuts roasted at different conditions

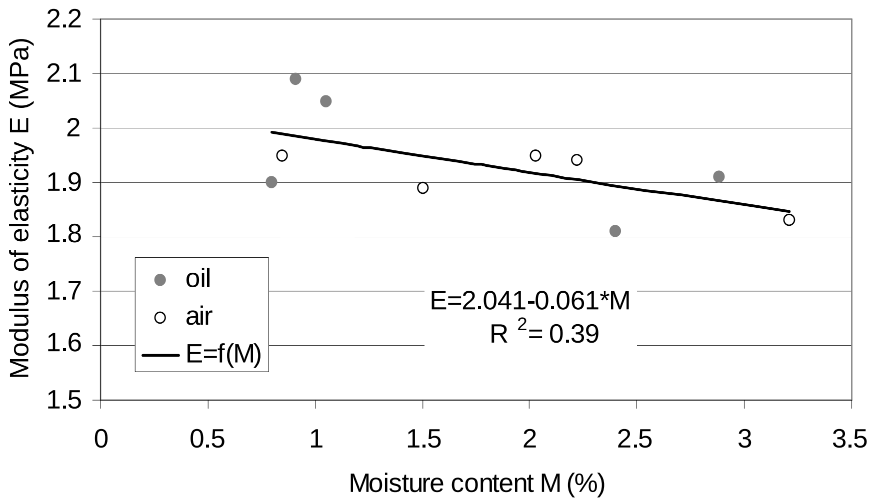

Fig. 10. Effect of moisture content on the modulus of elasticity (*E*) of walnuts roasted at different conditions

CONCLUSIONS

1. Mechanical properties of walnuts were dependent on temperature and time of roasting.
2. As roasting temperature increased nut hardness decreased. The time of roasting at lower temperatures also affected hardness alterations – the longer roasting time, the lower nut hardness values.
3. There were recorded dependencies between moisture of roasted nuts and their texture. The nuts of lower moisture featured less hard and more crispy texture, which was expressed by lower values of forces needed to destroy nuts.
4. The kind of heating medium (air or oil) did not significantly affect the strength properties of walnuts.

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WPŁYW PRAŻENIA NA KONSYSTENCJĘ ORZECHÓW WŁOSKICH

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S t r e s z c z e n i e. Celem pracy było porównanie właściwości mechanicznych orzechów włoskich prażonych metodą suchą w powietrzu oraz w oleju. Stwierdzono, że właściwości mechaniczne orzechów uzależnione były od temperatury i czasu prażenia. Wraz ze wzrostem temperatury prażenia obniżała się twardość orzechów. Czas prażenia w niższych temperaturach również wpływał na zmiany twardości – im dłuższy czas tym mniej twarda konsystencja orzechów. Stwierdzono zależności pomiędzy wilgotnością orzechów, a ich konsystencją. Orzechy o niższej wilgotności charakteryzowały się mniej twardą i bardziej kruchą konsystencją zobrazowaną niższymi wartościami sił potrzebnych do zniszczenia. Rodzaj medium grzejnego (powietrze lub olej) nie wpływał istotnie na cechy wytrzymałościowe orzechów.

S ł o w a k l u c z o w e: prażenie, orzechy włoskie, wilgotność, tekstura