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Effect of Roasting Process on Moisture Content and Colour of Polish Inshell Hazelnuts

Hanna Ciemniewska-Żytkiewicz[1,✉], Joanna Bryś[1], Andrzej Bryś[2], Katarzyna Sujka[1], Piotr Koczoń[1]

[1]Department of Chemistry, Faculty of Food Sciences, Warsaw University of Life Sciences, Nowoursynowska St. 159c, 02-776 Warsaw, Poland
[2]Department of Fundamental Engineering, Faculty of Production Engineering, Warsaw University of Life Sciences, Nowoursynowska St. 164, 02-787 Warsaw, Poland

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✉ *Corresponding author (Yazışmalardan Sorumlu Yazar): hanna_ciemniewska_zytkiewicz@sggw.pl (H. Ciemniewska-Żytkiewicz)*
✆ +48 22 59 37 607 🖷 +48 22 59 37 635

ABSTRACT

The effects of roasting parameters (temperatures of 100, 130 and 160°C for 10, 30 and 60 minutes each at a constant air flow rate) on moisture content and shell colour of inshell hazelnuts were determined in this present study. The scope of this study included drying curves development, moisture and colour analysis of a shell surface in CIE L*, a* and b* system for the '*Kataloński* hazelnuts variety cultivated in Poland. Colour intensity (chroma – C) and total colour difference (ΔE) were calculated as well. Results indicated that the temperature was the main factor that affected colour development in roasted samples. The significant changes occurred in every colour parameter (*L**, *a** and *b**), which was related to the water loss.

Key Words: Hazelnuts, Roasting, Colour, Moisture content

Polonya'da Üretilen Kabuklu Fındıkların Nem Miktarı ve Rengi Üzerine Kavurma İşleminin Etkisi

Bu çalışmada kabuklu fındıkların nem miktarı ve dış rengindeki değişiklikler üzerine sabit hava akışındaki 100, 130 and 160°C'de uygulanan 10, 30, 60 dakikalık kavurma işleminin etkileri karşılaştırılmalı olarak incelenmiştir. Çalışmanın amaçları içerisinde Polonya'da yetiştirilen '*Kataloński* fındık çeşidi için kuruma eğrilerinin oluşturulması ve nem miktarı ve kabuk yüzeyinin renginin CIE L*, a*, b* sistemi ile analizi de yer almaktadır. Renk yoğunluğu (kroma - C) ve toplam renk farkı (ΔE) da hesaplanmıştır. Elde edilen sonuçlar kavurma uygulanan örneklerde renk gelişimine etki eden başlıca faktörün sıcaklık olduğunu göstermiştir. Kuruma sırasındaki nem kaybıyla ilgili olarak her bir renk parametresinde önemli değişiklikler meydana gelmiştir.

Anahtar Kelimeler: Fındık, Kavurma, Renk, Nem miktarı

INTRODUCTION

In accordance with the FAO database from 2012, Poland ranks as the 10th biggest hazelnuts producer worldwide with production about 4200 MT a year [1]. In Poland, there are produced mainly large-fruited hazelnuts e.g. *Kataloński (Catalan)*, *Barcelona*, and *Hall's Giant*, commonly used for direct, unprocessed kernel consumption; hence inshell nuts distribution is most common in Poland [2]. It is in contrast to global scale where merely 10% of hazelnuts produced are consumed as a raw product [3].

Roasting is one of the basic operations used in nut processing, that can lead to both, desirable and/or

undesirable changes in physical, chemical and nutritional properties of seeds [4]. The most expected ones from the consumer and producer point of view is improvement of flavour, colour, crispiness and crunchiness together with better oxidative stability and nutritional parameters. According to available literature data, roasting is defined as a thermal operation (e.g. using dry hot air, infrared and microwave treatment) in the temperature range of 104–180°C for 6 to 45 minutes [5], while in industry conditions the roasting time range can be extended. Usually kernels are used as a roasting material.

An innovative approach is roasting of whole inshell hazelnuts. It could encourage producers from Poland and other countries to offer to the market quite new product that is inshell roasted hazelnut for direct consumption. It could be an attractive alternative to the raw hazelnuts, currently available on the wide market. The nuts inside the shell would be more nutty, crunchy and crispy but still in traditional inshell form. The aim of this paper was to assess the moisture content in whole hazelnuts as well as determine the change of colour of their shell as an effect of different roasting conditions.

MATERIALS and METHODS

Plant Material

The investigated hazelnuts (*Corylus avellana* L.), *Kataloński* variety were from the orchard located in Silesian region, the south of Poland. Hazelnuts in shell classified in "Extra" class according to Commission Regulation (EC) No 1284/2002, with a diameter equal to or above 16 mm, were exclusively included in this study. Inshell fruits were collected at technological maturity, sun-dried for 3 days and then stored in shell at 4°C until they were analysed.

Moisture of Raw Material

Approximately 50 g of the unroasted sample was dried in a drying oven for 6 hours in 105°C until constant weight according to Commission Regulation (EC) No 1284/2002, followed by moisture calculations.

Roasting Process

Hazelnuts were roasted at nine specific temperature/time conditions: 100°C/10min, 100°C/30min, 100°C/60min, 130°C/10min, 130°C/30min, 130°C/60min, 160°C/10min, 160°C/30min, 160°C/60min, at a constant air flow rate (0.8-1.0 m× s^{-1}). These conditions were set according to the range commonly used in the hazelnut industry. The average air flow was determined using Kestrel 4000 (Nielsen-Kellerman) anemometer. Roasting was conducted in a laboratory convective dryer Memmert UFP400 (Germany). Recording of mass loss (with accuracy of 0.01 g) was registered continuously, in 1 min intervals. Every roasting processes was duplicate. After roasting, nuts were cooled immediately and stored at -18°C until they were analysed. Relying on the measurements of mass losses of the sample during roasting process, drying curves representing moisture content change in time domain were plotted [6].

Colour Measurement

Colour of raw and roasted inshell hazelnuts surface was measured using CM5 Konica Minolta Chroma Meter. The colorimeter was multi-calibrated against standard plates and CIE L*a*b* system was set. The Chroma Meter had CIE Standard Illuminate D65, CIE: 2° Standard Observer and measurement area covered 3 mm (diameter). The colour analysis was repeated 10 times, each time placing inshell nuts in a different way. In the purpose of measure colour changes after roasting, C (chroma) and ΔE (total colour change) parameters were calculated based on following Eqs. 1 and 2 [7, 8]:

$$C = \sqrt{(a*)^2 + (b*)^2} \quad (1)$$

$$\Delta E = \sqrt{(\Delta L*)^2 + (\Delta a*)^2 + (\Delta b*)^2} \quad (2)$$

where *ΔL*, Δa** and *Δb** are the differences of lightness, red and yellow colours parameters, respectively, between raw and roasted hazelnuts. ΔE is expressed in NBS units [8, 9].

Statistical Analysis

Relative standard deviation was calculated, where appropriate. One-way analysis of variance, ANOVA (Tukey's honest significant difference multiple comparison) was evaluated using Statgraphics Plus software. P-values lower than 0.05 were considered statistically significant and homogenous groups were denoted with the same letters in tables and graphs. The Pearson's linear correlation analysis allowed determination of the degree and correlation trend of indicators studied.

RESULTS and DISCUSSION

Initial moisture of whole inshell nuts was on average 12.69% (Table 1), while the moisture of their kernels was reported previously to be 7.56% [10]. The fibrous skin, present between shell and thin skin, particularly distinctive for *Kataloński* variety could be responsible for additional water retention. As presented in Table 1, one can notice that during roasting process, the moisture of inshell nuts decreases according to the temperature/time conditions applied. The most substantial water losses were observed during 60 min treatment in 100, 130 and 160°C and during 30 min roasting in 160°C. As presented before [10], the same conditions applied for kernel roasting induced lower moisture content accounted for 4.15, 2.56, 0.36 and 2.66%, respectively. Nevertheless, herein study provides the confirmation that prolonging duration and increasing temperature of roasting process decreases the moisture of treated nuts [11].

Table 1. Moisture changes in whole hazelnuts during roasting process

Roasting conditions		Moisture (%)
Temperature (°C)	Time (min)	
Inshell raw nuts		12.69
100	10	11.67
	30	9.57
	60	5.93
130	10	10.70
	30	7.35
	60	4.43
160	10	9.38
	30	5.20
	60	0.79

Drying curves representing changes within roasting in 100 and 130°C presented at Figure 1 had convergent courses and the moisture contents after 60 min. treatment accounted for 0.0631 and 0.0463 kg H_2O kg d.m.$^{-1}$, respectively. In the case of inshell nut roasting in 160°C, the effectiveness of moisture diffusion was significantly higher from the very beginning of the treatment, and the final moisture content was 0.0080 kg H_2O kg d.m.$^{-1}$. Furthermore, the moisture content in material studied herein dried in 160°C for 60 min. was over 16 times lower comparing to the initial moisture content, while in the case of roasting treatment of the kernel alone the process was significantly more effective with the final moisture content over 20-fold lower as compared to its initial value [10].

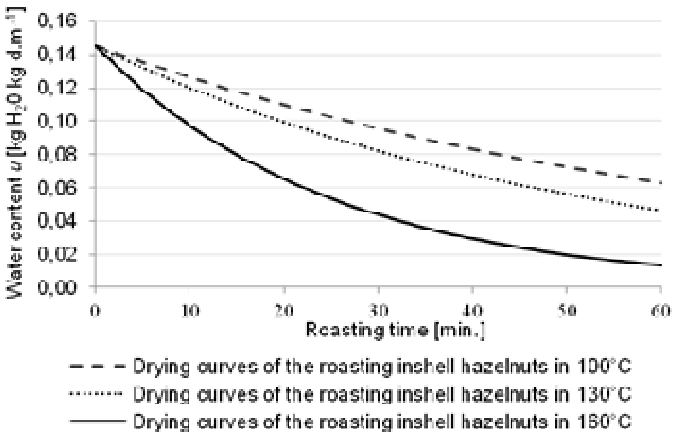

Figure 1. Drying curves of inshell hazelnuts roasting process conducted in 100, 130 and 160°C for 60 min.

During roasting process, temperature of the flowing air is most relevant parameter influencing the changes of both, moisture content and colour parameters [12]. The experimental values of the colour dimensions, *L**, *a**, *b** and chroma (C) for the shell surface measurements are given in Table 2. The shell lightness (*L**), red (+*a**) and yellow (+*b**) colours of roasted samples decreased significantly in the course of roasting in applied conditions (Figure 2).

In the case of shell lightness (*L**) the significant differences between raw and roasted samples were reported for the following conditions: 100°C/60min, 130°C/30min, 130°C/60min and for all time intervals tested in 160°C (Table 2). The dry roasting process caused also a significant decrease in red (+*a**) and yellow (+*b**) colours values of the shell, while the adverse relationship was reported before when it compares to changes occurring in pure kernel roasting [10, 12]. Parameter *a** changed significantly after treatment in 160°C for 60 minutes, whereas *b** values were significantly decreased after roasting in 60°C for 30 and 60 minutes.

One of the most important parameters defining the share of the chromatic parameters (*a**, *b**) in the overall colour perception is saturation or chroma (C). The parameter describes the hue of the colour by its intensity and depth in a qualitative manner [7, 13]. The roasting process is significantly responsible for the change of saturation ($p<0.05$), which is strongly positively correlated ($r=0.91$) with the lightness (*L**) of roasted material. However, the significant decrease of chroma (C) value of the shell is exclusive for material roasted in 160°C for 30 and 60 minutes (Table 2).

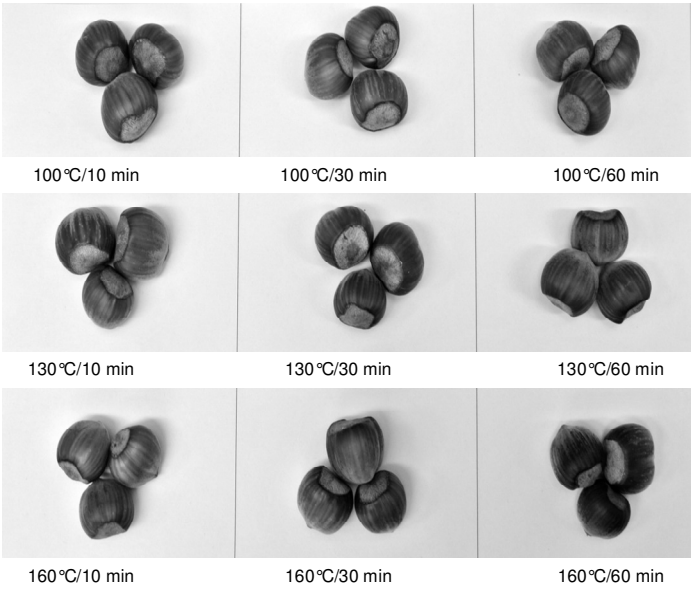

Figure 2. Colour changes of hazelnuts shell according to applied roasting conditions

Table 2. Colour assessment of the hazelnuts shell according to applied roasting conditions

Roasting conditions		Colour parameters			
Temperature (°C)	Time (min)	*L**	*a**	*b**	Chroma (C)
Inshell raw nuts		45.28 ± 2.42 ^{a}	18.05 ± 1.65 ^{a}	25.38 ± 4.54 ^{ab}	31.19 ± 4.44 ^{ab}
100	10	44.61 ± 2.25 ^{a}	17.77 ± 1.73 ^{a}	24.57 ± 4.32 ^{ab}	30.36 ± 4.36 ^{ab}
	30	44.80 ± 1.49 ^{a}	17.98 ± 1.88 ^{a}	26.98 ± 2.60 ^{a}	32.44 ± 2.98 ^{ab}
	60	39.43 ± 2.20 ^{cd}	18.38 ± 1.42 ^{a}	22.21 ± 1.90 ^{b}	28.85 ± 2.05 ^{b}
130	10	43.70 ± 2.45 ^{ab}	19.62 ± 1.96 ^{a}	28.42 ± 2.67 ^{a}	34.56 ± 2.98 ^{a}
	30	39.75 ± 3.58 ^{bcd}	18.22 ± 1.27 ^{a}	21.50 ± 3.01 ^{b}	28.23 ± 2.81 ^{bc}
	60	38.25 ± 2.10 ^{de}	18.81 ± 1.32 ^{a}	20.81 ± 2.95 ^{bc}	28.08 ± 2.98 ^{bc}
160	10	43.01 ± 2.76 ^{cd}	18.98 ± 1.13 ^{a}	25.48 ± 4.14 ^{ab}	31.83 ± 3.82 ^{ab}
	30	34.76 ± 2.28 ^{ef}	17.01 ± 2.06 ^{a}	16.09 ± 3.28 ^{c}	23.45 ± 3.63 ^{c}
	60	31.20 ± 2.46 ^{f}	11.97 ± 2.17 ^{b}	9.21 ± 1.83 ^{d}	15.14 ± 2.66 ^{d}

The total colour difference (ΔE) of the shell of roasted hazelnuts was in the range of 1.71 (100°C/10min) and 21.77 (160°C/60min) (Figure 3). For almost all roasted samples (except 100°C/10min and 100°C/30min conditions), the total colour difference values were higher than 2, which means that change of hazelnut's shell appearance for these samples during roasting was noticeable by an outside observer, so by consumer as well [9].

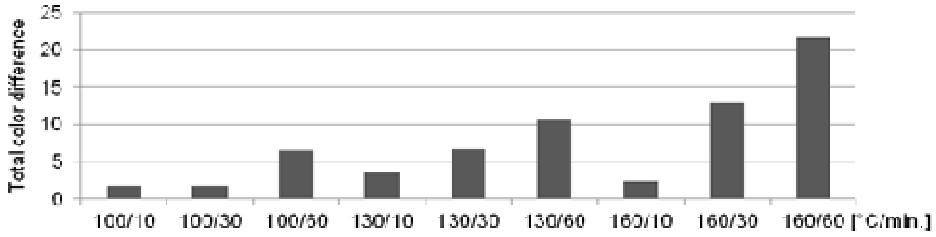

Figure 3. Total colour difference of the hazelnuts shell according to applied roasting conditions

CONCLUSIONS

According to Commission Regulation (EC) No 1284/2002, moisture of hazelnuts in shell is limited up to 12% of the whole hazelnut. In the raw nuts percentage abundance of moisture was around 12.69%, while processing hazelnuts under all studied roasting conditions decreased the moisture level down to expected limit, what can positively influence their shelf life. Moreover, roasting applied did significantly decrease the lightness, red and yellow colours and overall saturation of hazelnuts shell. The visual

assessment of colour of the shell indicated 130°C/30min, 130°C/60min and 160°C/30 min as the process conditions leading to the most desired results. Further research on the influence of roasting process on polish hazelnuts quality (PV, FFA, anisidine value, oxidative stability) and nutritional (fatty acids composition, tocopherols content) parameters of their oil is conducted.

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