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Effects of different roasting conditions on physical-chemical properties of Polish hazelnuts (*Corylus avellana* L. var. *Kataloński*)

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ABSTRACT

The influence of different roasting conditions on the physical-chemical (water activity, moisture, colour, volatile compounds, tocopherols, phenolic content) properties of Polish hazelnuts (cv. *Kataloński*) was determined. Nuts were roasted at specific temperature/time conditions: 130 °C/40 min, 130 °C/50 min, 130 °C/60 min, 160 °C/20 min, 160 °C/25 min, 160 °C/30 min. Hazelnuts roasted at 160 °C showed a darker colour and a lower water activity and moisture than samples roasted at 130 °C. Compared to raw hazelnuts, the phenolic content increased in all roasted samples, although with a more concentration in nuts roasted at 160 °C (2998.84 mg/100 g, 3429.52 mg/100 g and 2927.81 mg/100 g after 20, 25 and 30 min, respectively). The different roasting conditions led to several aroma modifications, in fact in raw hazelnuts were identified just only 22 compounds, whereas in samples roasted at 130 °C and 160 °C were found 79 and 102 volatile compounds, respectively.

1. Introduction

Hazelnut (*Corylus avellana* L.) belongs to the family of *Betulaceae* and is one of the most popular nuts worldwide; it is produced especially in the coasts of Black Sea region of Turkey, in southern Europe (Italy, Spain, Portugal and France) and in some areas of the United States (Oregon and Washington). Furthermore hazelnuts are grown in New Zealand, China, Azerbaijan, Chile, Iran, Georgia, Kirgizstan, Poland and Croatia (Ciemniewska-Żytkiewicz et al., 2015b; Pelvan, Alasalvar, & Uzman, 2012).

The biochemical composition of hazelnuts has been extensively studied because of their health promoting properties and their good source of energy due to a fat content of about 60% (Ciemniewska-Żytkiewicz et al., 2015b). Hazelnuts provide also essential minerals (Ca, Mg, P, K), vitamins E and B complex, fibres and amino acids. Moreover, several studies have shown that hazelnuts are rich in some antioxidant compounds, such as tocopherols and polyphenols, which exhibit a beneficial effect on human health, reducing oxidative stress and risk of cancer, stroke, inflammation, and other neurodegenerative diseases (Kornsteiner, Wagner, & Elmadfa, 2006; Shahidi, Alasalvar, & Liyana-Pathirana, 2007; Yurttas, Schafer, & Warthesen, 2000). Besides, phenolic compounds contribute greatly to some hazelnuts organoleptic properties, such as astringency and bitterness (Cristofori, Ferramondo, Bertazza, & Bignami, 2008).

Roasting process is carried out to remove the pellicles of kernels, inactivate enzymes, destroy microorganisms and reduce water activity (Özdemir et al., 2001); moreover, roasting is used to improve the colour, the crispy texture and the flavour of the product (Burdack-Freitag & Schieberle, 2010). The thermal treatment applied during roasting processes leads to physical changes such as dehydration (Amaral, Casal, Seabra, & Oliveira, 2006), colour modifications (Alamprese, Ratti, & Rossi, 2009), biochemical changes including lipid structure modification (Amaral et al., 2006) and Maillard reactions that give rise to pyrazines compounds associated with the development of typical roasted flavour (Saklar,

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Katnas, & Ungan, 2001).

The roasting conditions generally used for hazelnuts are in a range from 100 to 160 °C for 10–60 min (Donno et al., 2013). Ciemniewska-Żytkiewicz, Bryś, Bryś, Sujka, and Koczoń (2014) roasted hazelnut *Kataloński* variety at three temperatures (100, 130, 160 °C), of which 130 and 160 °C were reported as the most suitable for hazelnut sample final characteristics. Roasted hazelnuts are used in food production such as chocolate spreads, ice creams, cereal bars, cookies, etc. (Cucu et al., 2011).

Different authors studied the influence of roasting conditions on physical-chemical properties of hazelnuts. Ciemniewska-Żytkiewicz et al. (2014) showed a decrease of moisture content according to the temperature/time conditions and a change of hazelnuts' colour with a decrease of L^* and a^* values compared to raw samples. Schmitzer, Slatanar, Veberic, Stampar, and Solar (2011) and Pelvan et al. (2012) have observed a loss in phenol content of about 66.3% in roasted hazelnuts in respect to raw ones, due to the removal of the skin which contains the majority of phenols. Some authors investigated also the trend of tocopherols during roasting: Schlörmann et al. (2015) showed a decrease of α and β-tocopherols after roasting treatment of about 34% and 40%, respectively, whereas Amaral et al. (2006) found only a reduction of 9% of α-tocopherol content at roasting conditions of 185 °C/15 min, as compared to raw hazelnuts. Finally, Alasalvar, Shahidi, and Cadwallader (2003) have compared the volatile compositions of raw and roasted hazelnuts (165 °C/25 min). After roasting, hazelnut volatile profile was more concentrated and rich in new other compounds, not present in the raw samples.

During roasting a lot of volatile compounds, belonging to ketones, aldehydes, pyrazines, alcohols, aromatic hydrocarbons, furans, pyrroles, terpenes and acid classes are released from hazelnuts; among these compounds, the 5-methyl-(E)-2-hepten-4-one (filbertone) has been reported as primary odorant (nutty-roasty and hazelnut-like) of roasted hazelnuts (Alasalvar, Shahidi, & Cadwallader, 2003; Langourieux, Perren, & Escher, 2000).

Studies regarding the effects of roasting on *Kataloński* hazelnut variety are limited in literature (Ciemniewska-Żytkiewicz et al., 2014; Ciemniewska-Żytkiewicz, Bryś, Sujka, & Koczoń, 2015; Ciemniewska-Żytkiewicz et al., 2015b); therefore this research was conducted in order to evaluate the influence of different roasting conditions on some physical and chemical characteristics of this Polish variety. Obtained results were compared and related to available literature data.

2. Materials and methods

2.1. Chemicals

All the solvents and reagents for phenolic compounds and lipid extraction were from Sigma Aldrich (Saint Louis, MO, USA). Folin Ciocalteu's reagent was purchased from MercK (Darmstadt, Germany) and Na_2CO_3 for the determination of total phenolic content was from BDH AnalaR® (Poole, England). All the solvents for the determination of tocopherols were supplied by VWR Prolabo Chemicals (Dublin, Ireland).

2.2. Samples

Kataloński variety hazelnuts (*Corylus avellana* L.) were obtained from an orchard located in the south of Poland (Jankowice, Pszczyna 50°0′5″N 18°59′18″E) in 2013. Hazelnuts were collected at complete maturity, sun-dried for 3 days at 20–25 °C and stored with shell at 4 °C until the analysis.

Hazelnuts were manually cracked and shelled with a nutcracker before roasting. The fibrous skin, particularly distinctive for *Kataloński* variety, was removed by hands. Before the analyses the hazelnut samples were ground with a blender (Moulinex, France).

2.3. Roasting of hazelnuts

Approximately 50 g of shelled hazelnuts were roasted in a lab-scale ventilated oven (Vismara, Italy) at different time and temperature conditions: 130 °C (Low Temperature, LT) for 40 (1), 50 (2) and 60 (3) minutes, and 160 °C (High Temperature, HT) for 20 (4), 25 (5) and 30 (6) minutes. Each roasting protocol was carried out three times.

For each roasting cycle, temperature data were recorded every 15 s during the experiment using a digital multimeter mod. SCC-TC02 (National Instruments, Assago, MI, Italy) coupled with thermocouples and a personal computer. During all roasting tests, three thermocouples were inserted inside three hazelnuts by the help of a tip needle, in order to measure the temperature profile in the kernel core during the heating process. One thermocouple was also positioned inside the oven in a central point in which the oven temperature represented the average value according to results of preliminary experiments.

2.4. Moisture and water activity determination

Water activity (a_w) was measured at 20 ± 2 °C on 3 replicates of grounded hazelnuts for each sample with a dew point hygrometer Aqualab® series 3 TE (Decagon Devices Inc., Pullman, WA., U.S.A.).

Water content (%) was evaluated on ground hazelnut samples in an oven at 105 °C until constant weight was reached. For each sample, 3 replicates of 3 g weighted were dried (AOAC, 1995).

2.5. Colorimetric analysis

The colour of chopped hazelnuts was measured with a colour spectrophotometer mod. Colorflex (Hunterlab, USA) equipped with a measuring head (diameter 127 mm). Colour was measured using the CIE L*a*b* scale and illuminant D65. The instrument was calibrated with a white tile ($L^* = 98.03$, $a^* = -0.23$, $b^* = 2.05$) and the calibration was also validated with green standard tile ($L^* = 53.14$, $a^* = -26.23$, $b^* = 12.01$) before the measurements. The hazelnut's colour was described in terms of luminosity (L^*) and red index (a^*). The results are the mean of 10 measurements for each sample.

Browning index (BI) was also calculated based on CIE L*a*b* coordinates, using the following expression (Mohapatra, Bira, Kerry, Frías, & Rodrigues, 2010):

$$BI = 100 \times \left(\frac{X - 0.31}{0.17}\right),$$

where,

$$X = \frac{(a^* + 1.75L)}{(5.645L + a^* - 3.012b^*)},$$

2.6. Extraction of phenolic compounds

To collect the phenolic fractions, the extraction protocol of Ciemniewska-Żytkiewicz et al. (2015b) was used. Approximately 3 g of ground hazelnut kernels were defatted by *n*-hexane and then extracted in an ultrasonic bath using 30 mL of ethanol/water solution (4/1 v/v) at 40 °C for 15 min. After centrifugation at 3500 rpm for 15 min, the supernatant was collected and the residue was re-extracted under the same conditions. Supernatants were pooled,