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Effect of Processing Temperature on Storage Quality of In-Shell Hazelnut

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HIGHLIGHTS

- Drying temperature had significant effect on drying time, acidity, and peroxide values of hazelnuts.
- The lowest acidity and peroxide values were recorded for the samples dried at 60 °C with the values of 0.15% oleic acid and 1.3 meq/kg, respectively.
- Sensory results showed that all of the treated hazelnuts were acceptable after six months storage.
- In-shell hazelnuts drying at temperature of 60 °C can lead to production of good quality products.

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ABSTRACT

Background: Drying is the one of the oldest methods for increasing the shelf life of food products. The objective of the present study was evaluation of effect of different drying temperatures on drying time and storage quality parameters of in-shell hazelnut.
Methods: Hazelnuts were dried as a thin layer at three temperatures (40, 50, and 60 °C). The time required for drying and quality parameters (lipid and protein content, acidity, and peroxide value) were evaluated. Besides, sensory and oxidation evaluations were performed in order to evaluate the effect of the drying temperatures on quality of hazelnuts before and after 6-month storage. Data were analyzed by SPSS software (V. 16.0).
Results: The mean drying times at 40, 50, and 60 °C were 29.75, 25, and 20.25 h, respectively. In fact, an inverse significant ($p<0.05$) relationship was observed between temperature and time of the hazelnuts drying process. The mean protein content of the hazelnuts dried at 40, 50, and 60 °C were 13.06, 12.83, and 13.62 (% dry basis), respectively. Lipid content of the samples were significantly ($p<0.05$) increased with drying temperature. The lowest acidity and peroxide values were recorded for the samples dried at 60 °C with the values of 0.15% oleic acid and 1.3 meq/kg, respectively. Sensory results showed that all of the treated hazelnuts were acceptable after six months storage.
Conclusion: The evidences of the present study point that in-shell hazelnuts drying at temperature of 60 °C can lead to production of good quality products.

Introduction

For a long time hazelnut (*Corylus avellana* L., Betulaceae family) grows wildly and naturally in the most parts of the northern hemisphere, from Western Asia to Europe (Costa et al., 2012; Esposito et al., 2017).

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Hazelnut contains a wide range of nutritional and phytochemical compounds, such as specific fatty acids, proteins, carbohydrates, vitamins, minerals, dietary fibers, and phenolic compounds; that the latter posse substantial antioxidant and antiradical effects (Alasalvar et al., 2006; Seyhan et al., 2007).

Drying is the one of the oldest methods for increasing the shelf life of food products. The basic objective of drying of agricultural foods is removal of water in the solid up to a certain level at which microbial and chemical deteriorative reactions are greatly minimized (Ojediran and Raji, 2010). Moisture content of hazelnut during harvest time ranges between 25 to 35% on a dry basis (based on the condition of regions), and it should be 5% on a dry basis for improving its quality and shelf life (Lopez et al., 1997). The disadvantages of the traditional open air-sun drying system, including slow speed of the process, higher risk of environmental contamination, and lower quality of final products, urged industries to develop more efficient drying systems (Ojediran and Raji, 2010). Among the various drying systems, thin layer drying is an efficient drying technique.

Quality of dry hazelnuts depends on its chemical and sensorial characteristics which drying process has significant impact on them. The formation of various tastes and colors during the drying process decreases the shelf life of the dried products (Heldman et al., 2019). Lipid oxidation is the most important factor limiting shelf life of the dried products. It most often occurs to unsaturated fatty acids which their oxidation is self-catalytic and the speed of the reaction increases with time. Among nuts, hazelnuts has high percentage of oil (about 60% of kernel weight) that unsaturated fatty acids form most of it (Hosseinpour et al., 2013). Consequently, hazelnuts are intrinsically sensitive to oxidative spoilage.

The quality of the final product depends on the time, temperature, and speed of drying air. With the lower temperatures, the material will have better stability during storage, but the drying process will take a longer time (Heldman et al., 2019). Therefore, set an ideal drying condition to prevent damages to hazelnut is very essential. Several published works evaluated the effects of different drying variables on some important characteristics of various nuts (Gazor and Minaei, 2005; Kashaninejad et al., 2007; Kosoko et al., 2009; Ojediran and Raji, 2010). They mentioned that increasing the drying temperature resulted in lower drying time and had different effects on taste, lipid and protein content, acidity, and oxidation progress of the tested nuts.

The objective of the present study was evaluation of the effect of different drying temperatures (40, 50, and 60 °C) on drying time and some important quality parameters of in-shell hazelnut. Besides, sensory and oxidation assessment were performed in order to evaluate the effect of the drying temperatures on quality of the nuts before and after 6-month storage.

Materials and methods

Samples preparation

Gerd cultivar hazelnut (dominant type in Guilan Province, Northern Iran) collected from gardens in Ashgurat area. Only uniform size (10-12 mm), unharmed, and pest-free nuts were used in this study. The initial moisture content of tested in-shell samples was 4-5% on a dry basis, which measured by gravimetric method after a drying at 105 °C for 6 h in oven. For each test sample, 1.5 kg of hazelnuts was considered.

Experiments

Hazelnut samples were dried by a laboratory scale dryer unit. This dryer had three units that work simultaneously (Figure 1). Drying tests were carried out at 40, 50, and 60 °C drying air temperatures and 1 m/s drying air velocity.

In the dryer used in the study, inlet air temperature, weight, and outlet air temperature changes were entered automatically from the dyer to main computer by automated data collection system in 30 min intervals. Drying lasted until the reading weights stabilized (equal weights in three consecutive reading). After drying of the hazelnuts, samples were poured into polyethylene plastic bags. In order to prevent moisture exchange with the surroundings environments, the bags were pinned with a special sewing machine. The final moisture was measured by an oven as mentioned above. A part of the samples was transferred into a traditional warehouse of Guilan province (similar to other common traditional warehouses) for a period of 6 months at 15-18 °C and 75-80% of relative humidity.

Moisture content

To determine the moisture content of the hazelnuts samples, equation 1 was carried out according to Gazor and Minaei (2005) as indicated below:

(1)

$$\mathrm{M.c} = \frac{\mathrm{W1} - \mathrm{W2}}{\mathrm{W2}}$$

where
W1=weight of sample at any moment of experiment (g)
W2=final weight of sample (g)
M.c=moisture content of sample at any moment of experiment (% d.b.)

Quality parameters

Total lipid and protein content of the samples were measured using the Soxhlet petroleum-ether extraction technique and the Kjeldahl method, respectively (AOAC, 1990). Peroxide Value (PV) measured by iodometric titration method and expressed as milliequivalent/kg of oil, and titratable acidity (percentage of oleic acid) were determined on each hazelnut samples in accordance with Commission Regulation (1991). All mentioned parameters were measured in triplicate before 6-month storage.

Sensory evaluation

Sensory attributes of the hazelnuts, including shell appearance, firmness, sweetness, rancidity, roasted flavor, and overall acceptability were evaluated using a 9-points hedonic scale by a group of 30 trained panelists (Savage et al., 2005). Three 1-h training sessions were held in order to train the panelists what they need to consider during the sensory evaluation. The hazelnut samples were put at room temperature (12 h before evaluation), and served to the panelist in white plastic plates. All of the sensory evaluations were held at a sensory laboratory and they were replicated three times. Between each test tap water was provided for palate cleansing.

Statistical analyses

The data were analyzed by analysis of variance (ANOVA) using SPSS software (V. 16.0 for Windows, SPSS Inc., Chicago, Illinois). The results were expressed as mean±standard deviation, and the Duncan comparison test was used to determine differences among means. Differences were considered significant at $p<0.05$.

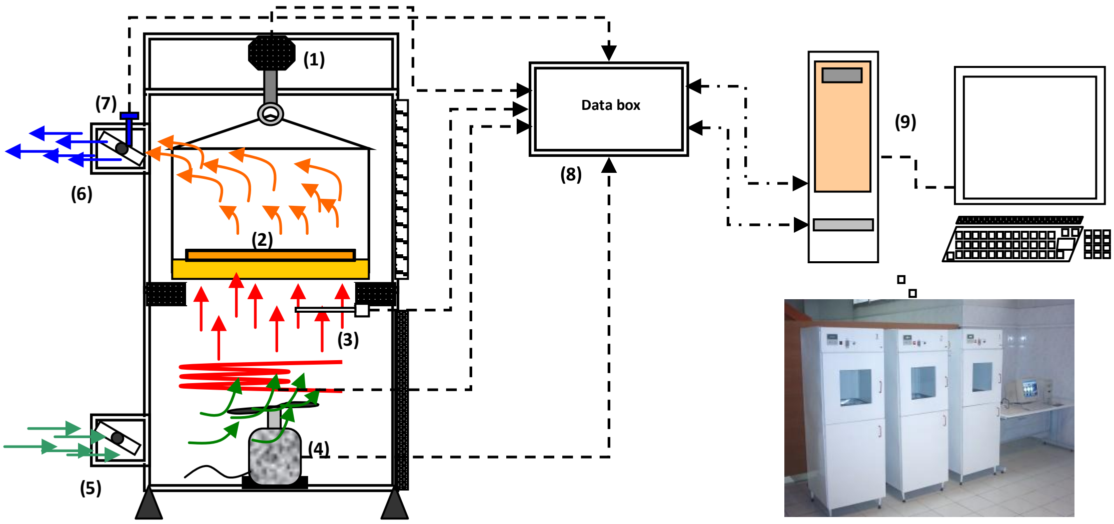

Figure 1: Schematic of the dryer used in present study
(1) load cell, (2) tray containing the sample, (3) inlet air sensor into the product, (4) DC motor, (5) inlet air valve, (6) exhaust air valve, (7) exhaust air temperature sensor, (8) information card and controller, (9) computer

Results

The mean drying times at 40, 50, and 60 °C were 29.75, 25, and 20.25 h, respectively. In fact, an inverse statistical significant ($p<0.05$) relationship was observed between temperature and time of the hazelnuts drying process.

Figure 2 shows the effect of the different temperatures on moisture content changes of the hazelnut as a function of time. The graph related to 60 °C temperature had larger slope than the others. The initial moisture content of the samples was 35% on dry basis, which after drying it reached 2, 7, and 5% (on dry basis) at 60, 40, and 50 °C temperatures, respectively. As shown in Figure 2, when the graphs for different temperatures reached to the mentioned moisture content, their slopes were almost zero.

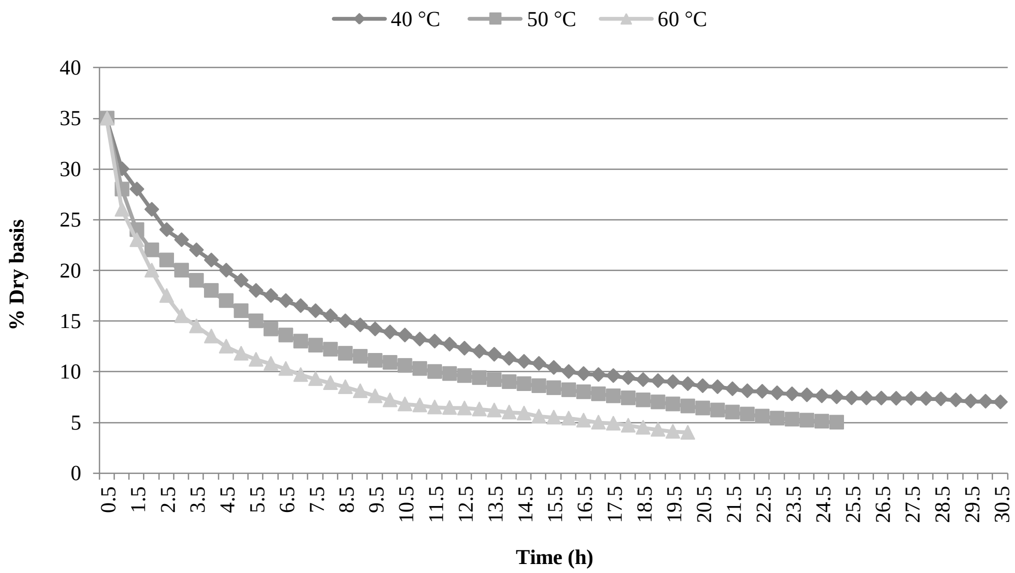

Figure 2: Moisture content reduction of hazelnuts over time at different temperatures (40, 50, and 60 °C)

The acidity and peroxide values of the hazelnuts oil and also protein content of the nuts were significantly (p<0.05) affected by the applying temperatures. On the other hand, temperature had no significant (p>0.05) effect on the oil content of the samples (Table 1). Titratable acidity in edible oils was measured according to the amount of free oleic acid. The lowest acidity was recorded for the samples dried at 60 °C with the value of 0.15% oleic acid. The average acidity of the hazelnut oil samples dried at a temperature of 50 °C was 0.28% (oleic acid), which possessed the highest value (Table 1).

The mean protein content of the hazelnuts dried at 40, 50, and 60 °C were 13.06, 12.83, and 13.62 (%dry basis), respectively, which the value of the samples dried at 60 °C was significantly (p<0.05) higher than the other treatments. Lipid content of the samples were significantly (p<0.05) increased with drying temperature, which the highest oil extracted was recorded for the samples dried at 60 °C (Table 1).

Average peroxide value of the pre-stored hazelnut oil samples dried at 60 °C, with 1.3 meq/kg value was significantly (p<0.05) lower than the hazelnuts dried at 40 to 50 °C (Table 1). As expected, peroxide values of all the samples (treated at different temperatures) increased after 6-month storage. Greater oxidation occurred in the oil of hazelnuts dried at 40 °C in comparison with the others after the storage period. Peroxide values of the samples treated at 40, 50, and 60 °C increased by 3.5, 0.82, and 2.33 meq/kg after the storage.

Table 1: Comparison of peroxide value, acidity, lipid, and protein content of hazelnut samples at different temperatures*

Quality parameters	**Drying temperature (°C)**		
	40	50	60
Acidity (% oleic acid)	0.23±0.01 ^{b}	0.28±0.02 ^{a}	0.15±0.01 ^{c}
Lipid content (% dry basis)	65.71±4.29 ^{c}	68.52±6.02 ^{b}	72.26±2.74 ^{a}
Protein content (% dry basis)	13.06±0.34 ^{b}	12.83±0.11 ^{b}	13.62±0.05 ^{a}
PV (meq/kg)			
Before storage	8.25±0.15 ^{aB}	6.85±1.65 ^{aB}	1.30±0.10 ^{bB}
After storage	11.07±0.12 ^{aA}	7.67±2.27 ^{bA}	3.63±1.33 ^{cA}

* Data are presented as mean±standard deviation.
a-c Different lowercase letters within a row indicate significant differences (p<0.05)
A-B Different uppercase letters within a column indicate significant differences (p<0.05)

The results of sensory evaluation of the hazelnut samples before and after storage are presented in Figure 3. Almost all of the sensory attribute scores dropped after storage in traditional warehouse condition. It is notable that only the samples subjected to 60 °C drying temperature more preferred after storage for some of the sensory parameters (overall acceptability, firmness, and roasted flavor). The effect of drying temperature on sensory parameters varied among the treatments. Shell appearance of the samples dried at 40 °C received the best scores before and after storage period, while the firmness of the hazelnuts samples dried at 60 °C was more acceptable.

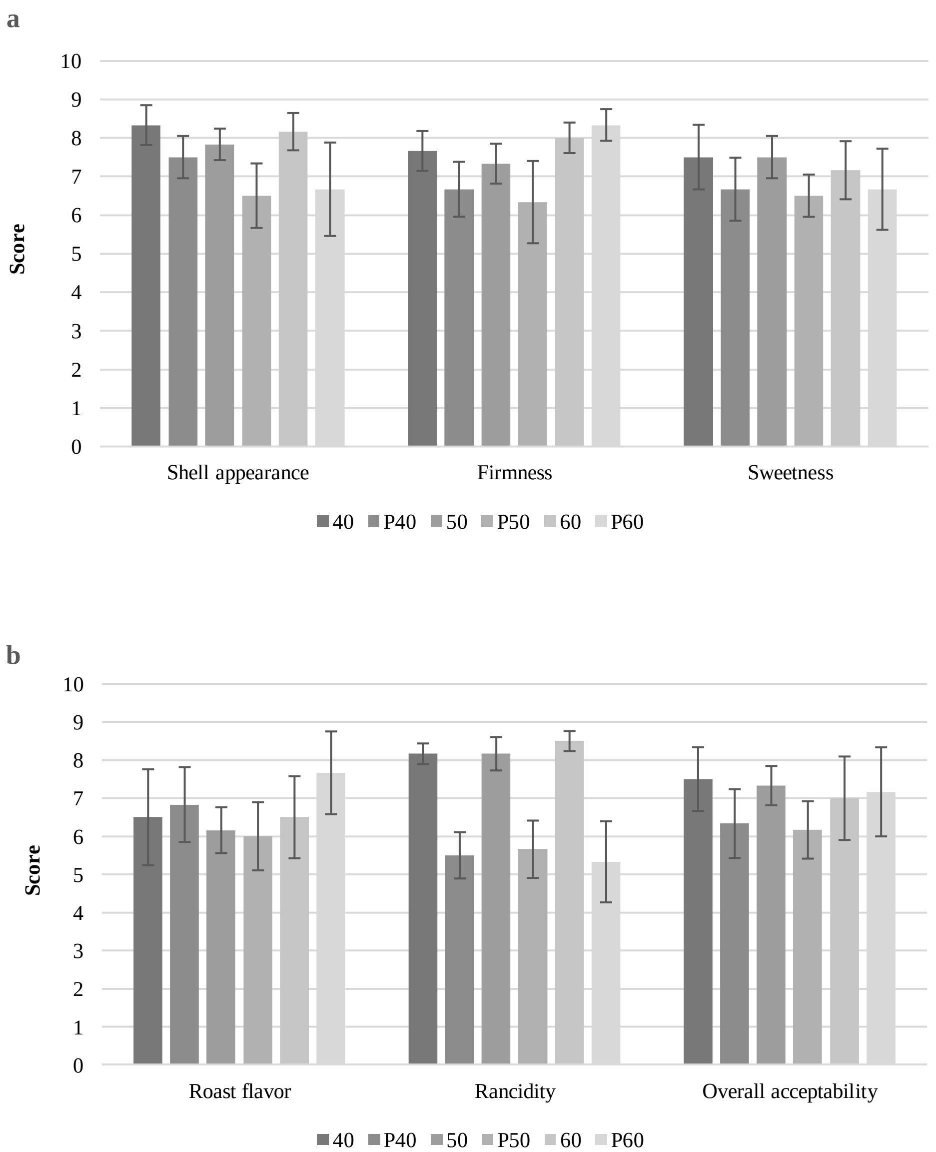

Figure 3: Effects of various drying temperatures on sensory quality attributes (a: shell appearance, firmness, and sweetness; b: roasted flavor, rancidity, and overall acceptability) of dried hazelnuts before and after 6-month storage (40, 50, and 60 indicate samples tested before storage; P40, P50 and P60 indicate samples tested after storage)

Discussion

Generally, with the increase in inlet air temperature, more thermal energy is applied into the hazelnuts mass, and consequently, it caused inter-tissue moisture evaporate more efficiently in less time. Similar to our result, significant impact of temperature on drying time reported in number of publications for hazelnut and pistachio, which it was raised as main variable affecting drying rate (Gazor and Minaei, 2005; Kashaninejad et al., 2007).

We found that higher moisture content of the hazelnuts shell along with the ease of moisture removal of these parts caused slopes of the graphs for all of the three temperature were great in initial steps of drying process. After early steps in drying process, moisture removed from the inner parts of kernel, which as the inner tissues had low moisture content and also because of the difficulty in removing water from these parts, the slope of the graphs in these stages were smaller for all of the three tested temperatures. Similar to the present work, Gazor and Minaei (2005) stated that different drying temperature could not significantly affect oil content of pistachio. It seems that dryer temperature is not an important variable in determining the oil content of various nuts.

According to the Iranian National Standards Organization (2010), maximum acceptable acidity for edible oils is 2% (oleic acid), which in this study the acidity values of the hazelnuts were less than the mentioned acceptable number and those values could not be problematic in hazelnuts processing. Acidity of hazelnuts oil is a factor reflects progress of triglyceride hydrolysis in the oil. Lopez et al. (1997) reported that with increasing in dryer air temperature percentage of acidity of shelled Pauetet cultivar was stable, while the acidity of the shelled Negret cultivar rose with temperatures of over 50 °C. These researchers stated that cultivar type has significant impact on the oil acidity at different temperatures during drying process. Furthermore, Ghirardello et al. (2013) mentioned that storage temperature was another effective parameter determining the acidity of hazelnuts. Also, the protein content of hazelnuts can be affected by cultivar and size of the nuts (Oliveira et al., 2008; Pershern et al., 1995).

The increase of lipid content of the samples with drying temperature has been reported previously for cashew nut by Kosoko et al. (2009) at drying temperature ranged between 50-70 °C. They revealed that removal of more bound water from the nuts at higher drying temperatures probably resulted in higher oil extraction of the products.

Peroxide value is well recognized as primary oxidation indicator which displays the amount of hydroperoxides in the product (Ciemniewska-Żytkiewicz et al., 2015). Production of off-flavors and odors along with nutritional losses arising from the actions of hydroperoxides are among the most important shortcomings of lipid oxidation in different food products. Considering the peroxide value of 15 meq/kg of oil as upper acceptable level of peroxide value for hazelnut oils (Codex Alimentarius, 2015), the results of PV remained low for all treatments applied in this research. Our oxidation evaluation results are well comparable to that of previous study done by Gazor and Minaei (2005) who reported higher peroxide values for the pistachios dried at higher temperatures. Moreover, increase of peroxide value during storage of nuts in different conditions was previously demonstrated by Ghirardello et al. (2013).

Appearance of shell nuts is a determining factor in pricing of them for export. The sensory results revealed that all of the dried samples stored for 6 months in traditional condition were extensively rancid in compare with the pre-stored hazelnuts. The sensory results are in agreement with our findings of oxidation evaluation, which peroxide values increased after the storage period. Considering the score 5 as threshold of sensory acceptability, all of the hazelnuts were acceptable after 6-month storage. Sena-Moreno et al. (2015) evaluated the effect of drying temperature of pistachio nuts on the sensory properties of their oils. They stated that the pistachio oils which faced to a higher drying temperature received the highest acceptability scores. In another study Ghirardello et al. (2013) reported that sensory differences emerged after 12 months storage among the hazelnut samples refrigerated and stored at ambient temperature.

Conclusion

The evidences of the present study point that in-shell hazelnuts drying at temperature of 60 °C can lead to production of good quality products.

Author contributions

Z.Y. and G.J.M. did the design of study and experiments; M.R.R. analyzed the data and wrote the manuscript. All authors read and approved the manuscript.

Conflicts of interest

There was no conflict of interest in the study.

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