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Physical and Sensory Changes in Pistachio Nuts as Affected by Roasting Temperature and Storage

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Abstract: The effect of roasting temperature and storage period on the moisture, texture and sensory attributes of pistachio nuts were investigated. Pistachio nuts were salted and roasted with conventional method at 90, 120 and 150°C for 30 min. The changes of moisture, textural properties including hardness, fracture force and firmness as a sensory attribute of salted roasted pistachio nuts were determined during 3 months of storage. In order to analyze results, Pearson correlation method, response surface methodology (RSM) and least mean square regression were used. The textural properties were correlated with sensory attributes, RSM was used to predict the effects of roasting temperature and storage on textural properties and the first-order model was used to describe textural changes at different roasting temperatures during storage period. Firmness as well as hardness and fracture force increased with the storage time. Furthermore, during the storage period, the moisture content of roasted pistachio nuts increased. Using high roasting temperature led to less firmness, moisture content, hardness and fracture force were significantly decreased. The results indicated that the correlation between instrumental and sensory properties was highly significant.

Key words: Pistachio nuts · Roasting · Storage · Moisture content · Textural and sensory attributes

INTRODUCTION

Pistachio nuts are the most important agricultural products which cultivated in Iran. Roasting is one of the common form of pistachio nuts processing. This processing lead to physical, chemical, textural and sensory changes in products [1-3].Purpose of roasting is to increase overall palatability of the products. Roasting alters and significantly enhances the flavor, color, texture and appearance of nuts. During the roasting, nuts become more crumble and brittle, which are typical characteristics of the roasted products. With textural measurements that performed on instruments, assessment of the textural changes of foods might be made more quickly, cheaply and sensitively and, since the mechanical parameters can be referred to specific aspects of the shape, chemistry, water content, etc. of the food item, quality control would become more of an objective science and so rendered much easily [4]. Hardness and fracture force are widely used in nuts as texture attributes. Brittle texture of roasted nuts makes them delicious and full of pleasure for substantial eating. The effects of roasting on textural properties of different products have been determined by other researches; hazelnut [5-7], coffee [2] sesame seeds [8], cashewnuts [9] and many others.

Drying is one of the processes occurring during roasting operation and was related with textural changes during roasting [3, 6, 7]. In spite of low initial moisture content of the nuts, which is generally in the range of 5-9%, moisture loss occurs during roasting due to high roasting temperature (>100°C). Kahyaoglu [10] showed that the changes in moisture content during roasting of pistachio nuts. Furthermore Kahyaoglu and Kaya [8] studied the effects of conventional roasting on moisture content of sesame seeds. Moisture changes during roasting have been investigated for split chickpea [11]. The objective of this study is determining the effect of roasting temperature on moisture content and textural properties (instrumental) of pistachio nuts. In addition, sensory attributes of product firmness were analyzed. To predict the textural changes of roasted pistachio nuts during storage, modeling of these changes was performed.

MATERIALS AND METHODS

Sample Preparation: Dried O'hadi (or Fandoghi) pistachio nuts were obtained from Karevan Tandis Toos Company, Khorasan province in Iran. The pistachio nuts were kept in refrigerator (4°C) until processing. To

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roasting the samples, they were taken out from refrigerator and processed as follows:

a) Salting: Five hundred grams pistachio nuts were soaked in 15% NaCl (99.98% pure) in water (w/v) for 5 hr [12].
b) Drying: The salted nuts were dried in an electrical oven (LP-402) at 80±1°C for 3 hr (until 4% moisture).
c) Roasting: Dried samples divided into three parts. Each part was roasted separately at 90, 120 and 150°C respectively. Thin layer roasting was performed in an electrical oven (LP-402) for 30 min.
d) Cooling: Roasted samples were cooled to room temperature and the experiments sampling from each part was done immediately.

Storage Condition and Sampling: Roasted samples were stored in the laboratory at room temperature (25±2°C) for three months. The experiments were performed on samples immediately after roasting and every month of storage.

Moisture Determination: Moisture content of roasted pistachio nuts was determined using oven method at 103±2°C until a constant weight was reached [13].

Texture Measurements: The textural analysis of the pistachio nuts were performed using an OTS-25 Texture Analyzer. Pistachio nuts were placed individually on the plate and compression test was applied using cylinder probe (diameter: 20 mm). The samples were compressed at a constant deformation speed of 50 mm min^{-1}. The deformation was selected as 4 mm for samples. Five measurements were performed for each sample. Two textural parameters; fracture force (N) and hardness (N) were considered to evaluate textural properties of pistachio nuts samples.

Sensory Evaluation: Initially and after every month of storage, the roasted pistachio nuts were given to a panel of ten trained judges to evaluate firmness on a 5 point hedonic scale, with five for excellent and one for highly disliked.

Statistical Analysis and Modeling: The data were analyzed using the SigmaStat software, version 1.0. Means was also calculated. Analysis of variance (ANOVA) was used to detect significant differences sampling month in sensory attributes and textural analysis, using Duncan tests to find significant differences (α=0.05) between means. Pearson coefficient was used to calculate correlation between dependent variables from textural and sensory analyses. RSM (Response Surface Methodology) was used to model the response variables with respect to independent parameters (roasting temperature and storage time). The first-order model was used to describe textural changes at different roasting temperatures and during storage period.

RESULTS AND DISCUSSION

Moisture Content: Figure 1 shows the effects of roasting temperature and storage time on moisture content of pistachio nuts. At the end of the drying stage the moisture of the pistachio nuts reached about 4%. As shown in Fig. 1, by increasing the roasting temperature from 90 to 150°C the moisture content decreased significantly ($P<0.05$) from 2.02 to 1.47%. The suitable moisture content for roasted pistachio nuts is about 3%, so the moisture of the samples for all roasting temperature was acceptable. Significant decrease of the moisture content as influenced by applying higher temperature during roasting has been reported by Kahyaoglu and Kaya [8] and Bhattacharya and Prakash [11] for sesame seeds and split chickpea respectively.

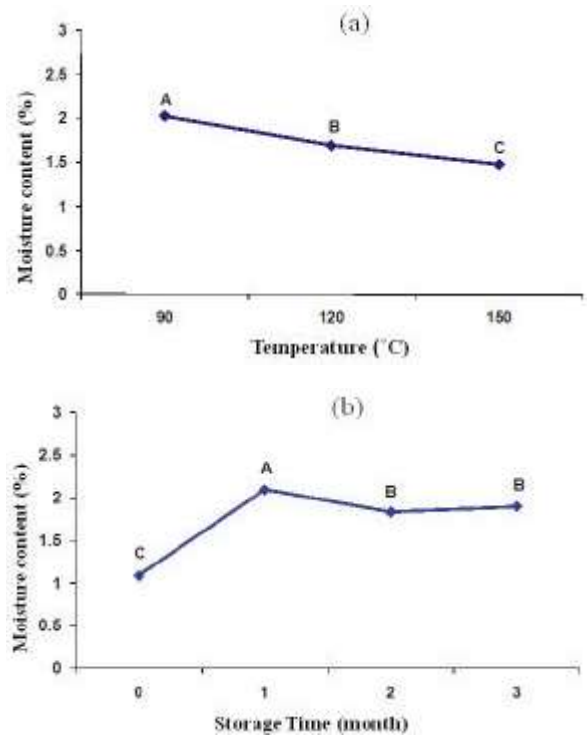

Fig. 1: The effects of roasting temperature (a) and storage time (b) on moisture content of pistachio nuts

Table 1: Equation and coefficient of determination of first order model for the textural changes of pistachio nuts as affected by roasting temperature and storage

Independent variable (X)	Dependent variable (Y)	Linear regression equation	R^2
Temperature	Hardness	y = -16.49x + 101.2	0.978
Temperature	Fracture Force	y = -10.75x + 66.69	0.977
Storage Period	Hardness	y = 5.570x + 54.30	0.996
Storage Period	Fracture Force	y = 3.864x + 35.52	0.998

Table 2: Response surface equation of textural changes of roasted pistachio nuts during storage

Y	Equation	R^2	F	P
Hardness	$Y = 119.5 - (0.508 * X_1) + (5.90 * X_2)$	0.89	35.4	<0.0001
Fracture Force	$Y = 82.4 - (0.358 * X_1) + (3.86 * X_2)$	0.94	75.1	<0.0001

X_1= Roasting temperature, X_2= Storage period

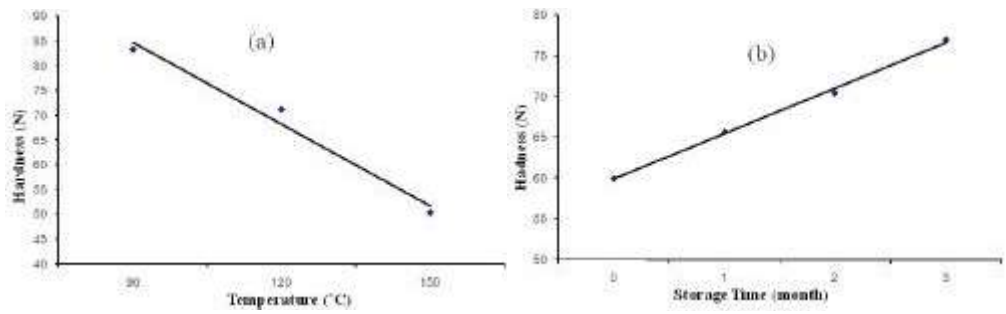

Fig. 2: The effects of roasting temperature (a) and storage time (b) on hardness of pistachio nuts

Data mean comparison showed that immediately after roasting the moisture content of the pistachio nuts was the least and it significantly increased until the first month of storage. The significant increase in the moisture content of the roasted samples during the first month of storage could be attributed to the low moisture content of them immediately after roasting, storing at room temperature without packaging and consequently faster moisture absorption. After one month of storage until third month moisture content of roasted pistachio nuts equilibrated to room moisture and indicated trivial decrease.

Hardness: The effects of different roasting temperatures on hardness was significant (P<0.05). The hardness of samples which were roasted at 90-150°C changed from 76.73 to 51.36 (N). Figure 2 shows the effects of roasting temperature and storage on hardness of pistachio nuts. There was a reverse relation between roasting temperature and hardness, so by increasing the temperature from 90 to 150°C, the hardness decreased. In Table 1, regression equations were given to describe changes of hardness at different roasting temperatures and during storage period via first order model .The higher and lower hardness obtained for samples roasted at 90°C and 150°C respectively. Decreasing the hardness due to use of higher temperature during roasting has been shown by Kahyaoglu and Kaya [8] for sesame seeds.

The effects of storage on hardness was also significant (P<0.05). As shown in Fig. 2, hardness significantly increased during storage. Data mean comparison showed that immediately after roasting hardness of pistachio nuts was the least and it was the most after storage for three months. The hardness changes of roasted samples during storage may be due to increase the moisture content of the pistachio nuts during three months for storage. Furthermore, during storage lipid oxidation increases, so degradation products formed through oxidation as well as peroxides and lipid free radicals can react with vitamins, amino acids and proteins witch impairs flavor besides staling (e.g., reaction of lysine and Threonine with the oxidized linoleic acid) and toughening [14-16].

Analysis of variance (ANOVA) indicated that the effect of roasting temperature and storage on hardness was completely significant at P<0.05. According to data mean comparison and as given in Fig. 3, the most hardness was obtained while using temperature of 90°C and at third month of storage. From Table 2 it can be seen that a response surface analysis can predict the changes

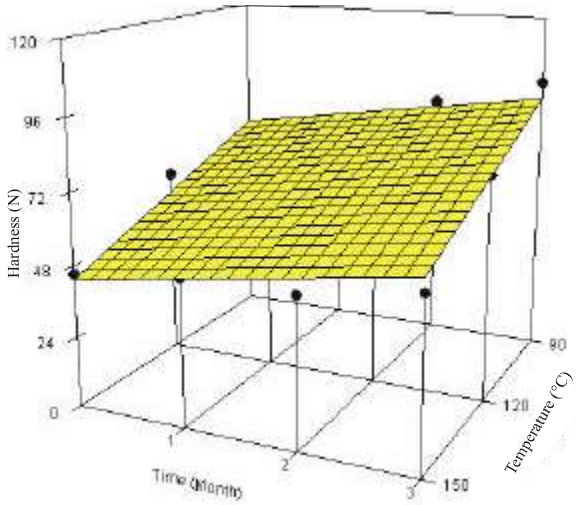

Fig. 3: Response surface of hardness of roasted pistachio nuts during storage

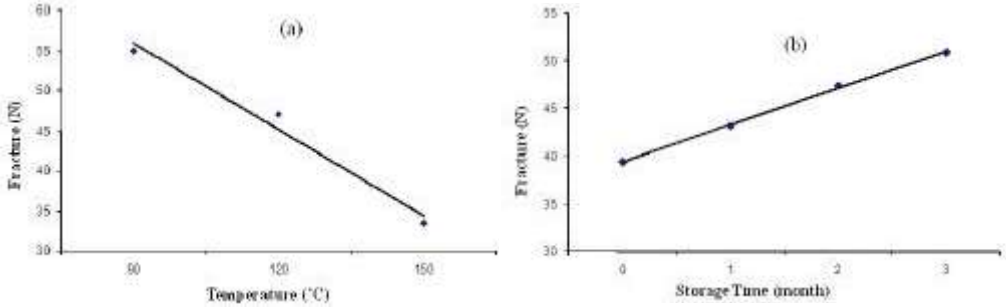

Fig. 4: The effects of roasting temperature (a) and storage time (b) on fracture force of pistachio nuts

in hardness of pistachio nuts for different conditions (roasting temperature and storage).

Fracture Force: Analysis of variance (ANOVA) indicated that the effect of roasting temperature and storage on fracture force was significant ($P<0.05$). The Fracture Force of samples which were roasted at 90-150°C changed from 58.3 to 34.24 (N). Figure 4 shows the effects of roasting temperature and storage on fracture force of pistachio nuts. As it mentioned about hardness, increasing the temperature from 90 to 150°C led to decrease the Fracture Force. In Table 1, regression equations were given to describe changes of fracture force in different roasting temperatures and during storage period via first order model. During the roasting, nuts become more crumble and brittle, which are typical characteristics of the roasted products [4]. Kahyaoglu and Kaya [8] reported that during the conventional roasting of sesame seeds, fracture force decreased. Moreover, they indicated that applying higher temperature for roasting caused lower fracture force. Saklar *et al.* [7] also observed the decreasing in the first fracture point during roasting of hazelnuts. Pittia *et al.* [2] calculated that roasting process influence the textural properties of coffee beans and high temperature roasting caused fragile and brittle texture. Dogan and Cronin [5] reported that both roasting temperature and time had significant effects on the texture changes in hazelnuts and by increasing the temperature and time, fracture stress (MPa) reduced.

According to analysis of variance (ANOVA), the effect of roasting temperature and storage on fracture force was completely significant at $P<0.05$. Data mean comparison indicated that the most fracture force was obtained while using 90°C and at third month of storage. As shown in Fig. 3, by increasing the roasting temperature fracture force decreased and increasing the time of storage led to increase the fracture force. From Table 2 it can be seen that a response surface analysis can predict the changes in fracture force of pistachio nuts for different conditions (roasting temperature and storage).

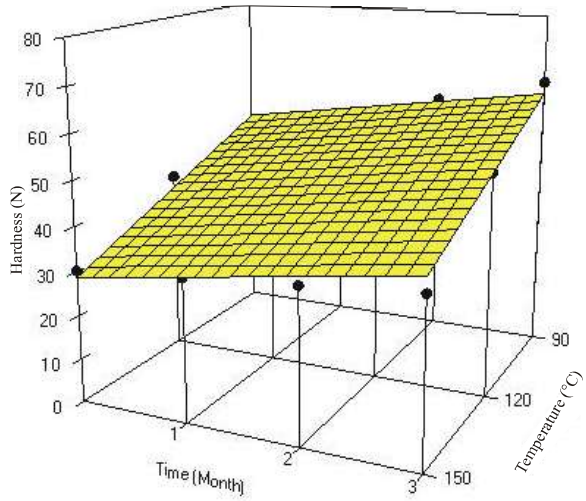

Fig. 5: Response surface of fracture force of roasted pistachio nuts during storage

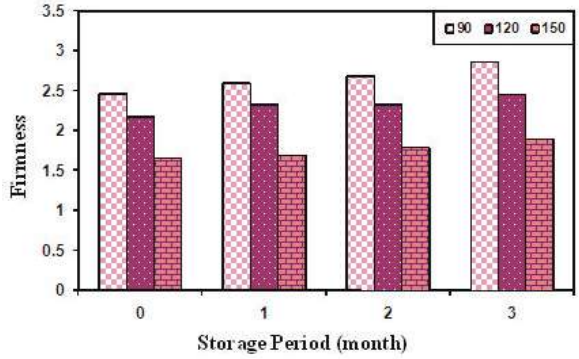

Fig. 6: Effect of roasting temperature and storage on pistachio nuts firmness

Table 3: Correlation coefficient among the hardness, fracture force and firmness of roasted pistachio nuts

Variable 1 (X_1)	Variable 2 (X_2)	r (correlation coefficient)	P value
Firmness	Hardness	0.996	0.004
Firmness	Fracture Force	0.984	0.016

Firmness: Analysis of variance (ANOVA) showed that the effect of roasting temperature and storage on firmness is significant ($P<0.05$). The panel scores which are given for this sensory parameter changed from 1.66-2.85. The significant decrease of firmness while using high roasting temperature was shown in Fig. 6.

The least firmness attribute in roasted pistachio nuts was observed immediately after processing. But, during the storage it increased until the third month of storage.

Correlation: Correlation between dependent variables from textural and sensory analyses is presented in Table 3. Positive and powerful correlations of 0.996 and 0.984 were observed between firmness and hardness and between firmness and fracture force, respectively.

CONCLUSION

The results of this study showed that the effect of both roasting temperature and storage period were significant on moisture content, textural changes and sensory attributes of pistachio nuts. Effects of roasting temperature and storage on textural properties satisfactorily ($R^2>0.8$) predicted by applying Response Surface Methodology (RSM). Moreover, textural changes in roasted pistachio nuts at different roasting temperatures or during storage period were appropriate in first order model ($R^2>0.9$). Hardness and fracture force as well as firmness increased across the storage time for all roasted pistachio nuts. Furthermore, during the storage, the moisture content of roasted pistachio nuts increased. By increasing the roasting temperature, moisture content, hardness and fracture force were significantly decreased. Using high roasting temperature led to less firmness. The results also indicated that the correlation between instrumental and sensory properties was highly significant ($r>0.9$).

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