

## Effect of Different Salting and Roasting Methods in Oven and Fluidized bed Roaster on the Quality and Shelf life of Pistachio Nuts

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Information	Abstract
<p><b>Article Type:</b> Original Article</p>	<p><b>Introduction:</b> Roasting process improve the taste, colour, texture, and overall acceptability of the tree nuts.</p> <p><b>Materials and Methods:</b> In this study, raw pistachio were placed in a solution containing 10, 15, 20 and 25% salt for 15 min to select suitable conditions of salting and roasting. Then pistachio roasted in oven and fluidized bed roaster for 10-25 min (130-190°C). Sensory evaluation was carried out in terms of frangibility, salt percent, oil rancidity, flavor, color of shell, splitting of shell and overall acceptability. Salted and roasted pistachio samples stored at 25°C for one year. Peroxide value, acid value, amount of salt and moisture content was measured each two months during storage period.</p> <p><b>Results:</b> The pistachio salted in 10% salt solution and roasted in fluidized bed roaster at 130°C (30 min), 190°C (10 min) and 190°C (30 min) obtained highest score respectively. Quality test results showed that salted and roasted pistachios maintain its quality up to 10 months.</p> <p><b>Conclusion:</b> The best condition for salting and roasting of pistachio was salting in 10% salt solution and roasting at 130°C for 30 min in fluidized bed roaster.</p>
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## 1. Introduction

Pistachio is one of the most delicious and nutritious nuts. Splitted pistachios both roasted and salty, or even unsalted are consumed as snacks. Non- splitted Pistachio is also used in the production of oil, butter, chocolate and halva. Pistachio is also an additive used in the sausage, confectionery and sauces industry [1]. Roasting is a process step used in the tree nuts industry to improve the taste, colour, texture, and overall acceptability of the product [2- 4]. In general, the purpose of roasting is to increase the desire for food and produce foodstuffs with different flavors, aromas and textures. It also destroys enzymes and microbes, resulting in preserving food [5]. Changes in food texture depend on the type of food, moisture, the relative composition of fats, proteins, and structural carbohydrates (cellulose, starch, and pectin), and the roasting temperature and its duration. Many aromatic compounds are produced during roasting which have been elaborated [6, 7]. According to Kader et al. (1980), extreme heating conditions cause Millard reactions between glucose and amino acids in food [8].

If the temperature rises during drying (116 to 138°C), the over-roasting can occur. Many studies have been done in this area. For example, the effect of different heating methods on fat quality, sensory evaluation and percentage of pistachio splitting showed that different methods of pistachio drying had no significant effect on free fatty acids and peroxide value but their impact on pistachio appearance and splitting percentage is significant [9]. Reducing moisture content of pistachio nuts during the roasting process to

4% improves the sensory properties compared with higher moisture content (6-11%)[10]. Shakerardekani et al. (2011) reported that hardness and colour attributes ('L' and 'b' values, yellowness index) of kernels could be used to monitor the roasting quality of whole-kernels [11]. Oxidation of fats occurs at low amounts of water activity due to the free radicals. Above this amount of monolayer water, the antioxidants and the constituents of the complex with metals dissolve and reduce the rate of oxidation. Most enzymes are ineffective in water activity less than 0.85. But lipase can be active up to 0.3 or even 0.1 water activity. This range has a protective effect on the oil's oxidation [12].

According to Maskan and Karatas (1997), the lowest rate of lipid oxidation and hydrolysis reactions occurs in pistachio nuts when its water content is reduced to a monolayer. Under this situation, it can be concluded that salted pistachio is stable under all storage conditions [13]. Lipid oxidation may be controlled by minimizing changes of nut microstructure. Non-enzymatic browning also forms antioxidants [14].

Generally, two methods including dry roasting and roasting in oil are used for roasting kernels. In the dry roasting method, the heating is produced using warm air or microwave radiation, and in the second method the kernels are immersed in boiling oil and then the extra oil is removed. In the first method, nuts such as hazelnuts are exposed to hot air for 5 to 60 minutes at temperatures between 100 and 180°C [15, 16]. As the temperature increases, the nut's moisture decreases, for example, when the nut's internal temperature increase from 121 to 148°C,

the nut's moisture content decrease to about one percent. In addition to reducing the moisture content, the aromatic and volatile compounds are produced in nuts. These compounds impart a good taste [15].

The development of roasting odor depends both on the roasting temperature and time, as well as on the type of tree nuts and roasting method. The appropriate temperature and timing of macadamia roasting for consumption as a snack is 135°C for 20 minutes which has been reported [17]. Texture properties of whole grains are also affected by roasting conditions. During roasting, the moisture content of most tree nuts decreases [18] and the texture becomes brittle, in other words, their hardness softens [19]. In respect to texture changes during roasting, many researchers have considered hardness as a qualitative indicator in products such as pistachios [20, 21]. During roasting, the reactions of caramelization and browning occur, resulting in the formation of brown pigments [22]. The effect of roasting conditions on color changes by several researchers in their studies on peanuts [23], hazelnuts [24, 25], sesame [26] and Macadamia [27] have been reported. Other studies in the field of pistachios have focused on the effect of roasting conditions on nutrients [28, 29] and its stability during storage [20, 21]. In this study, in order to achieve the optimum conditions for salting and roasting of pistachio, the effect of salt on salting and also the effect of two types of hot air roasters (oven and roasting with fluidized bed) and temperature and roasting time on quality, shelf life and nutritional value of pistachio were evaluated.

## 2. Materials and Methods

In this study, pistachio samples of Ohadi, Ahmad Aghaei, Kalleh Ghoochi and Akbari were selected. Initially, protein content, sugar content and fat content were measured by Kjeldahl method, Fehling method and Soxhlet method using Wrolstad et al. (2001) method in three replications, respectively [30]. The pistachios immersed in a solution containing 0.5% citric acid and 10 and 25% Sodium Chloride (independent variable), for 10 minutes. At this stage, moisture content and salt absorbed by the pistachios were measured. Salted pistachios were then placed at ambient temperature for several hours to remove their apparent moisture content. Roasting of pistachios was carried out at 130 to 190°C (10 to 25 minutes) in two ovens (Memmert model, Germany) and fluidized bed roaster (RFB-S model, Germany). The first part of the experiment was a factorial experiment with four factors including type of device, salt concentration, roasting time and roasting temperature for each cultivar separately and in 3 replications. Sensory evaluation on 7 traits of frangibility, salinity, fat rancidity, roasting rate, shell colour, splitting rate (ratio of number of splitting pistachios to total number of pistachios per 100 g) and overall acceptability by 32 panelists (not good at all: 1, Not good: 2, not good or bad: 3, good: 4, very good: 5). panelists were given three pistachios each time and this experiment was repeated three times. Samples were randomly numbered [31]. The means were compared using Tukey's test. Salted and roasted pistachios were selected from the sensory evaluation stage for one year at ambient temperature (25°C). at the beginning and at

intervals of two months, peroxide number, acid number, salt content and moisture content were measured. Protein, sugar and fat levels were also measured in the best treatments to determine the effect of saline and roasting of pistachio on its nutritional value. The second part of the research was completely randomized with treatments selected from the first stage and analyzed in 3 replications. Finally, suitable conditions were suggested for roasting and roasting of pistachios.

### 3. Results

The percentage of measured salts in pistachio nuts immersed in brine solution containing 10 and 25% salts were 0.9 and 3.1 respectively. The final moisture content of pistachios in these solutions was 10.1 and 8.8%, respectively. The results for different pistachio cultivars are shown in Table 1. The amount of moisture in different pistachio cultivars was not significant. Sugar content in Kale Ghoochi and Ahmad Aghaei cultivars was not significantly different. Other pistachio cultivars had significant differences in protein, sugar and fat.

**Table 1-** Protein, Sugar, Fat and Moisture Content of Akbari, Kalle Ghoochi, Ohadi and Ahmad Aghaei Cultivars

Cultivar	Protein	Carbohydrate	Fat	Moisture
Akbari	22.7 ± 0.2 <sup>b</sup>	14.4 ± 0.1 <sup>b</sup>	56.5 ± 0.5 <sup>d</sup>	4.4 ± 0.4 <sup>a</sup>
Kale Ghoochi	21.3 ± 0.1 <sup>c</sup>	15.7 ± 0.1 <sup>a</sup>	56.8 ± 0.5 <sup>c</sup>	4.2 ± 0.2 <sup>a</sup>
Ohadi	23.6 ± 0.2 <sup>a</sup>	12.7 ± 0.1 <sup>c</sup>	57.4 ± 0.6 <sup>a</sup>	4.3 ± 0.2 <sup>a</sup>
Ahmad Aghaei	20.9 ± 0.1 <sup>d</sup>	15.8 ± 0.1 <sup>a</sup>	57.1 ± 0.6 <sup>b</sup>	4.3 ± 0.2 <sup>a</sup>

#### 3.1. Sensory Test

The results showed that roaster type, time and temperature have a significant effect on frangibility. Shakerardakani et al. (2011) reported similar report for roasting of pistachio kernel. Salt and temperature factors have the same effect on salinity and roasting rate, respectively. Also interaction effect of roaster type, salt and temperature on shell color was significant (P< 0.05). Interaction effect of roaster type and time have similar effect on splitting rate (P< 0.05). In terms of overall acceptability, which is a sum of sensory characteristics, salt factors, time and type of roaster have significant effect on sensory score

(P<0.05). The results of the sensory test are presented in Table 2. According to the results (Table 3), the salted pistachio formulations in 10% brine and roasted in a fluidized bed roaster at 130°C (30 min), 190°C (10 min) and 190°C, (30 minutes) have earned the most points respectively. The type of cultivar had no significant effect on the quality of salting and roasting. Hojjati et al. (2013) reported that raw pistachios had lower concentrations of most volatiles than roasted. A total of 26 compounds were detected in roasted pistachios. These compounds effect on the sensory evaluation of the roasted pistachios [32].

### 3.2. Nutritional Value of Roasted and salted Pistachio

Results of protein, sugar and fat measurement in the first treatment (10% salt, fluid bed, 10 min at 190°C) and the second one (10% salt fluid bed, 30 min at 130°C)

which have better shelf life, are listed in Table 4. According to these results, protein, sugar and fat content decreased during salting and roasting. Also, 10% salt, fluidized bed treatment (30°C at 130°C) had higher protein and fat content than 10% salt, fluidized bed treatment (190°C for 10 minutes).

**Table 2-** Mean of sensory scores for salty and roasted pistachio treatments

Treatment	Frangibility	Saltiness	Rancidity	Roasting rate	Shell Color	Splitness	Overall Acceptability
10% salt, oven, 10 min, 130°C	3.58 ± 0.2 <sup>b</sup>	3.52 ± 0.3 <sup>a</sup>	3.55 ± 0.3 <sup>a</sup>	3.76 ± 0.4 <sup>ab</sup>	3.94 ± 0.4 <sup>ab</sup>	3.91 ± 0.4 <sup>b</sup>	3.74 ± 0.3 <sup>b</sup>
10% salt, oven, 10 min, 190°C	3.56 ± 0.2 <sup>b</sup>	3.52 ± 0.3 <sup>a</sup>	3.60 ± 0.3 <sup>a</sup>	3.76 ± 0.4 <sup>ab</sup>	3.90 ± 0.4 <sup>ab</sup>	3.95 ± 0.4 <sup>b</sup>	3.75 ± 0.3 <sup>b</sup>
10% salt, oven, 30 min, 130°C	3.68 ± 0.3 <sup>ab</sup>	3.56 ± 0.3 <sup>a</sup>	3.50 ± 0.2 <sup>a</sup>	3.79 ± 0.4 <sup>a</sup>	3.94 ± 0.4 <sup>ab</sup>	4.08 ± 0.4 <sup>ab</sup>	3.68 ± 0.3 <sup>b</sup>
10% salt, oven, 30 min, 190°C	3.78 ± 0.3 <sup>ab</sup>	3.57 ± 0.3 <sup>a</sup>	3.50 ± 0.2 <sup>a</sup>	3.62 ± 0.3 <sup>b</sup>	3.74 ± 0.3 <sup>b</sup>	4.06 ± 0.4 <sup>b</sup>	3.84 ± 0.4 <sup>b</sup>
10% salt, FB, 10 min, 130°C	3.64 ± 0.3 <sup>ab</sup>	3.57 ± 0.3 <sup>a</sup>	3.52 ± 0.3 <sup>a</sup>	3.72 ± 0.4 <sup>ab</sup>	3.95 ± 0.4 <sup>ab</sup>	4.15 ± 0.4 <sup>ab</sup>	3.76 ± 0.3 <sup>b</sup>
10% salt, FB, 10 min, 190°C	3.75 ± 0.3 <sup>ab</sup>	3.57 ± 0.3 <sup>a</sup>	3.53 ± 0.3 <sup>a</sup>	3.77 ± 0.4 <sup>a</sup>	3.98 ± 0.4 <sup>ab</sup>	4.04 ± 0.4 <sup>b</sup>	3.95 ± 0.4 <sup>a</sup>
10% salt, FB, 30 min, 130°C	3.79 ± 0.3 <sup>ab</sup>	3.58 ± 0.3 <sup>a</sup>	3.62 ± 0.3 <sup>a</sup>	3.80 ± 0.4 <sup>a</sup>	4.07 ± 0.2 <sup>a</sup>	4.25 ± 0.4 <sup>a</sup>	4.05 ± 0.3 <sup>a</sup>
10% salt, FB, 30 min, 190°C	3.81 ± 0.3 <sup>a</sup>	3.58 ± 0.3 <sup>a</sup>	3.49 ± 0.2 <sup>a</sup>	3.59 ± 0.2 <sup>b</sup>	3.75 ± 0.3 <sup>b</sup>	4.25 ± 0.4 <sup>a</sup>	3.98 ± 0.4 <sup>a</sup>
25% salt, oven, 10 min, 130°C	3.60 ± 0.2 <sup>b</sup>	2.47 ± 0.2 <sup>b</sup>	3.47 ± 0.2 <sup>a</sup>	3.70 ± 0.2 <sup>ab</sup>	3.91 ± 0.4 <sup>ab</sup>	3.89 ± 0.3 <sup>b</sup>	3.54 ± 0.2 <sup>bc</sup>
25% salt, oven, 10 min, 190°C	3.65 ± 0.2 <sup>ab</sup>	2.47 ± 0.2 <sup>b</sup>	3.48 ± 0.2 <sup>a</sup>	3.76 ± 0.3 <sup>a</sup>	3.87 ± 0.4 <sup>ab</sup>	3.95 ± 0.4 <sup>b</sup>	3.48 ± 0.2 <sup>c</sup>
25% salt, oven, 30 min, 130°C	3.72 ± 0.3 <sup>ab</sup>	2.47 ± 0.2 <sup>b</sup>	3.48 ± 0.2 <sup>a</sup>	3.78 ± 0.3 <sup>a</sup>	3.90 ± 0.4 <sup>ab</sup>	3.93 ± 0.4	3.62 ± 0.2 <sup>bc</sup>
25% salt, oven, 30 min, 190°C	3.80 ± 0.3 <sup>ab</sup>	2.42 ± 0.2 <sup>b</sup>	3.51 ± 0.3 <sup>a</sup>	3.60 ± 0.3 <sup>b</sup>	3.75 ± 0.2 <sup>b</sup>	4.05 ± 0.4 <sup>b</sup>	3.57 ± 0.2 <sup>bc</sup>
25% salt, FB, 10 min, 130°C	3.70 ± 0.3 <sup>ab</sup>	2.45 ± 0.2 <sup>b</sup>	3.52 ± 0.3 <sup>a</sup>	3.71 ± 0.3 <sup>ab</sup>	3.95 ± 0.4 <sup>ab</sup>	4.16 ± 0.4 <sup>ab</sup>	3.48 ± 0.2 <sup>c</sup>
25% salt, FB, 10 min, 190°C	3.67 ± 0.2 <sup>ab</sup>	2.46 ± 0.2 <sup>b</sup>	3.50 ± 0.2 <sup>a</sup>	3.70 ± 0.3 <sup>ab</sup>	3.96 ± 0.4 <sup>ab</sup>	4.07 ± 0.4 <sup>b</sup>	3.50 ± 0.2 <sup>c</sup>
25% salt, FB, 30 min, 130°C	3.76 ± 0.3 <sup>ab</sup>	2.44 ± 0.2 <sup>b</sup>	3.49 ± 0.2 <sup>a</sup>	3.80 ± 0.4 <sup>a</sup>	3.97 ± 0.4 <sup>ab</sup>	4.07 ± 0.4 <sup>b</sup>	3.67 ± 0.2 <sup>bc</sup>
25% salt, FB, 30 min, 190°C	3.84 ± 0.3 <sup>a</sup>	2.47 ± 0.2 <sup>b</sup>	3.50 ± 0.2 <sup>a</sup>	3.60 ± 0.2 <sup>b</sup>	3.74 ± 0.2 <sup>b</sup>	4.35 ± 0.4 <sup>a</sup>	3.61 ± 0.2 <sup>bc</sup>

**Table 3-** Quality test for three treatments selected from sensory test

Treatment	Storage Month	Peroxide value (meq/kg)	Acid Value (%)	Salt (%)	Moisture (%)
10% salt, FB, 10 min, 190°C	0	0.60 ± 0.1	0.59 ± 0.1	1.12 ± 0.1	1.60 ± 0.1
	2	1.32 ± 0.1	0.71 ± 0.1	1.11 ± 0.1	1.65 ± 0.1
	4	1.91 ± 0.1	1.12 ± 0.1	1.09 ± 0.1	1.78 ± 0.1
	6	2.54 ± 0.2	1.20 ± 0.1	1.01 ± 0.1	2.05 ± 0.1
	8	3.13 ± 0.2	1.39 ± 0.1	0.96 ± 0.1	2.50 ± 0.1
	10	4.98 ± 0.3	1.58 ± 0.1	0.94 ± 0.1	3.00 ± 0.2
	12	6.74 ± 0.4	1.81 ± 0.2	0.93 ± 0.1	3.11 ± 0.2
10% salt, FB, 30 min, 130°C	0	0.55 ± 0.0	0.62 ± 0.1	0.93 ± 0.1	1.31 ± 0.1
	2	1.14 ± 0.1	0.73 ± 0.1	0.91 ± 0.1	1.43 ± 0.1
	4	1.73 ± 0.1	1.11 ± 0.1	0.88 ± 0.1	1.57 ± 0.1
	6	2.32 ± 0.1	1.17 ± 0.1	0.84 ± 0.1	1.91 ± 0.1
	8	2.98 ± 0.1	1.32 ± 0.1	0.83 ± 0.1	2.02 ± 0.1
	10	4.76 ± 0.3	1.49 ± 0.1	0.79 ± 0.1	2.61 ± 0.1
	12	5.81 ± 0.4	1.64 ± 0.1	0.75 ± 0.1	2.96 ± 0.2
10% salt, FB, 30 min, 190°C	0	0.70 ± 0.0	0.58 ± 0.1	0.90 ± 0.1	1.12 ± 0.1
	2	1.41 ± 0.0	0.65 ± 0.1	0.87 ± 0.1	1.29 ± 0.1
	4	2.05 ± 0.0	1.03 ± 0.1	0.84 ± 0.1	1.59 ± 0.1
	6	2.64 ± 0.1	1.10 ± 0.1	0.78 ± 0.1	1.98 ± 0.1
	8	3.42 ± 0.2	1.24 ± 0.1	0.73 ± 0.1	2.32 ± 0.1
	10	5.49 ± 0.4	1.37 ± 0.1	0.72 ± 0.1	2.64 ± 0.2
	12	6.83 ± 0.4	1.59 ± 0.1	0.69 ± 0.0	2.88 ± 0.2

**Table 4-** Comparison of protein, sugar and fat content (%) in salted, roasted and raw pistachios

Treatment	Protein	Carbohydrate	Fat
Raw pistachio	23.5 ± 2.1 a	12.8 ± 1.2 a	57.7 ± 4.1 a
10% salt, FB, 10 min, 190°C	22.4 ± 2.0 b	11.1 ± 1.0 c	48.7 ± 4.2 b
10% salt, FB, 30 min, 130°C	22.5 ± 2.1 b	11.5 ± 1.1 b	48.9 ± 4.3 b

#### 4. Discussion

The results of quality test including peroxide value, acid value, salt content and moisture content showed that according to the conditions mentioned in National Standard No. 15, the maximum shelf life of salted and roasted pistachios was up to 2 months in two 10% salt treatments. It was Fluidized bed, 10 minutes at 190°C and 10% Salt, Fluidized bed, 30 minutes at 130°C. The peroxide value was the most important limiting factor. This result is in agreement with the report of Maskan and Karatas [13] on the peroxide value [33]. Results of protein, sugar and fat measurement in the first treatment (10% salt, fluid bed, 10 min at 190°C) and the second one (10% salt fluid bed, 30 min at 130°C) which have better shelf life, are listed in Table 4. According to these results, protein, sugar and fat content decreased during salting and roasting. Also, 10% salt, fluidized bed treatment (30°C at 130°C) had higher protein and fat content than 10% salt, fluidized bed treatment (190°C for 10 minutes).

In general, according to the results of the first part of the design, the salted pistachio formulations, diluted in 10% brine, and roasted in a fluidized bed roast at temperatures

of 130°C (30 min), 190°C (10 min) and 190°C (30 minutes) respectively, have earned more points. According to Balasubramanian and Srinivasakannan [34], the advantages of fluidized bed application are effective surface contact, high degree of material mixing and uniformity of the final product [34]. According to Topuz, Gur and Gul [35], this method reduces roasting time.

#### 5. Conclusion

Considering the nutritional value of the formulas, it is observed that the amount of protein, sugar and fat in roasted and salted pistachio decreased due to the Millard reaction between sugars and amino acids. In respect to sensory test, quality test and nutritional value of salted pistachio in 10% saline solution and roasted in a fluidized bed roast at 130°C (30 min) was selected as the best treatment.

#### Conflict of Interest

The authors declare no conflict of interest.

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