

## The Effect of Different Non-mechanical Treatments on Splitting Pistachio Nuts

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### Abstract

One of the undesirable features in pistachio nuts (*Pistacia vera* L.) is the incidence of non-split nuts, which affects the price of the final product. In order to attain the kernel inside, the non-split nuts are mostly cracked mechanically. However, this practice may damage the kernel. Akbari variety of pistachio nut was selected to evaluate the influence of different non-mechanical treatments on splitting the nuts. Different treatments were applied by soaking the nuts in water at different temperatures (10, 100 °C) and roasting and heating by oven and microwave in different orders. The results indicated that soaking along with thermal treatment had a significant effect on the amount of splitting ( $P<0.05$ ), while no significant effect was observed in the methods in which the samples were not soaked. Furthermore, the temperature of the water applied for soaking and also thermal treatment medium led to significant differences in the final results. Additionally, the order of application of different treatments were analyzed and proved to be significantly effective ( $P<0.05$ ) on the splitting percentage of the nuts.

**Keywords:** Microwave, Non-mechanical methods, Pistachio, Splitting.

### Introduction

Pistachio nut (*Pistacia vera* L.) is one of the popular tree nuts. Several species of the genus *Pistacia* are referred to as pistachio, but only the fruits of *P. vera* attain a large enough size to be acceptable to consumers as edible nuts (Shokraii and Esen 1988).

Pistachio nut is grown mainly in Iran, USA, Syria, Turkey, Greece and Italy (Kucukoner and Yurt 2003). Based on FAO statistics (FAO 2009), with the production of 446,647 Mt pistachio nuts in 2009, Iran is the biggest producer of this commodity all around the world. Pistachio kernels are a good source of fat (50–60%) and contain unsaturated fatty acids (linoleic, linolenic and oleic acids), essential for human diet (Garcia et al. 1992; Shokraii 1977).

The pistachio shell splits as the nut matures, a desirable feature for marketing and consumption. Split means more than 3/4 of a half kernel split lengthwise (United States department of agriculture 2004). However, the hull remains intact in the majority of mature pistachios at harvest (Sommer et al. 1976). The hull protects the kernel from invasion by molds and insects as nuts that are poorly protected by hulls are most prone to contamination in the orchard.

To delay the harvest in order to have more split nuts results in excessive hull tissue breakdown, which causes shell staining and increased insect damage and Aflatoxin contamination (Doster and Michailides 1995). Zeng et al. (1999) showed that the potassium sulfate ( $K_2SO_4$ ) treated trees produced significantly higher percentages of split nuts, higher 100-nut weight, and a significant lower percentage of blank and stained nuts than in the control trees not receiving K ions. This clearly demonstrates improved nut quality due to K fertilization. The un split nuts are usually used as raw material in wafer, ice cream,

pistachio butter, pistachio oil, etc. production. The percentage of split, blank, and stained nuts and 100-nut weight are the major quality criteria used to grade pistachio nuts. It is desirable to produce a high percentage of split nuts and a high 100-nut weight, but low percentages of blank and stained nuts (Zeng et al. 1999). When pistachios arrive at the processing plant, the split nuts separation is conducted to separate split nuts from unsplit ones (Kashaninejad et al. 2003). Empty or partially empty pistachios are separated by an air stream and unsplit pistachios by floatation in water and split mechanically, which results in cracking the kernel and according to a study achieved by Ahmadi and Tajabadipour (2011) increases the risk of nuts contamination with Aflatoxin. On the other hand the unsplit nuts contain kernels of a desirable deep green color, which are of interest for confectionaries (Woodroof 1979). Therefore, opening the nuts in a way that the kernels are not cracked is quite desirable.

Microwave is an electromagnetic wave in the frequency range of 300–30,000 MHz which its fields interact with the non-magnetic materials. The conversion of microwave energy into heat in the food is because of the presence of bipolar molecules of water that rotate in the changing electromagnetic field (billion times a second), heat is generated within the food product due to friction between the water molecules. The quick absorption of energy by water molecules leads to fast evaporation of water that causes an outward flux of fast escaping vapor (Schiffmann 1992) which was hoped to favor pistachio nut splitting in this study. Kouchakzadeh and Shafeei (2010) have already applied microwave for drying pistachio nuts but its application in splitting the nuts has not been reported.

Literature review demonstrated that there is not enough work in this field except for a study by Bilim

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### Abbreviations

|           |                                   |
|-----------|-----------------------------------|
| ANOVA     | Analysis of variance              |
| FAO       | Food and Agriculture Organization |
| $K_2SO_4$ | Potassium sulfate                 |
| K         | Potassium                         |
| MHz       | Megahertz                         |
| SAS       | Statistical Analysis System       |

and Polat (2008) in which they combined the effect of temperature, moisture and mechanical force. The objective of this study was to determine the optimum of non-mechanical treatments for splitting the unsplit pistachio nuts.

## Materials and methods

### Samples

The "Akbari" variety of pistachio nuts with the moisture content of 7% was selected for the experiments. The unsplit pistachio nuts were divided into several 100 nut groups and were treated with different treatments in 3 replications.

### Treatments

In order to facilitate interpreting the final results all 21 desired treatments were categorized into two groups of *wet treatments* and *dry treatments*. In *wet treatments*, the samples were exposed to moisture (either cold (10°C) or hot (100°C)) and in *dry treatments* the samples were not treated with moisture. As for simplifying the comparison among different groups the *wet treatments* were also divided into *wet – microwave treatments* and *wet – non microwave treatments*. Which in the former the samples were treated with microwave oven and moisture and in the latter ones the samples were not heated with microwave oven. In this study domestic microwave oven (AEG, England, MC153E 900 Watts) and a laboratorial oven (Borel, Switzerland, CT 250) for used for thermal treatment.

All the treatments were abbreviated as below and were applied in different orders as explained later:

B.W= soaking in boiling water at 100°C for 1 minute.

C.W= soaking in cold water at 10 °C for 12 hours.

R = roasting in oven at 200 °C for 1 hour.

C = cold dry storage at 5°C for 24 hours.

M=microwave at 900 watt for 3minutes.

Calculation of split nuts

By counting the number of split nuts in every 100 nuts, the amount of split pistachio nuts in each group was reported in percentage splitting.

### Statistical analysis

The effect of different treatments on splitting of pistachio nuts was determined using the analysis of variance (ANOVA) method. The splitting percentage was treated as the dependent variable. Significant differences of variable means were compared using the Duncan's test at 5% level using SAS statistical package (SAS 2001).

## Results

### Wet – microwave treatments

The effect of different treatments on splitting the pistachio nuts in this group were highly significant ( $P < 0.05$ ). Considering the means of samples treated by different wet-microwave methods indicated that the highest amount of splitting was achieved in group A with 25% split pistachio nuts ( $P < 0.05$ ), while the lowest amounts were observed in sample groups of B, F and G. These latter groups had no significant difference in their means ( $P > 0.05$ ). Likewise no significant difference ( $P > 0.05$ ) was observed in groups C, D, E and H (Table 1) either. It's worth mentioning although the method applied in group B was the same as applied in group A, however due to different orders of the treatments applied, significant difference was noticed between these two groups.

Table 1. The effect of different wet-microwave treatments on splitting the pistachio nuts.

| Group | Treatment     | Splitting (%)            |
|-------|---------------|--------------------------|
| A     | C.W / M       | 25.00 <sup>a</sup> ±3.73 |
| B     | M / C.W       | 6.66 <sup>c</sup> ±1.09  |
| C     | M/ C.W / M    | 18.05 <sup>b</sup> ±1.73 |
| D     | B.W / M       | 13.33 <sup>b</sup> ±1.88 |
| E     | B.W / M / B.W | 13.33 <sup>b</sup> ±1.88 |
| F     | M / B.W       | 5.83 <sup>c</sup> ±1.44  |
| G     | M / B.W / R   | 3.33 <sup>c</sup> ±1.77  |
| H     | R / C.W / M   | 16.61 <sup>b</sup> ±1.29 |

C.W= soaking in cold water at 10 °C for 12 hours, M=microwave at 900 watt for 3minutes,

B.W= soaking in boiling water at 100°C for 1 minute, R = roasting in oven at 200 °C for 1 hour.

a, b, c, d values followed by different alphabets within a column are significantly different ( $p < 0.05$ ).

### Wet – non microwave treatments

In this group of study I and J treatment groups led to the highest splitting rates with 31.11% and 22.11% respectively, which were significantly higher from the other treatment groups ( $P < 0.05$ ). However, in these groups the higher moisture content is critical. In fact the pistachio nuts safety depends very much on the final moisture content of the nuts as the risk of mycotoxin contamination increases in high moisture

content products (Marin et al. 2008). The second rank was dedicated to group K with 9.65% split (Table 2).

### Dry treatments

The treatments applied in this group showed the lowest rates of splitting (Table 3). There was no significant difference observed among the treatments involved ( $P > 0.05$ ), implying almost no splitting occurs in lack of moisture.

Table 2. The effect of different wet non-microwave treatments on splitting the pistachio nuts.

| Group | Treatment   | Splitting (%)            |
|-------|-------------|--------------------------|
| I     | B.W/C.W/B.W | 31.11 <sup>a</sup> ±3.73 |
| J     | C.W/B.W/C.W | 22.11 <sup>a</sup> ±3.65 |
| K     | C.W/R       | 9.65 <sup>b</sup> ±0.65  |
| L     | R/B.W       | 0 <sup>c</sup> ±0.00     |
| M     | R/B.W/C/R   | 3.61 <sup>c</sup> ±1.27  |
| N     | B.W/R       | 4.16 <sup>c</sup> ±1.44  |
| O     | B.W/R/C/R   | 6.11 <sup>c</sup> ±1.90  |

C.W= soaking in cold water at 10 °C for 12 hours, C = cold dry storage at 5°C for 24 hours,  
B.W= soaking in boiling water at 100°C for 1 minute, R = roasting in oven at 200 °C for 1 hour.  
a, b, c, d values followed by different alphabets within a column are significantly different (p < 0.05).

Table 3. The effect of different dry treatments on splitting the pistachio nut.

| Group | Treatment | Splitting (%)           |
|-------|-----------|-------------------------|
| P     | R/C       | 3.75 <sup>a</sup> ±1.5  |
| Q     | C/R       | 3.33 <sup>a</sup> ±1.25 |
| R     | R/M       | 1.66 <sup>a</sup> ±0.95 |
| S     | R/M/C     | 3.50 <sup>a</sup> ±1.32 |
| T     | M/R       | 3.50 <sup>a</sup> ±1.32 |
| U     | M/R/C/R   | 3.75 <sup>a</sup> ±1.5  |

C = cold dry storage at 5°C for 24 hours, M=microwave at 900 watt for 3minutes,  
R = roasting in oven at 200 °C for 1 hour.  
a, b, c, d values followed by different alphabets within a column are significantly different (p < 0.05).

## Discussion

### Wet – microwave treatments

The difference noticed between groups A and B indicates not only the operation units but also their sequence play a significant role in splitting the nuts. The same trend is also observed between D and F in which the cold water is substituted by hot water, which supports the same idea. Additionally, comparing group A with group D suggests the water temperature applied before treating by microwave is also of high importance, as cold water results in more splitting percentage. However, comparing the results in groups B and F suggests when the nuts are first treated by microwave, the temperature of the water in which the nuts are soaked causes no significant difference ( $P>0.05$ ) in splitting the nuts. On the other hand comparing groups D and E suggests applying any wet treatment after microwave won't be helpful in splitting the nuts, while in contrast microwave treatment right after soaking is much more effective (compare B-C and A-C) (Table 1).

The other applied method, which was expected to lead to more splitting rate, was roasting. However, roasting Splitting the pistachio nuts and it was concluded that energy required for splitting the nuts is highly dependent on moisture content (Maghsoudi et al. 2012). Bilim and Polat (2008) also suggested striking the pistachio nuts in higher amounts of moisture (22% wb) resulted in 29.33% splitting which is in accordance with the results achieved in this study.

### Wet – non microwave treatment

Comparing groups I and J suggests as long as the processing medium is water, its temperature does not lead to a significant difference ( $P>0.05$ ) in splitting rate of the nuts and likewise the other groups in which the nuts were roasted, roasting could not significantly help splitting the nuts and no difference was observed in the mean value of splitting rate in groups L, M, N and O ( $P>0.05$ ). As it is summarized in Table 2, just like the wet-microwave treatment groups, soaking

the nuts not only did not assist splitting the nuts, but also reduced the number of the split nuts (compare groups A and H). Additionally, the results achieved in groups G and H suggested roasting application in conjunction with the application of microwave but prior to microwave processing. This fact may be due to the moisture content of the nuts in group H which is already reduced by microwave application (Schiffmann 1992) in group G. Likewise, microwave application before soaking the nuts, disables them to split (compare groups A and C). Therefore, it is suggested to soak the nuts preferably in cold water before roasting or microwave treatment, as soaking increases the moisture content and it consequently results in softening the shell. Subsequently, the soft shell requires lower energy in order to split the nuts. This fact was also proved in other study by Vursavus and Ozguven (2005) on pine nut in which conditioning the nuts at higher moisture contents reduced the force required for rupturing the nuts. Additionally, in a similar study on pistachio nuts increasing moisture contents from 5 to 20% (wb), regardless of nut variety, led to decreased amount of energy required for prior to thermal treatments resulted in more splitting percentage (see groups K, L and N). Specially soaking the nuts in cold water prior to thermal treatment is preferred to hot water (compare groups K and N). Regarding Table 1 it is also concluded that any treatment after roasting does not cause any significant differences in splitting rate of the nuts ( $P>0.05$ ). On the other hand when the similar treating groups are compared, it can be concluded that application of microwave was much more successful than roasting in splitting the pistachio nuts. Comparing A-K, D-N and F-L results suggests the nut splitting rate is greater in those groups treated by microwave.

### Dry treatments

In a similar study Bilim and Polat (2008) also claimed that heating process on its own has no effect on splitting. However, conjunction of heating and

crushing together increased splitting percentage. The experiments indicated that wet thermal treatments – both microwave and non-microwave – are more effective in splitting the pistachio nuts than dry thermal treatments. Among all mentioned treatments A, I and J samples showed the best results and indicated no significant difference ( $P > 0.05$ ). However, A treatment is more applicable as the final product contains less moisture, which enables longer storage. However, groups I and J require a drying unit and considering the increased amounts of moisture it requires more energy in order to dry them. It can be concluded that in general wet treatments can be more effective than dry treatments in splitting the pistachio nuts. Actually not only the presence of moisture but

also its introduction order in treating the samples is of high importance. Exposing the samples to moisture at the earlier stages of splitting operation is more efficient. Additionally, even in wet processing methods, roasting could not help splitting the nuts. On the other hand, application of microwave immediately after soaking the nuts seem to be helpful in splitting the nuts and should not be considered before soaking the samples. Due to decreasing the moisture content and hardening the shell after microwave treatment, more energy would be required for splitting the nuts. Furthermore, the temperature of the water in which the nuts are soaked is of importance, since cold water resulted in higher amounts of nut splitting.

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