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# Investigating Different Methods of Closed Shell Pistachios Splitting and Effects of Freezing Prior to Drying on Shell Splitting Percentage

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**ABSTRACT**

In this study, different methods for shell splitting and the effect of freezing prior to drying on shell splitting percentage of pistachio were investigated. A completely randomized design was used to investigate the effects of different freezing temperatures (0, -6, -12 and -18°C), different drying temperatures (80, 90 and 100°C) and different cultivars (Akbari and Kalehghouchi) on shell splitting percentages. The results showed that both freezing and drying temperature significantly ($p \leq 0.05$) affected the splitting of closed shells into open shells. The effect of cultivar was insignificant. The highest shell splitting percentage (16.56%) was observed with a freezing temperature of -18°C and when a drying temperature of 100°C was used. Freezing and drying temperatures did not significantly increase the number of isolated kernels. However, in most treatments, isolated kernels were observed. Despite the isolated kernels, The shell splitting percentage did not decrease in any of the treatment groups. The results showed that freezing prior to drying can increase the percentage of split pistachio nuts. Thus, by increasing the difference between the temperature of the freezing and the temperature of drying, the percentage of split pistachio increased.

**Keywords:** Closed shell, Cultivar, Pistachio, Shell splitting.

## Introduction

Pistachio nut (*Pistacia vera* L.) is one of the most popular tree nuts in the world. Due to its high nutritional value, the split pistachio nut is an increasingly important nut product consumed in the form of raw, roasted and salted (Rosengarten, 2004). Pistachio nut grows well in countries with warm-arid climate such as Iran, United States, Turkey, Italy and Syria, which represent the major producers and exporters of pistachio nuts in the world (FAO, 2013).

Pistachios are served principally as salted nuts. A large percentage of pistachios are marketed in the shell for snack food. Non split, filled nuts are used for processing (Kashani Nejad *et al*., 2007). Pistachio nuts contain 25% protein (mainly essential amino acids), 16% carbohydrate (mainly sucrose) and 55% oil (Rosengarten, 2004). A one-ounce serving of pistachio contains more than 10% of the daily value for dietary fiber, vitamin B-6, thiamin, magnesium, phosphorus and copper (Herber *et al*., 2008).

Pistachios are divided into three groups according to their splitness: split, half split, non split. Split pistachios are the chosen ones for producing; half split and non

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split ones are separated because of the lack of quality (Maghsoudi *et al*., 2012).

If the bony shell of pistachio is not cracked along the gap or longitudinal swell or the crack developed wider than the index with thickness of 0.4 and length of 6mm, the pistachio was considered non-split. The pistachio that contained a shell crack was considered an assumed split. A half-split pistachio was one with a crack less than 2mm (Institute of Standards and Industrial Researches of Iran, 2013).

Post harvest processing is very important to pistachio nut quality. The closed shell pistachios are manually split, which is a very slow, difficult, un-hygienic and worker intensive operation. A survey that was conducted in the Kerman province, the main pistachio producing area in Iran, showed that about 31% of the pistachios were closed shelled (Maghsoudi *et al*., 2012). The closed shell pistachios of the United States were found to be 20.6% of the total yield (California Agricultural Statistical Service, 2002).

The shell splitting is an important quality parameter in the marketability of pistachio fruits (Panahi, 2011; Afshari, 2008; Tsantili, 2010; Shakerardekani, 2011). Pistachios enclosed in shells are worth less than those that have opened for the extra cost incurred when opening the shells mechanically (Zheng, 2011). The non-split pistachios are used as raw material for production of wafers, ice cream, chocolate, pistachio halva, pistachio butter, pistachio oil, pistachio baklava and sausage (Ardakani, 2006).

Generally, splitting unsplit pistachio is done in two ways: water splitting and mechanical splitting. Most are split in water, which is easier. Water splitting is actually done in I.W.D, W.D and W.I.D. methods. In I.W.D method, the pistachios are delivered to contractors so that they impact them by hammer and change unsplit pistachios to impacted and split ones. Then, the pistachios are moved to steel silos and are soaked in water for five hours. After this step, the pistachios' skins have become soft and an elecrtric shock is administered for splitting. To complete this task, the pistachios are immediately moved to a drying machine with 90-degree Celsius air. Pistachios are out of the machine after their humidity is 10% of the first amount of humidity. Then, the pistachios are moved to the silos, which are equipped with blower fans. In this step, ambient air crosses until the humidity is 5% to keep in warehouses and for consuming and exporting (Kouchakzadeh, 2013). In the W.D. method, unsplit pistachios must be soaked in cold water for 24 hours until kernels become wet as outer shell. Then, pistachios are put in a drying machine directly and placed in contact with 90-degree Celsius air. The pistachios will be split with electric shock. The disadvantage of this method is that because the drying process is not the same, the kernels and crusts of pistachios moisture cannot reach 10% because if they do, the outer shell would be roasted. Accordingly, pistachios must stay in the drying machine for fewer periods than the last method. In order to reach 5% of humidity, the pistachios must be kept in the sunlight for several times or must be moved to silos, which are equipped with blower fans (Hoseinzadeh, 2013; Kouchakzadeh, 2013). In the W.I.D. method, the unsplit pistachios are soaked in cold water for 24 hours. Whenever the inner crust is completely soft, they are impacted with a hammer by hands. Then, for drying, they must be under sunlight or be dried by drying machine (Foroutanaliabad, 2010). Splitting pistachios via the mechanical method is done by splitting machines. An experiment was done on 35 unsplit pistachios for assessment of machine's operation. The result showed that 92.5% of pistachios were spilt exactly on their edges (the natural line of pistachios that are created when they are on trees), and the average time for splitting each pistachios was 9.3 seconds.

Until now, there has been some research regarding splitting pistachios by heating treatment. Kouchak

Zadeh (2013) studied this topic with microwave and heating treatment. In his study, 100 unsplit pistachios were put in 5,10,15,20 and 25 °C of water for 5,10,20 and 24 hours and then inserted 180,360,540,720 and 900-watt heating shock by microwave. The result showed that all the samples became split at more than 540 watts.

Shayanfar and Kashani Nejad (2012) studied the effects of non-mechanical factors on splitting pistachios. 100 unsplit pistachios were placed in water, in different temperatures, between 10 and 100F. Then, electric shock was done by oven and microwave. The result showed that soaking had a considerable effect on the number of split pistachios. In addition, the water temperature and duration of soaking had a meaningful effect on the final result. However, there was not a significant effect on the samples that were not soaked.

Bilim *et al*., (2008) investigated the effect of the combination of temperature, humidity and stroke for splitting fresh pistachios. In this experiment, the heating process was at 350 degrees Celsius for the pistachios. The pistachios would drop on a rotating disk and hit the wall of container by centrifugal power. Three different speeds of (400, 500, 600) round per minute for the disk and three levels of humidity (6.5, 22, 42.5)% were used.The result showed that the biggest amount of split pistachioswas about 29.33%, verified by 22% of humidity and 400 RPM for the disk.

Kashani Nejad, *et al*., (2012) researched the effect of the drying processfor splitting pistachios. The level of splitting was measured by an electronic digital caliper, which was repeated after drying. This method resulted in an increase percentage of splitting. The results showed that temperature degree and air speed had a positive effect on splitting in that increasing the temperature and air speed increased the splitting rate.

To split nuts in both the traditional (via water) and industrial methods (via machine) requires drenching dried nuts. Soaking and drying a second time caused an unpleasant taste and reduced the nutritional value of pistachio.

The aim of this study was to investigate closed shell pistachios splitting and methods in increasing the percentage of open shell pistachios via a drying process and treatment with heat shock.

## Materials and Methods

### *Materials*

12kg of Akbari and Kalehghouchi cultivars was received from the Pistachio Research Center (Rafsanjan, Iran).

### *Methods*

After washing the nuts, the samples were divided to three categories: first category contained nuts with a longitudinal gap in their shell on both sides (splitting), second category contained nuts with gaps that were on one side of shell (half splitting) and the third category contained nuts with no gapin their shell (not splitting) (Fig. 1).


Fig. 1. Split, half split and non split pistachios.

For every treatment, 50 nuts were randomly selected, which contained: 25 split nuts (50%), 15 half split nuts (30%) and 10 non split nuts (20%). The experimental procedure was that every treatment group was frozen for one hour in 0, -6, -12 and -18°C and immediately dried in the oven at 80, 90, 100 °C in order to give a heat shock to the nuts. The drying process ended when the moisture content of samples became 5% (based on wet weight) and the number of splitting, half splitting and not splitting nuts were counted. The samples were kept in the oven at 103°C for three hours to completely dry and in the change in weight was less than 0.001g. All experiments were repeated three times.

**Statistical analysis**

To study the effect of different treatments, a factorial experiment in a completely randomized design was used. Analysis of variance using SPSS software version 19 was performed. Excel software was used to draw graphs.

**Results**

The results showed that both freezing temperatures and drying temperatures have a significant influence on the amount of pistachios and shell splitting. Increasing the drying temperature and reducing the refrigeration temperature resulted in an increase in the percentage of pistachio splitting (Figs. 2 and 3).

Analyzing the data showed that none of the variable influenced the free nuts amount, which was not similar to the findings by Kashani Nezhad. The percentage of half-splitting pistachios was reduced (Table 1).

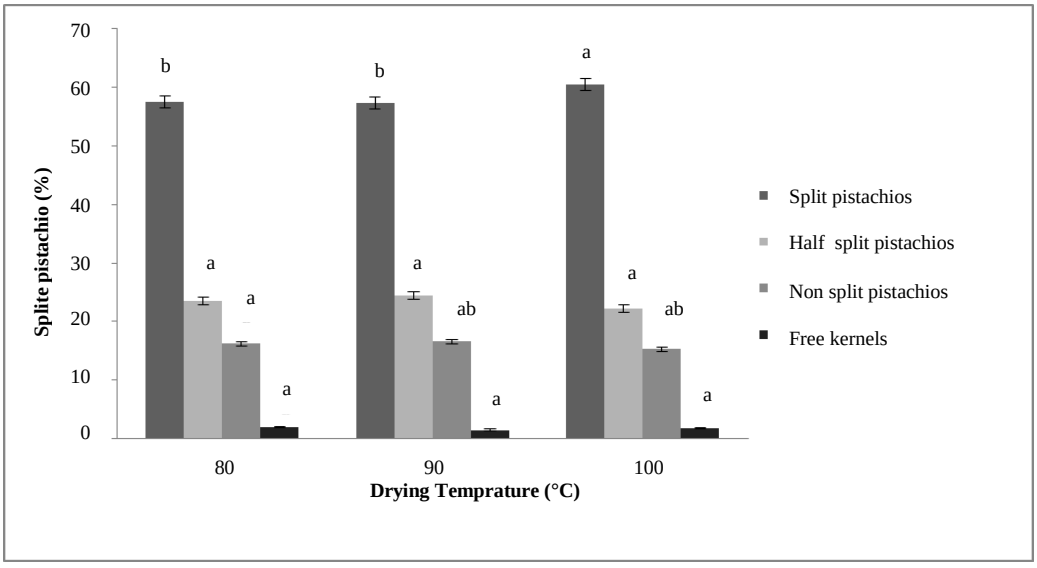


Fig. 2. Influence of drying temperature on split, not split and half split pistachios and free kernels percent
(Average that have the same letters are based on Duncan test at the 5% level are not significant)

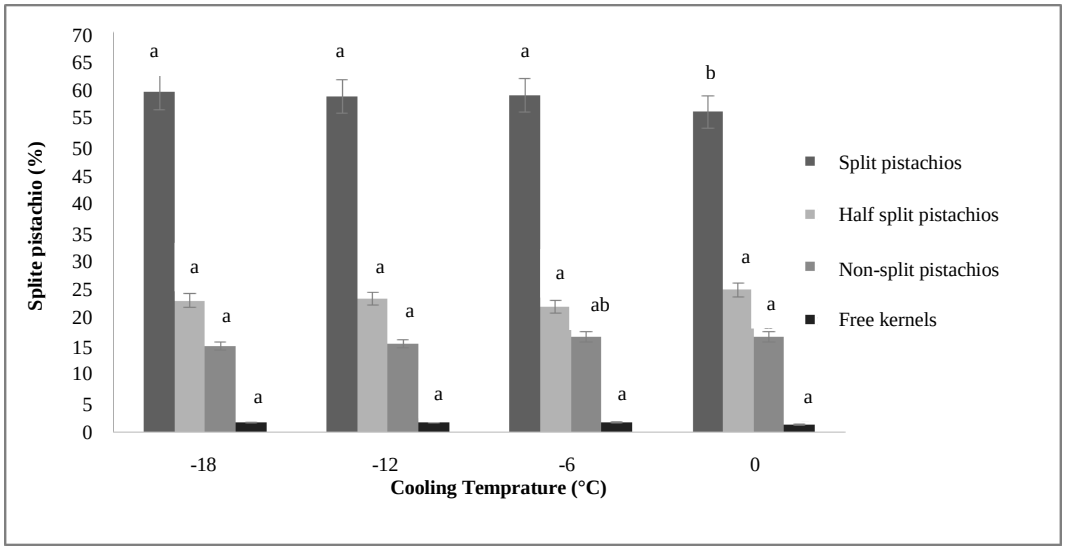


Fig. 3. Influence of refrigerating temperature on split, non split and half split pistachios and free kernel percent (Average that have the same letters are based on Duncan test at the 5% level are not significant)

The effect of freezing temperatures and drying temperature and their interaction on the percentage of splitting of pistachio nuts were not significant (Table 1). The effect of freezing temperatures, drying temperature and cultivar on the percentage of splitting of pistachio nuts was significant (Table 2). The best condition was observed in the Akbari cultivar in freezing temperature of -18°C pistachios and drying temperature of 100°C.

**Table 1. The effect of freezing and drying temperature on the splitting.**

| Treatment | Split Pistachios | Half split Pistachios | Non split Pistachios | Free kernels |
|---|---|---|---|---|
| C1-T1 | 55.33$^{b}$ | 25.16$^{a}$ | 17.66$^{a}$ | 1.83$^{a}$ |
| C1-T2 | 57.66$^{ab}$ | 26.0$^{a}$ | 16.0$^{ab}$ | 1.66$^{a}$ |
| C1-T3 | 56.33$^{ab}$ | 26.0$^{a}$ | 17.0$^{a}$ | 0.66$^{a}$ |
| C2-T1 | 60.0$^{ab}$ | 22.0$^{a}$ | 16.33$^{ab}$ | 1.66$^{a}$ |
| C2-T2 | 57.66$^{ab}$ | 22.33$^{a}$ | 18.0$^{a}$ | 2.0$^{a}$ |
| C2-T3 | 60.0$^{ab}$ | 22.0$^{a}$ | 16.0$^{ab}$ | 2.0$^{a}$ |
| C3-T1 | 58.0$^{ab}$ | 23.66$^{a}$ | 16.16$^{ab}$ | 2.16$^{a}$ |
| C3-T2 | 58.0$^{ab}$ | 25.0$^{a}$ | 16.33$^{ab}$ | 0.66$^{b}$ |
| C3-T3 | 61.0$^{ab}$ | 21.3$^{a}$ | 14.33$^{b}$ | 3.33$^{a}$ |
| C4-T1 | 58.0$^{ab}$ | 23.6$^{a}$ | 16.66$^{ab}$ | 2.66$^{a}$ |
| C4-T2 | 56.66$^{ab}$ | 26.33$^{a}$ | 16.0$^{ab}$ | 1.0$^{a}$ |
| C4-T3 | 64.66$^{a}$ | 23.0$^{a}$ | 14.0$^{a}$ | 1.66$^{a}$ |

C: $C_1$=0 , $C_2$ = -6 , C3 = -12, $C_4$ = -18 , T: $T_1$= 80, $T_2$ = 90,$T_3$ = 100 Average that have the same letters are based on Duncan test at the 5% level are not significant

**Table 2. Comparing deduction average of making dried pistachios splitting.**

| Treatment | Split Pistachios | Half split Pistachios | Non split Pistachios | Free kernels |
|---|---|---|---|---|
| C1-T1-V1 | 56$^{cde}$ | 26.33$^{ab}$ | 16.67$^{abcd}$ | 1$^{ab}$ |
| C1-T1-V2 | 54.66de | 24$^{ab}$ | 18.66$^{a}$ | 2.66$^{ab}$ |
| C1-T2-V1 | 56.66cde | 25.33$^{ab}$ | 16.6$^{abcd}$ | 1.33$^{ab}$ |
| C1-T2-V2 | 58.66bcde | 24$^{ab}$ | 15.33$^{bcde}$ | 2$^{ab}$ |
| C1-T3-V1 | 60$^{abcd}$ | 23.33$^{ab}$ | 33.67$^{abcd}$ | 0$^{b}$ |
| C1-T3-V2 | 25.66$^{e}$ | 66.38$^{a}$ | 17.33$^{abc}$ | 1.33$^{ab}$ |
| C2-T1-V1 | 60.66$^{abcd}$ | 33.19$^{b}$ | 16.67$^{abcd}$ | 3.33$^{a}$ |
| C2-T1-V2 | 59.33$^{bcde}$ | 24.66$^{ab}$ | 16$^{abcd}$ | 0$^{b}$ |
| C2-T2-V1 | 56.66$^{cde}$ | 22.66$^{ab}$ | 17.33$^{abc}$ | 3.3$^{a}$ |
| C2-T2-V2 | 58.66$^{bcde}$ | 22$^{ab}$ | 18.66$^{a}$ | 0.66$^{ab}$ |
| C2-T3-V1 | 60$^{abcd}$ | 21.33$^{ab}$ | 15.33$^{bcde}$ | 1.33$^{ab}$ |
| C2-T3-V2 | 60$^{abcd}$ | 22.66$^{ab}$ | 66.67$^{abcd}$ | 0.66$^{ab}$ |
| C3-T1-V1 | 61.33$^{abcd}$ | 22$^{ab}$ | 15.33$^{bcde}$ | 1.33$^{ab}$ |
| C3-T1-V2 | 54.66$^{de}$ | 25.33$^{ab}$ | 17$^{abcd}$ | 3$^{ab}$ |
| C3-T2-V1 | 57.33$^{cde}$ | 25.3$^{ab}$ | 16.67$^{abcd}$ | 0.66$^{ab}$ |
| C3-T2-V2 | 58.66$^{bcde}$ | 24.66$^{ab}$ | 16$^{abcd}$ | 0.66$^{ab}$ |
| C3-T3-V1 | 66.56$^{cde}$ | 23.33$^{ab}$ | 16.67$^{abcd}$ | 3.33$^{a}$ |
| C3-T3-V2 | 65.3$^{ab}$ | 19.33$^{b}$ | 12$^{e}$ | 3.33$^{a}$ |
| C4-T1-V1 | 59.33$^{bcde}$ | 22.66$^{ab}$ | 14.67$^{bcde}$ | 3.3$^{a}$ |
| C4-T1-V2 | 56.6$^{cde}$ | 24.66$^{ab}$ | 16.6$^{abcd}$ | 2$^{ab}$ |
| C4-T2-V1 | 54.66$^{de}$ | 26.33$^{ab}$ | 18$^{ab}$ | 2$^{ab}$ |
| C4-T2-V2 | 58.66$^{bcde}$ | 25.33$^{ab}$ | 14$^{cde}$ | 2$^{ab}$ |
| C4-T3-V1 | 62.66$^{abc}$ | 22.66$^{ab}$ | 14.67$^{bcde}$ | 2$^{ab}$ |
| C4-T3-V2 | 66.66$^{a}$ | 23.3$^{ab}$ | 13.33$^{de}$ | 3.33$^{a}$ |

$C_1$= 0. $C_2$ = -6. C3 = -12. $C_4$ = -18, $T_1$= 80. $T_2$ = 90, $T_3$ =100, $V_1$= Kalehghouchi.$V_2$= Akbari .Average with same letters are not significant

## Discussion

An increase in the percentage of split pistachios was related to reducing the temperature to -18 and drying at 100F. Kashani Nezhad *et al*., (2007) showed that by increasing the drying temperature, the splitting amount of pistachio was increased. The pistachios must be soaked in water and dried once (Hoseinzadeh, 2013). This resulted in repeating the process of drying, consuming energy and time. In addition, theouter skin (hull) would be separated with a single movement (Shakerardekani, 2011), which is called kernel's hulling. It is one reason for contamination. Additionally, splitting takes a lot of time and energy. It takes about 20 days to produce 25 tons of split pistachios. Also, 40 kilo watt electricity is used every hour of this process (Kouchakzadeh, 2013). Accordingly, one hundred ampere line of electricity is necessary.

In general, it is better to use unsplit pistachios as kernels considering that split pistachios are a significant matter in the market's choices. Every year, a part of produced pistachios is unsplit. Therefore, a good method for reducing the amount of unsplit ones is needed. This study suggeted a method of freezing pistachios before drying them while still fresh, which increased the amount of split pistachios.

**Conclusions**

The results showed that cooling prior to drying can increase the percentagage of split pistachio nuts. By increasing the difference between the temperature of freezing and the temperature of drying, the percentage of split pistachio increased. The highest increase of split pistachio was 16.6%, at a freezing temperature of -18°C and a drying temperature of 100° C. The amount of free kernels in certain treatment groups was more than maximum levels in standard (1%). Despite the increase in free kernels, the percentage of split pistachio nuts was not reduced in any of the treatment groups.

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