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INFLUENCE OF DIFFERENT PACKAGING MATERIALS AND STORAGE CONDITIONS ON THE QUALITY ATTRIBUTES OF PISTACHIO (*PISTACIA VERA L.*) CV. OHADI

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Abstract
Due to appropriate horticultural conditions of Iran, its produced Pistachio has a very high quality, and Iran is the largest producer and exporter of this nut in the world. In this research, processed pistachios were packaged in four materials including celuphane, two and three layers plastic pouches, and metal cans along with one sample without packaging as control (in bulk). Purpose of this research was to compare these packagings in terms of storage stability of pistachio by considering some important quality attributes during storage in order to select a suitable kind of packaging. The samples were stored in two temperatures (ambient and 40℃) for one year. They were analyzed every four months in terms of moisture content, peroxide value, acidity and tiobarbitoric acid value. Our results revealed that pistachio samples stored under ambient conditions had better shelf life compared with 40℃ treatments. Among packaging materials, two layer plastic pouches resulted in higher quality attributes for the stored pistachios, especially regarding their fat quality. This confirms that two layer pouches had less permeability to oxygen compared with other packaging types. Regarding moisture loss, three layer plastic pouches were the best ones which can be very important from economic point of view.

Keywords: Pistachio, shelf life, packaging, physico-chemical properties, oxidation.

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1. INTRODUCTION

Pistachio (*Pistacia vera L.*) is from Anacardiaceae and Iran is one of the most important countries regarding producing and exporting pistachio in the world. Among non-oil export items of Iran, pistachio is in the second ranking after carpet. Annual amount of pistachio production at 2005 in Iran was 190,000 Mt which constitutes 62% of the world pistachio production. After Iran, the U.S.A with 140,000 Mt of production is the second major country in terms of pistachio production and Turkey with 60,000 Mt of production is in the third place (Amirteimoori and Chizari, 2008). Pistachio nut is mainly consumed as salted, roasted, in confectionery and snack foods. It is also used as the main ingredient of desserts such as baklava and nut paste in Turkey.

Pistachio contains around 23% protein, 19% carbohydrate and 5% moisture (Kucukoner & Yurt, 2003; Pala, Ackurt, & Loker, 1994). It also contains high amounts of K and P, and various amounts of Ca, Mg and Fe. In a research carried out on 8 varieties of pistachio in Greece, fatty acid compositions of its kernel oil were 51.6 % oleic, 27.03 % linoleic, 10.24 % palmitic and 0.5 % linolenic acid (Tsantili, *et al* 2010). A great difference in fat content of pistachio nut was reported by several researchers. It was reported 56% by Kuecukoner and Yurt, 2003 and Pala *et al.* 1994, and between 40.6% and 53.5% by Koroglu (1997). Therefore, as seen from these data, the pistachio is a nut with high nutritional value, lipid content and very rich in unsaturated fatty acids. It makes pistachio susceptible to oxidation producing a variety of off-flavors and off-aromas.

The quality of a food product depends not only on its original state, but also on the extent of changes during processing and storage. The influence of different variables such as temperature, relative humidity, light, time, etc., on the stability of a product has been reported from many studies.

In comparison with other food products, studies on the storage stability of pistachio nuts are very limited. In a study by Faruk *et al*, 2007, samples of pistachio paste were produced by boiling a mixture of 51% sucrose, 16% pistachio, 8% glucose, and 25% water as much as final brix equal to 75 was obtained. These samples were stored in 4°C and 20°C under three types of packaging materials including polypropylene (pp) with vacuum, pp without vacuum and glass jars sealed. This study showed that Pistachio paste stored at 4°C in sealed glass jars had better acceptance with respect to chemical properties compared with other samples.

Kader *et al.* ,1982 investigated the effect of temperature (0, 5, 10, 20 and 30ºC) on chemical and sensory characteristics of pistachio nut during storage time of 6-12 months. Their results revealed that a moisture level of 4-6% resulted in the best quality. Dried pistachio nuts can be kept for 12 months at 20ºC. Maskan and Karatas (1998) studied the storage stability of pistachio nuts under various conditions. Lowest rate of product oxidation and hydrolysis occurred at or near the monolayer moisture content and under CO2 atmosphere. In another research, they shown that fatty acid reduction and peroxide formation were higher in ambient storage, but storage at monolayer moisture content and under CO2 atmosphere improved the stability of pistachio nuts (Maskan and Karatas, 1999).

Tavakolipour *et al*., 2010 evaluated the storage stability of whole split Kerman pistachio nuts (Pistacia vera L.) stored at 5, 15, 25 and 35 °C and a relative humidity range of 11 to 87 percent. They found that rate constants of lipid oxidation reaction at 5 to 35 °C varied between 0.145 to 0.567 ($month^{-1}$). Also, the oxidation activation energy was 31.459 kJ/mol and lowest product oxidation and lipolysis occurred at or near monolayer moisture content. Some researchers have worked on new methods of pistachio preservation. For example, ozone was used for degradation of aflatoxins in pistachio (Akbas and Ozdemir, 2009). It was found increasing of exposure time and ozone concentration increased aflatoxin degradation and simultaneously fatty acid compositions and quality factors of pistachios didn't change significantly after ozonation treatments.

Considering important parameters in packaging material selection such as price, availability, mechanical resistance, gas penetration, thermal resistance, translusance and compatibility to food stuffs and being non-toxic, we decided to evaluate commercial packaging materials such as celluphane, two and three layers pouches and metal cans for pistachio. Purpose of this research was to compare these packagings in terms of storage stability of pistachio by considering some important quality attributes during storage in order to select a suitable kind of packaging.

2. MATERIALS AND METHODS

Pistachio (cv. Ohadi) was picked from Feizabad area in Khorasan province (Iran), randomly and was transported to a pistachio terminal for processing. After washing and drying the samples, four packaging materials including celluphane, two layers (PS/Al) and three layer (PET/Al/PE) plastic pouches and TP can with general lac were used for product packaging and one sample (in bulk without packaging) was considered as control. Weight of pistachio inside each sample was 150 gr. The pistachio samples were stored for one year at two temperatures: ambient temp., and 40°C in an oven (Memmert). All measurements were performed in triplicate based on a fully randomized factorial design. Obtained data were analyzed by Minitab (14 version) software at a 95 % significance level and the graphs were drawn by Microsoft Excel (2007). Following analyses were carried out at 4 months time intervals.

The moisture content of the samples was determined by drying of ground samples in a vacuum oven at 60 ºC until a constant weight was reached (AOAC, 2005). For determination of pistachio oil attributes, ground samples were extracted by hexane (by a ratio of 3:1 w/w with pistachio) solvent for

24 hr in darkness at ambient temperature. The solvent was evaporated under vacuum at 30ºC (Maskan and Karatas, 1998). The Peroxide value of pistachio kernel oils was measured by the iodometric titration method (BS, 1987) and free fatty acids were determined by titration method based on oleic acid percent (AOAC, 2005). Tiobarbitoric acid value (TBA) was measured by centrifugation and spectroscopic absorbance reading at 532 nm (AOCS, 2005).

3. RESULTS AND DISCUSSION

3.1. Moisture content

Comparison of the mean values of moisture content among pistachio samples revealed that there is a significant difference ($P<0.05$) between storage temperatures at 20 °C and 40 °C (Figure 1). Samples stored at ambient conditions had higher moisture content which could be due to a lower mass transfer rate at room temperatures. In other words, by increasing temperature, moisture is evaporating faster and will be removed from the product. This is especially important from economic point of view since higher moisture evaporation means big loss in product weight. Also, moisture content can influence the product sensory and textural properties important to the customers. In our previous study (Raee *et al*, 2010), we reported that by decreasing moisture content crispness and tenderness of the pistachio nut will be influenced significantly.

As it can be seen from Figure 1, moisture means in different packaging materials was also statistically significant.

Pistachios without packaging (bulk) and those packaged in three layer plastic pouches had the lowest and highest moisture contents, respectively. It means that the influence of effective factors (such as temperature, relative humidity, light, gas, etc.) is minimum in three layer pouches and it can protect the sample well from moisture loss. On the other hand, bulk samples and those packaged in celuphane were easily affected by the environment and lost their moisture content.

Comparison of moisture means relative to time (Figure 2) shows a decreasing linear trend which is acceptable since, more the time progress, more the chance for water to evaporate from the product.

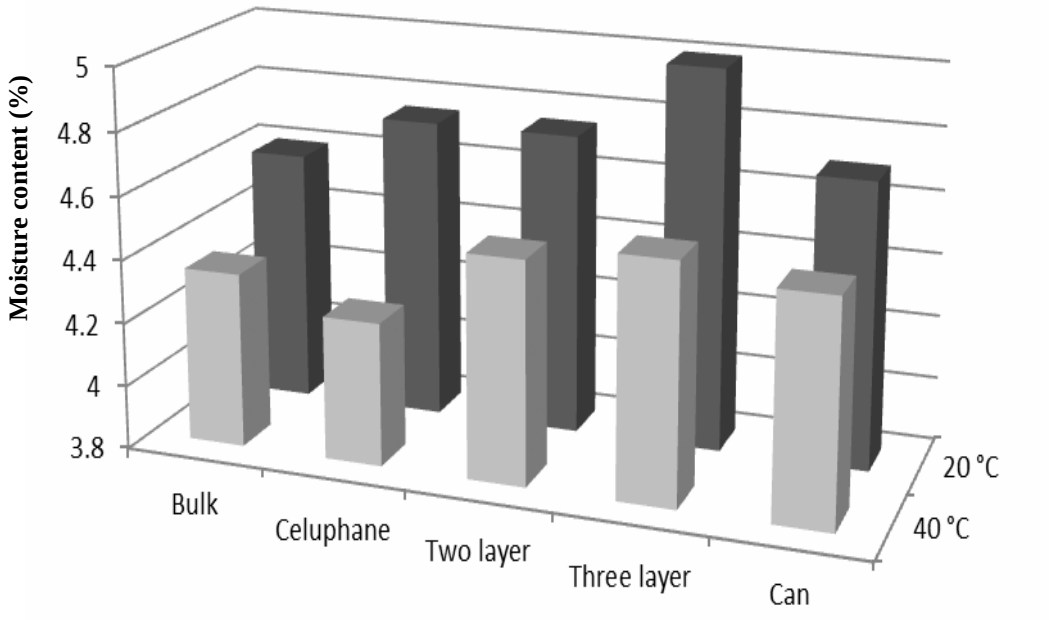

Figure 1. Moisture content of pistachio samples stored at different temperatures and various types of packages.

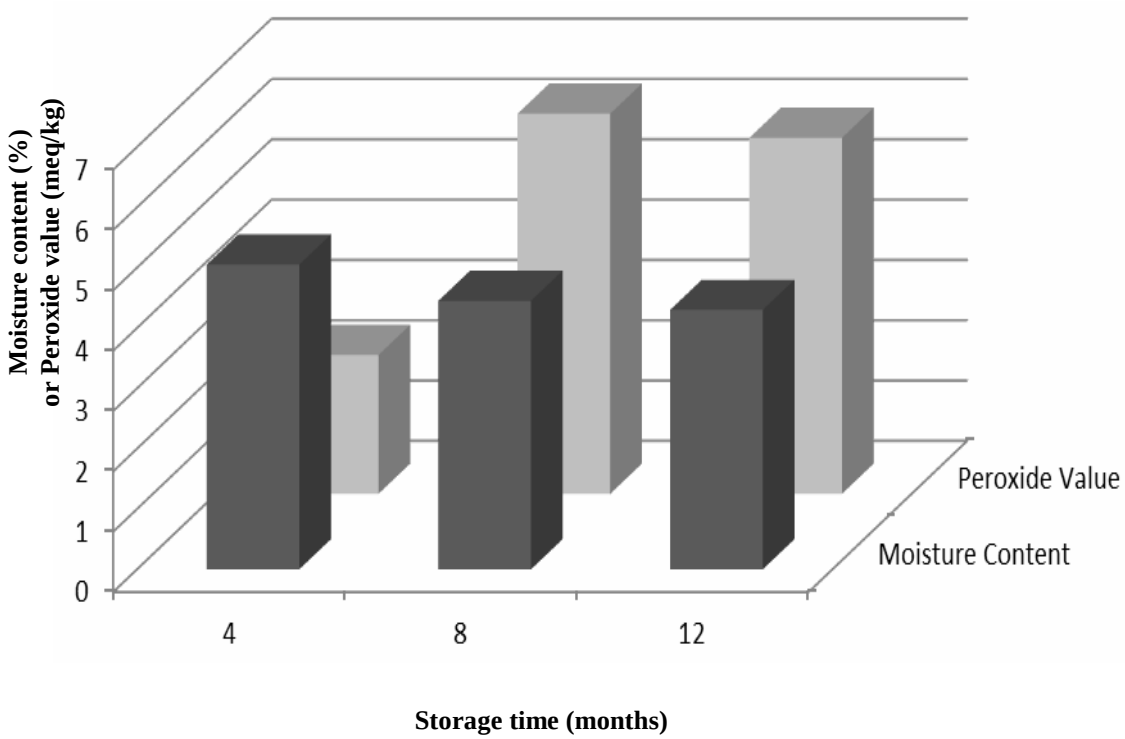

Figure 2. Influence of storage time on the moisture content and peroxide value of pistachios.

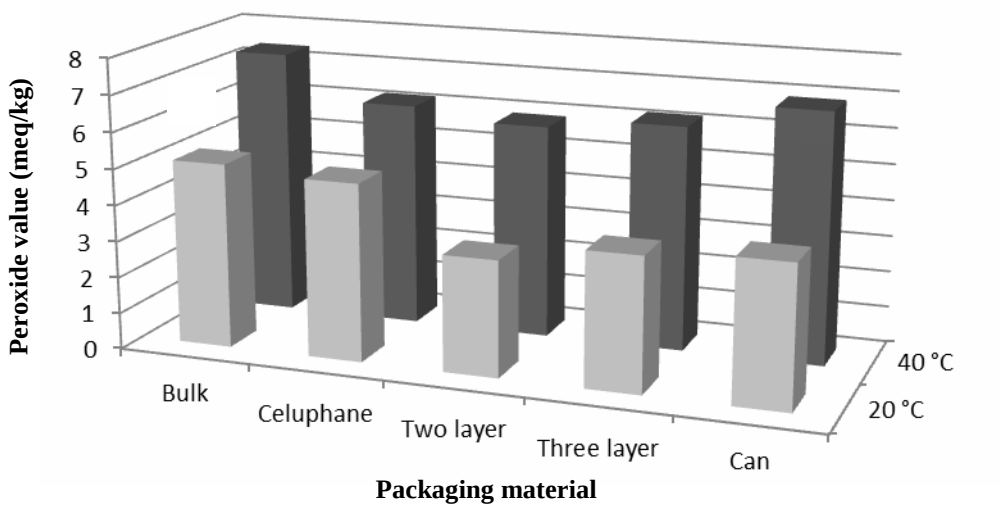

Figure 3. Peroxide value of pistachio samples stored at different temperatures and various types of packages

3.2. Peroxide value

Peroxide is the first chemical compound which is produced after oxidation of fats and oils. When peroxide value reaches to a limit, different reactions occur.
As a result, volatile substances such as aldehydes, ketones, and short chain fatty acids are produced that cause an unfavorable odor and flavor in the product.
Our results showed that peroxide formation was higher and statistically more significant ($P<0.05$) at 40 °C compared to room temperature (Figure 3) which is totally in agreement with previous results since at higher temperatures, rate of chemical reactions will be increased.
By increasing a 20 °C at the storage temperature of pistachio, peroxide value increased by almost 50% regardless of the packaging type.
Considering different packaging materials (Figure 3), bulk samples had the highest peroxide value and two layer plastic pouches had the lowest values, respectively. This confirms that two layer pouches had less permeability to oxygen compared with other packaging types.
It can be seen that temperature had a pronounced effect on two layer packages in terms of peroxide value since it was almost doubled from 3.2 to 6.2 (meq/kg). Surprisingly, pistachios packaged in metal cans had also higher values of peroxide which shows they are not good barriers to oxygen and even water vapor.
Evaluation of peroxide means relative to time (Figure 2) showed a sharp increase at the first storage period (4 months) and a gradual increase afterwards. This can be explained by conversions of first oxidation products to the secondary metabolites at the late storage time which was proved by TBA values.

3.3. Acidity

Rate of this qualitative index determines degree of fat hydrolysis and oxidation. We found that this value (% oleic acid) in average was about 1.05 and 1.16 in the samples stored at ambient and 40 °C storage conditions, respectively which was significantly different ($P<0.05$).
Higher acidity values at 40 °C could be again explained by higher rate of chemical reaction at higher temperatures. It was revealed that increasing trend of acidity had a direct relationship with primary peroxide formation which indeed, free fatty acids are the precursor of oxidized products.
Evaluation of acidity means in different packaging materials (Table 1) showed a significant difference ($P<0.05$) among control and other treatments so that tow layer plastic pouches resulted in a product by lowest acidity values similar to peroxide values. Bulk pistachios had the highest acidity value the same as peroxide value. Considering storage time, there was a linear increase for the acidity value (Figure 4).

3.4. Tiobarbitoric acid (TBA) value

In fact, TBA value is the amount of malondealdehyde which presents in1000 gr fat. Figure 4 shows TBA values of pistachio samples over time that are significantly different ($P<0.05$).
It shows that the rate of TBA increase at the late storage period is sharper since first fat oxidized compounds are present in high amounts and will be converted to secondary metabolites at a higher rate.
Regarding packaging type, our results (Table 1) revealed that two layer plastic pouches had the lowest TBA value.
On the other hand, bulk pistachios had the highest rate significantly different ($P<0.05$) than other samples. Unfortunately for comparison, few papers are available about the influence of packaging on pistachio quality.

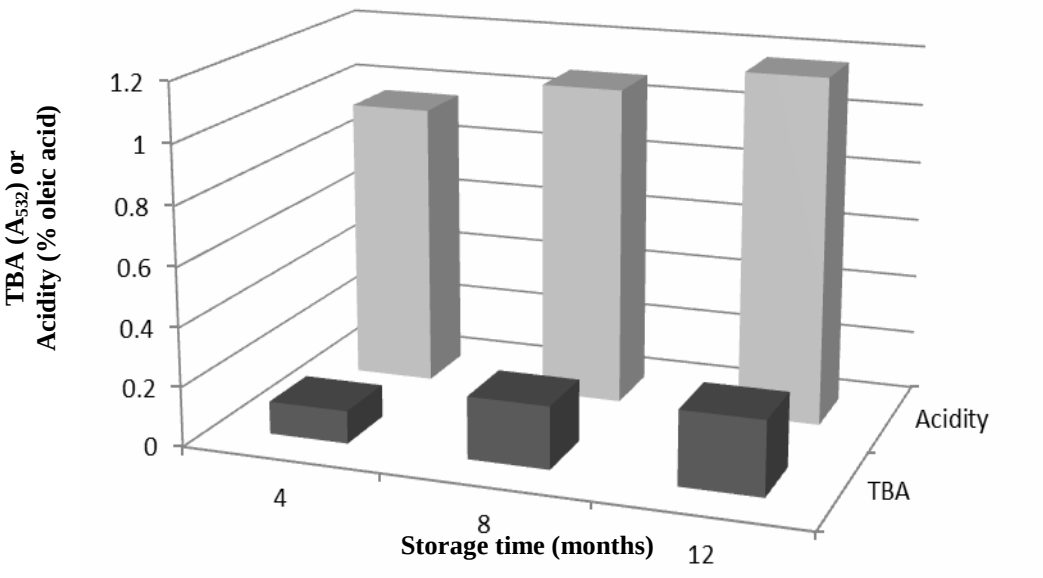

Figure 4. Influence of storage time on the TBA value and acidity of pistachios

Table 1. Means of moisture content, peroxide value, acidity, and TBA value in different packaged pistachios

Index / Type of package	Moisture Content (%)	Peroxide Value (meq/kg)	Acidity (% Oleic acid)	Tiobarbitoric acid value (A_{532})
bulk	4.5[b]	6.03[a]	1.19[a]	0.24[a]
celluphane	4.5[b]	5.6[b]	1.12[b]	0.15[c]
two layers	4.62[b]	5.31[b]	1.07[b]	0.14[c]
three layers	4.79[a]	5.08[b]	1.13[b]	0.16[c]
can	4.62[b]	6.04[a]	1.13[b]	0.19[b]

4. CONCLUSION

In order to have a pistachio product with the highest shelf life and the best quality, it is very important to package it in a proper material and store it under appropriate conditions. Our results showed that higher temperatures and longer storage times will result in a product with minimum quality attributes. Considering different studies packaging materials, we found that two layer plastic pouches are the best one in terms of preventing oxygen permeability and maintaining the pistachio fat quality. Regarding moisture loss, three layer plastic pouches were the best ones which can be very important from economic point of view. In our next study, hopefully we will focus on atmospheric modification inside the packages and using different gases.

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