International Conference on "Novel Approaches in Agro-ecology, Forestry, Horticulture, Aquaculture, Animal Biology and Food Sciences for Sustainable Community Development"
(Agro-tech-2017)

Storage Stability of Pistachio Nuts under different Packaging Material and Temperature

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Abstract—This study evaluated the effect of different storage conditions currently used by the industry, on the chemical, physical and sensory characteristics of pistachio nuts during one year of storage. The traditional method of in-shell preservation in a storage room at ambient temperature was compared with refrigerated storage of nuts. Pistachio nut paste samples were produced by boiling the mixture of 51% sucrose, 16% pistachio, 8% glucose and 25% water till the final 75 brix was reached. The samples were stored at refrigerated and ambient temperature within sealed glass jars and vacuumed HDPE pouches. The experimental nut samples in two packing types at two storage temperatures were analysed for peroxide values (meq kg^{1}), total acidity (%), free fatty acid (%), moisture content (%), pH, and TBA values. Pistachio nut pastes were analysed monthly during the storage period up to 210 days. The experiment was carried out according to randomized blocks design with three replications (3 packaging · 2 temperature · 3 replications). Chemical properties of pistachio nut paste samples that stored at refrigerated temperature were better than those stored at ambient within all packaging types. Storage of pistachio nut pastes at ambient temperature resulted in shorter terms of shelf life. Pistachio nut pastes stored at refrigerated temperature in sealed glass jars were more acceptable with respect to the chemical properties measured as compared to the other packaging types.

Key words:-Pistachio,pH, peroxide value, FFA value and TBA

1. INTRODUCTION

Pistachio nut (Pistachiavera L.) is grown mainly in Iran, USA, Syria, Turkey, Greece and Italy (Kuc¸ukoner& Yurt, 2001, 2003). It is one of the most popular nuts in the world with its high nutritional value and unique flavour as a snack and a food ingredient. It contains around 23% protein, 19% carbohydrate and 5% moisture (Kuc¸ukoner& Yurt, 2003; Pala, Ac¸kurt, &Lo¨ker, 1994). Pistachio nut also contains high amounts of K and P, and various amounts of Ca, Mg and Fe. The fatty acid composition of the nut is 54.4–71.8% oleic acid, 16.7–35.3% linoleic acid, 7.2–10.5% palmitic acid, 0.9–2.5% stearic acid and less than 2 % linolenic acid (Koroglu, 1997). A great difference in fat content of pistachio nut was reported by several researchers. It was reported 56% by Kuec¸ukoner and Yurt. (2003) and Pala et al. (1994), and between 40.6% and 53.5% by Koroglu (1997)

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. The major cultivars of nuts grown in Turkey are Siirt, Ohadi, Halebi, Kirmizi and Uzun. Producers prefer Kirmizi and Uzun cultivars for the production of baklava and nut paste because of their special green kernel color, flavour and texture (Kunter, Gulsen, &Ayfer, 1995). It is reported that these pistachio cultivars are preferred in many European and USA markets due to their unique characteristics (Satil, Azcan, & Baser, 2003).

Nut paste is made by mixing ground pistachio nut with boiled syrup (mixture of glucose–sucrose–water) and kneading the mixture when it reached to a moderate temperature, and finally, it is shaped. Pistachio nut paste is sold within one or two days, and consumed as fresh. In traditional way, it is not stored for longer term. No research was found on storage conditions and packaging material of pistachio nut paste. The pistachio nut paste contains water, fat, protein and high amount of sugar. Therefore, deteriorative reactions may occur during the long-term of storage of this product. These reactions are lipid oxidation and browning reactions (Maska & Gogus, 1997).

The water activity is another important factor that influences the deteriorative reactions. The water activity of the pistachio nut paste is around 0.72 at its initial moisture (Maskan & Gogus, 1997). In foods with water activities between 0.65 and 0.85, the lipid oxidation rate is rather fast (Ozc¸elik&Evranuz, 1998). The effect of temperature on lipid oxidation mainly occurs during decomposition of the alkyl peroxides, and resulting fatty acids accelerate as catalyzer the lipid oxidation (Ozc¸elik&Evranuz, 1998).There are very few research related to pistachio nut paste available in the literature.The aim of this research was to determine the factors affecting the quality of the pistachio nut paste and also to determine its shelf life.

Materials and methods

Pistachio nut paste was prepared according to local production processor. The pistachio nuts that to be processed into paste were harvested a month before harvesting

ISBN: 978-93-85822-60-5

maturation to keep the deserved aroma and color. The pistachio (4% moisture, 28% protein, 51% fat, 16% carbohydrate, 1% ash) was milled. Sucrose (51%) and glucose (8%) were dissolved in water (25%), mixed and boiled until Brix 75 was reached. The milled pistachio (16%) was added into boiled syrup, mixed and kneaded until a homogenous structure was obtained. Light and water vapour transmittance of packing material have affect on color and taste of product due to oxidation of pigments and fatty acids.

Storage temperature also affects the rate of these chemical reactions. Therefore, three casing methods and two storage temperatures were applied in the experiment. The pistachio nut paste was divided into three parts. The first part was filled into transparent glass jars of 200 g each, at processing temperature (hot-filling) completely to remove the air at top space. The second part was filled into transparent HDPE(32.5 l) pouches (8 · 15 cm) of 200 g each when it reached to room temperature and sealed. The last part was transferred into HDPE material, and closed by hot seaming process under vacuum application. The samples were stored at 4 and 20 C for 210 days in dark condition. At each test period one of each group was analysed

The experimental nut samples in three packing types, two storage temperatures were analysed for peroxide values (meq kg^{1}), total acidity (%) (O¨ zkaya, 1988), free fatty acid (%) (Nas, Gokalp, &Unsal, 1992), pH, moisture content (%)Koroglu, 1997; Kuc¸ukoner& Yurt, 2003; Kunter et al., 1995; Maskan&Gogus, 1997; Nas et al., 1992; Pala et al., 1994; Satil et al., 2003; Ozc¸elik&Evranuz, 1998; O¨ zkaya, 1988), fibre content (%) (Elgu¨n, Certel, Ertugay, &Kotancilar, 1998), protein content (%) (AOAC, 1990), Thiobarbutiric acid (TBA) values (Rudolph & Odell, 1992) of the pistachio nut paste on the first day and on the first day of each month during 210 days storage. pH and total acidity are of significance with respect to taste balance of pistachio nut during storage period. Because of high buffer capacity of proteins, not only pH but also total acidity were determined. Free fatty acids were measured to determine the extend of lypolysis and expressed as % oleic acid.

The thiobarbituric acid solution was prepared by dissolving 0.67 g of 2-thiobarbituric acid in distilled water with the acid in a steam cone, transferring into a 100 ml volumetric flask, cooling and making up the volume. The TBA reagent was prepared by adding 100 ml of glacial acetic acid to 100 ml of TBA solution. The pistachio nut paste oil was dissolved in benzene and TBA reagent was added into it and the mixture was blended by a vortex mixer, transferred to a funnel, finally oil was transferred to a boiling water bath, cooled and the absorbance was measured at 530 nm (Rudolph & Odell, 1992).

The experiment was carried out according to randomized blocks design with three replications (3 packaging · 2 temperature · 3 replications). Analysis of variance (ANOVA) was carried out using the least significance difference (LSD) test at the level of $p < 0.05$. The calculations were performed using SPSS 10.0 for windows. The data obtained were analyzed due to variance by using logarithmic, linear and exponential models. The mathematical model that gave the maximum regression coefficient was used to determine the shelf life of the pistachio nut pastes. 3. Results and discussion

The pistachio nut paste analysed contained 9.57% moisture, 7.84% fat, 0.86% ash, 9.21% protein, 1.10% fibre. The results also showed that the nut paste contained almost equal amounts of protein and moisture, and high amount of sugar being more than 70%. The composition of the pistachio nut paste is similar to the study based on the pistachio nut paste reported by Maskan and Gogus (1997), which contains 7.46% water, 7.00% fat, 6.16% protein, 78.14% sugar, 0.78% ash and 0.46% fibre.

As seen in Tables 1 packaging type, storage temperature and storage period affected the parameters of pistachio nut paste significantly ($p < 0.05$).

Table 1

The effects of packaging type on the some chemical properties of the pistachio nut paste

Parameters	Packaging type		
	Vacuumed HDPE	Non-vacuumed HDPE	Sealed jar
Peroxide values (meq kg1)	0.34b	0.40a	0.31c
pH	5.98b	5.98b	6.05a
Total acid (%)	2.35b	2.50a	2.19c
Free fatty acid (%)	0.61b	0.65a	0.56c
Moisture (%)	8.37b	7.65c	9.29a
TBA (A530)	0.03b	0.04a	0.03b

Different letters indicate that means differ at a level of 0.05

The peroxide values of the nut paste stored in sealed glass jar (0.31 meq kg^{1}) was lower than those stored in vacuumed (0.34 meq kg^{1}) and non-vacuumed(0.40 meq kg^{1}) HDPE materials (Table 1). The nut paste that stored in non-vacuumed HDPE materials had higher peroxide values than other samples. The slight increase in peroxide value in vacuum-packed samples may be due to penetration of oxygen through the packaging material from surroundings. The higher storage temperature resulted in higher peroxide values (Table 2). The increase in the peroxide values could be attributed to the oxidation of fats in nut paste. Increase in storage temperature causes oxidation of fats, which produces alkyl peroxides. Torun (1999) reported that the peroxide values of walnut paste stored at different temperatures increased throughout the storage. The peroxide values increased steadily during the

ISBN: 978-93-85822-60-5

storage period from 0.05 to 0.63 meq kg^1 (Fig. 1). Maximum peroxide level of 10 meq kg^1 is allowed for fat and fatty foods (Nas et al., 1992). The pistachio nut paste in sealed jar had higher pH values as compared to vacuumed and non-vacuumed HDPE materials (Table 1). The higher storage temperature (20° C) resulted in lower pH values than lower storage temperature (4° C) (Table 2). The pH values of the pistachio nut paste dropped gradually during the storage period (Fig. 2) from 6.39 to 5.61 at 20° C and to 5.95 at 4° C. The paste stored in sealed jar had lowest free fatty acid content as compared to the samples stored in vacuumed and non-vacuumed HDPE materials, respectively (Table 1). The free fatty acid values of the paste stored at 4 °C was lower as compared to the pastes stored at 20 C. The free fatty acid value of the pistachio nut paste increased from 0.33% to 1.16% during the storage period. It increased slightly up to the third stage of the storage period; afterwards increased dramatically (Fig. 3). Similarly, Torun (1999) reported that the free fatty acid (%) and total acidity

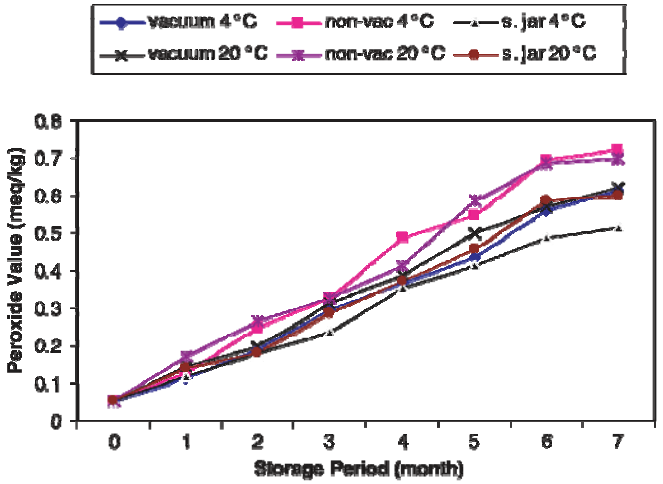

Fig. 1. Peroxide values of pistachio nut paste during storage

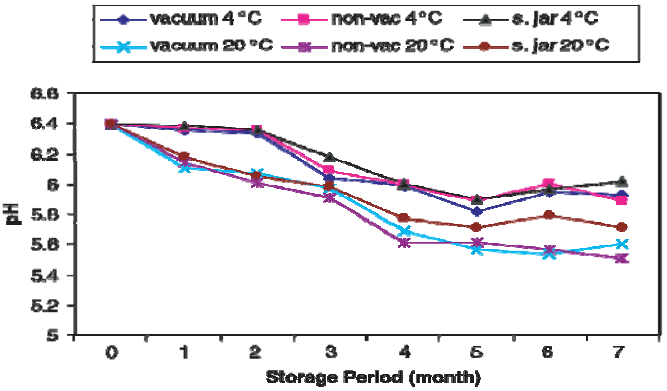

Fig. 2. pH of pistachio nut paste during storage

Similarly, Torun (1999) reported that moisture content of walnut paste decreased during the storage at (%) of the walnut paste increased during the storage. In the same way increasing storage temperature led to increases in the free fatty acid and total acidity (%), and to a decrease in the pH values of the walnut paste. Similarly, the total acidity of pistachio nut paste stored at 4° C was lower than that of stored at 20° C. The total acidity of pistachio nut paste stored in sealed jar was lower than either of those stored in vacuumed and non-vacuumed HDPE materials, respectively. It increased during the storage period from 1.24% to 3.57% (Fig. 4).

The pistachio nut paste stored in sealed jar had higher amount of moisture than those stored in vacuumed and non-vacuumed HDPE materials (Table 1). The moisture content of the pistachio nut paste stored at 4° C was higher than those stored at 20

The effects of storage temperature and storage period on some chemical properties of the pistachio nut paste

Parameters	Storage temperature		Storage p	
	4 C	20 C	0.P	
Peroxide values (meq kg1)	0.34b	0.36a	0.05h	(
pH	6.12a	5.89b	6.39a	(
Total acidity	2.05b	2.64a	1.24h	
Free fatty acid	0.52b	0.70a	0.33h	(
Moisture	8.65a	8.22b	9.57a	9
TBA (A530)	0.03b	0.04a	0.03b	(
Browning indice (A420)	1.39b	1.44a	1.32h	

Different letters indicate that averages differ at a level of 0.05.

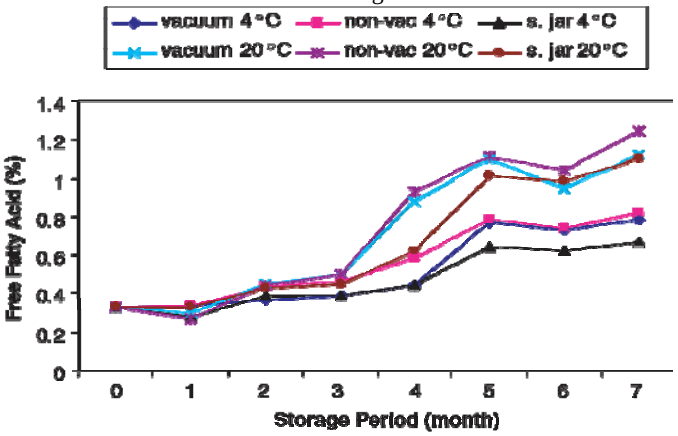

Fig. 3. Free fatty acidity of pistachio nut paste during storage.

C (Fig. 5). It decreased from 9.57% to 7.17% during the storage period

ISBN: 978-93-85822-60-5

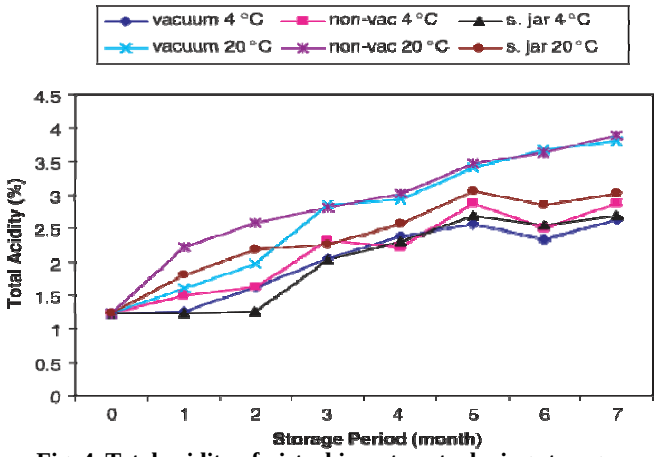

Fig. 4. Total acidity of pistachio nut paste during storage.

different storage temperature with various packaging materials.

The pistachio nut paste in sealed jar had lower browning indice as compared to those in vacuumed and non-vacuumed HDPE materials (Table 1). Browning reactions are reported to occur due to Maillard reactions in pistachio nut paste at higher water activity values and higher temperatures (Maskan&Gogus, 1997).

The 2-thiobarbituric acid is used as a reagent to indicate rancidity for foods which contain polyunsaturated fatty acids. It condenses with malonaldehydes (an oxidation product of linoleate) producing a pink color and also reacts with aldehydes and dienals, giving orange colors (Rudolph & Odell, 1992). This test, which gives the best result for foods that contain polyunsaturated fatty acids, was used by previous researchers to indicate the edibility of walnut. The TBA values of paste sample stored in non-vacuumedpackages was significantly higher than those in sealed jar and vacuumed PP. The TBA values of paste samples stored at 4 C were lower than those stored at 20 C in general. Though the difference was statistically significant ($p < 0.05$), the TBA values were very close to each other. The TBA values (A_{530}) during storage period were constant (0.03) until 5th period, afterwards it increased to 0.04. This result may be attributed to higher amount of oleic and less amount of linoleic acid content of pistachio nut paste (see Fig. 7).

Changes in peroxide values, moisture content, total acidity and free fatty acidity of the pistachio nut paste were measured due to variance analysis and linear, exponential and logarithmic mathematical models were applied to the obtained data during the storage at 4° and 20° C. The curves that have a higher regression coefficient among the mathematical models were accepted as shelf life curve of the pistachio nut paste and the shelf life was determined due to minimum values of the quality criteria (peroxide value, total acidity, free fatty acid and moisture content) of the nut paste that the average values found by using the multiple comparing test.

Considering the peroxide values, the shelf life of the nut paste stored in sealed jar at both 4 and 20 C were 69– 64 days, and 70–64 days in vacuumed HDPE, and 66–63 days in non-vacuumed HDPE packaging, respectively.The shelf life of the nut paste based on the equation of total acidity stored at 4°C and 20° C were 111–65 days in sealed jar80–58 days in sealed jar, 67–66 days in vacuumed HDPE and 49–24 days in non-vacuumed HDPE packaging, respectively.

Finally, the shelf lives of the nut paste based on the equation of browning indices stored at 4 and 20° C were 89–41 days in sealed jar, 50–36 days in vacuumed HDPE and 59–26 days in non-vacuumed HDPE packaging, respectively.

The obtained results were similar to the study of walnut paste production method and improvement of shelf life of walnut paste (Torun, 1999). The peroxide values, total acidity (%), free fatty acid (%) values of walnut paste which was produced with different formulas in aluminium packages increased during the storing up to 90 days at 4 and 20 C, respectively.Activation energies (E_a) were determined by using Arrhenius equation as 2413.4 J mole^{1} for peroxide, 10,680.4 J mole^{1} for total acidity, 12,551 J mole^{1} for free fatty acid and 1492.2 J mole^{1} for the browning reactions.

Finally, average values of the shelf lives of pistachio nut paste based on the obtained results change between 49 and 113 days stored at 4 C and 26–80 days stored at 20 C for sealed jar, vacuumed PP and non-vacuumed HDPE, respectively.

Pistachio nut paste is nutritious and preferred product. Because it is consumed as fresh and not stored in traditional way, it is produced and consumed locally. In recent years it is gaining popularity. This study showed that it can be stored in good condition.

As a result, the pistachio nut paste stored at 4°C was more acceptable due to low deteriorative reactions as compared to those stored at 20°C. The sealed glass jar was found to be more suitable as compared to the HDPE. Producers prefer the HDPE materials for packaging purpose but this study showed that sealed jar is more suitable for packaging. Pistachio nut paste that stored in sealed jar protected their properties up to the end of storage period.

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ISBN: 978-93-85822-60-5