Araştırma Makalesi
(Research Article)

Ege Üniv. Ziraat Fak. Derg., 2015, 52 (1): 235-242
ISSN 1018 – 8851

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Changes in Quality of Dried Fig (*Ficus carica* L.) Delight in Different Packages under Cold and Ambient Storage

Kuru İncir Lokumunun Soğuk ve Normal Depo Koşullarında Farklı Ambalajlarda Kalite Değişimleri

Alınış (Received): 21.01.2015 Kabul tarihi (Accepted): 27.05.2015

Key Words:

Fig delight; package; quality; shelf life; walnut

ABSTRACT

Different products are being developed based on dried fig fruit, a traditional export commodity in Turkey. A kind of Turkish delight, fig delight or locum, is also processed from dried figs either plain or mixed with nuts. A research was designed to test the durability of fig delight in storage in order to determine its performance in the market. Fig delights packed in carton or metal boxes as found commercially were stored in cold conditions (3°C, 55-65% RH) and ambient conditions (19.2°C, 56.7% RH) for 12 months. Changes in quality of the product were monitored. Divergence in oil content and quality were analyzed also in other raw materials, walnuts (as mixture) and coconut (as coating). Metal boxes retained the moisture content better under ambient conditions compared to carton boxes. Palatability of fig delight was lost after 6 months of storage under ambient conditions whereas quality was preserved for 12 months under cold conditions.

Anahtar Sözcükler:

İncir lokumu, paketleme, kalite, raf ömrü, ceviz

ÖZET

Türkiye'nin geleneksel ihracat ürünlerinden olan kuru incire dayalı olarak son yıllarda birçok farklı ürün geliştirilmektedir. Bir çeşit lokum olan incir lokumu da sadece kuru incir kullanılarak veya sert kabuklu meyvelerle karıştırılarak üretilmektedir. Bu araştırma, incir lokumunun pazar koşullarındaki performansını belirlemek üzere depodaki dayanımının belirlenmesi amacıyla planlanmıştır. Bu amaçla ticari olarak pazarda bulunduğu şekliyle karton veya metal kutularda paketlenen incir lokumları soğuk (3°C, % 55-65 oransal nem) ve normal oda koşullarında (19.2°C, %56.7) 12 ay süreyle depolanmıştır. Kalitedeki değişimler izlenmiştir. Ürüne ilave edilen ceviz (karışım halinde) ve Hindistan cevizi (kaplama şeklinde) gibi diğer hammaddelerde de yağ içerikleri ve üründeki kalite değişimleri izlenmiştir. Metal kutuların normal oda koşullarında lokumlardaki nemi karton kutulara göre daha iyi koruduğu belirlenmiştir. İncir lokumlarının yenme kalitesini normal oda koşullarında saklamada 6 ay sonunda kaybettiği, soğuk koşullarda ise 12 ay süreyle koruyabildiği belirlenmiştir.

INTRODUCTION

All over the world, Turkey plays a significant role in the sun-dried fruit trade. For dried figs (*Ficus carica* L.), Turkey is known for the supreme quality with large fruit size, light color and soft texture. Dried figs destined to the export market are produced in the western part of the country. The annual Turkish dried fig production ranges between 45 and 60 000 tonnes according to the yearly climatic conditions and comes from a single cultivar, Sarılop (=Calimyrna). Domestic consumption is rather limited, and 85 to 90 % are exported to the European market within a year (Anonymous, 2014). Dried figs are generally consumed without further processing. However, in recent years, different products made from dried figs have been demanded by the consumers.

Dried fruit including figs are accepted as part of a healthy diet because of their high nutritive value (Vinson, 1999; Javanmard, 2010). Dried figs are rich in pectic substances helping rapid removal of toxic substances from the digestive track, lowering LDL cholesterol, and preventing rapid increase of blood sugar levels. High mineral levels especially iron in dried fig fruit make it an attractive food for pregnant women, children or anemic patients (Vinson, 1999; Miller *et al.,* 2000). In this respect, diversifying the dried fig product range and preparing nutritive foods appealing for children becomes a challenge.

Dried fig fruit are used as an ingredient or raw material in food industry in biscuits (e.g. fig bars), muesli, or coffee (Aksoy *et al.,* 2007). The paste, basic raw material, is produced from dried figs by grinding and it is then further processed into sweets or snacks by mixing with nuts, sesame seeds or other suitable ingredients. Turkish delight or locum is a traditional product known for centuries in Turkey and the Middle East. Fig delight, a modified version of the Turkish delight, is prepared by mixing fig paste, sugar, starch (modified), walnut, coconut, water and citric acid.

Quality of fig delight is affected by storage conditions, and this effect is expected to enhance as the storage temperature and period is extended. The major quality changes in fig delight during storage in different conditions is the darkening of color, hardening of texture due to water loss, microbial growth and poorer palatability. Fig delight has higher added value compared to dried fig fruit and can be marketed throughout the year by maintaining the right packaging and storage conditions. For dried fig fruit, the storage conditions are recommended as 0-4ºC and 55-65% relative humidity (Sen *et al.,* 2008). In literature, no study has been found on the changes in the quality of fig delight during storage. Thus, this research is designed to identify the quality changes of fig delight packed in metal and carton boxes and stored under cold or ambient conditions.

MATERIALS and METHODS

Fig Delight and Storage Conditions

The research is carried out on products processed from sun-dried fig fruits of Sarılop (*Ficus carica* L.) variety. The dried fig fruits are obtained from TARIS Fig Sales Cooperative as Grade A. Fig delight is processed at TARIS premises according to the basic flowchart developed by mixing fig paste, sugar, starch (modified), walnut, coconut, water and citric acid. Each group was produced as 120 kg. Fig delights were packed in carton boxes (lined with cellophane, 62 micron, 500 g) or in metal boxes (lined with cellophane, 700 g) and wrapped with a shrink film (15-17 micron).

Fig delight was kept at cold storage (3±0.5ºC, 55-65% RH) and ambient (fluctuating temperature and relative humidity) storage conditions at TARIS Fig Processing Plant for 12 months. The average temperature and relative humidity were monitored during 12-months period from September to September under ambient storage conditions, and the values ranged between 9.7 and 30.1ºC (mean 19.2±7.5°C) and 38.7% and 69.7% RH (mean 56.7±10.6%).

Samples were derived from all tested variables (products) monthly as 4 replicates and analyzed to determine the same quality changes that occur during storage. Each treatment was composed of one metal and carton box. The oil analyses were performed at 2 months intervals in walnut and coconut.

Quality Attributes

Moisture content was measured by drying samples in an oven (65ºC, UM400, Memmert, Germany) to a constant weight (AOAC, 1990) and calculated based on the percentage of weight loss. Water activity was measured with a water activity meter (TH 500, Novasina, Pfaeffikon, Switzerland) at 25°C.

The surface color was measured on 20 fig delight cubes with a colorimeter (CR-300, Minolta Co., Osaka, Japan). The colorimeter had an 8 mm diameter viewing area and was calibrated with a white tile (L^*=97.26, a^*=+0.13, b^*=+1.71). Measurements were recorded in L^* (lightness), $+a^*$ (redness) and $+b^*$ (yellowness) CIE (Commission Internationale de l'Eclairage) color co-ordinates.

Total soluble solids content (TSS) was determined with a refractometer (ATC-1, Atago, Japan) and expressed as g/100 g. Titratable acidity content (TA) was analyzed by titration with 0.1 N NaOH up to pH 8.1 and expressed as g citric acid/100 g (Sen *et al.,* 2008).

Sensory Analysis

The sensory evaluation was based on five sensory attributes, appearance, color, texture, taste and overall acceptability. Fig delights were analyzed for sensory changes at monthly intervals by a panel of 6 judges who were previously acquainted with fig delight. The scores were noted over a hedonic scale with a maximum score of 5 for "like extremely" and minimum of 1 for "dislike extremely" (Amerine *et al.,* 1965).

Oil Content, Peroxide Value, Fatty Acid Content and Composition

Oil (AOAC, 1990) and fatty acid contents (AOCS, 1998a) and peroxide value (AOCS, 1998b) were determined in walnut and coconut used in processing fig delight. The fatty acid composition was determined on the lipid extracts after methylation to form fatty acid methyl esters (FAME) according to IUPAC Method No.: 2.301 (IUPAC, 1990) by a Hewlett Packard 6890N gas chromatograph (Agilent, Polo Alto, CA), equipped with a Supelco SP2380 capillary column (60 m x 0.25 mm i.d., 0.20 μm film thickness; Supelco, Bellefonte, PA) and flame ionization detector (FID). Helium was used as the carrier gas at flow rate of 1.1 ml/min; the split ratio was 1:20. An a a sampler/injector HP7683 B Series was used and the injector and detector temperatures were 220°C and 260°C, respectively. The oven temperature was programmed at 180°C, isotherm.

Statistical Analysis

The experiments were conducted as completely randomized design with four replicates. Significant differences among groups were determined using Duncan's multiple range test at $P<0.05$. The quality changes in the samples at ambient and cold temperatures were evaluated separately. Standard deviation of the mean (SD) was also calculated from the replicates. All data were subjected to analyses of variance (ANOVA) by using IBM® SPSS® Statistics 19 statistical software (IBM, NY, USA).

RESULTS

In fig delight, darkening was instrumentally detected after 7 months in storage under ambient conditions. Therefore, even if some of the analyses were carried onward, the experiment under ambient conditions were terminated after 8 months.

The moisture content did not change significantly in fig delights packed in metal or carton boxes stored under cold conditions. On the other hand, the moisture loss was significant ($P<0.01$) under ambient conditions in both packaging types. This loss was more appearent in carton boxes. The moisture loss became marked in both packaging types especially after 6 months of storage under ambient conditions (Fig. 1a).

The water activity (a_w) levels of fig delight displayed significant ($P<0.01$) variations during the storage period under both conditions. Under cold storage, the levels first increased in both packaging types however decreased to levels below the inital value at the end of the storage period. The decreases were marked towards the later part of storage under ambient conditions. The reduction in water activity was higher in fig delights packed in carton compared to metal in both tested storage conditions leading to higher mean a_w values ($P<0.01$) in metal boxes (Fig. 1b).

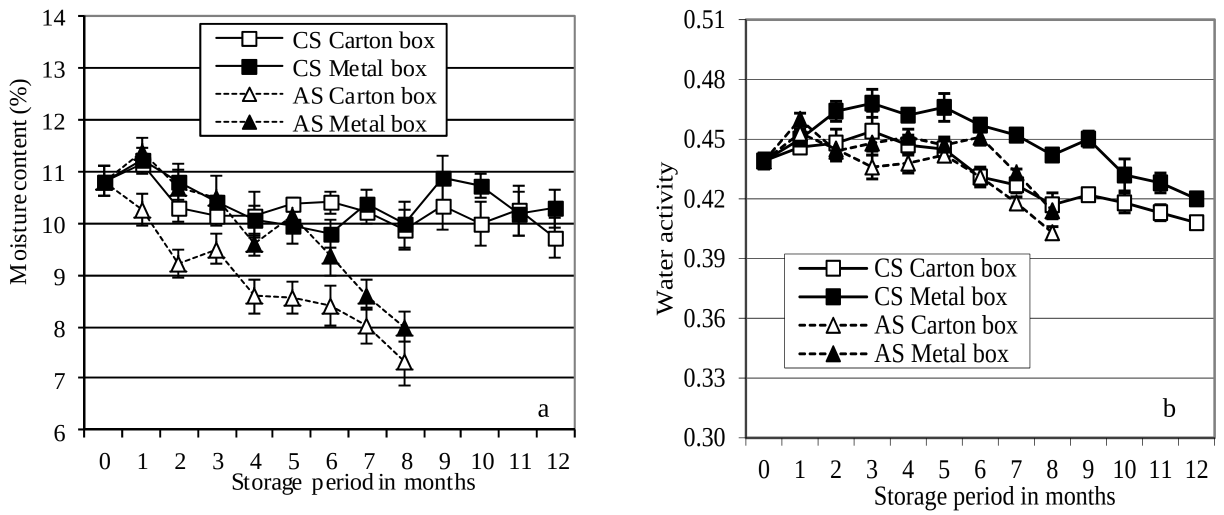

Figure 1. Changes in moisture content (a) and water activity (b) of fig delight packed in metal or carton and stored under cold or ambient conditions. CS, cold storage; AS, ambient storage.

L^* value showing the lightness of colour did not vary between the two packaging types in cold storage and ranged between 67.49 and 72.28. Under ambient conditions, the L^* value showed marked ($P<0.01$) decreases after 5 months of storage in both packages, and at the end of the storage (8th month) the values decreased to 60.81 in carton and to 58.36 in metal boxes (Fig. 2a). The colour b^* values of fig delight packed in carton or metal boxes demonstrated similar trends in cold storage. Under ambient storage, these changes were significant ($P<0.01$). The b^* value increased more rapidly during the initial period (first 3 months) and at the very end of storage (8th month) as a result of the prevaling higher temperatures compared to the winter period. The mean b^* values were slightly higher ($P<0.05$) in metal boxes compared to carton boxes (Fig. 2b).

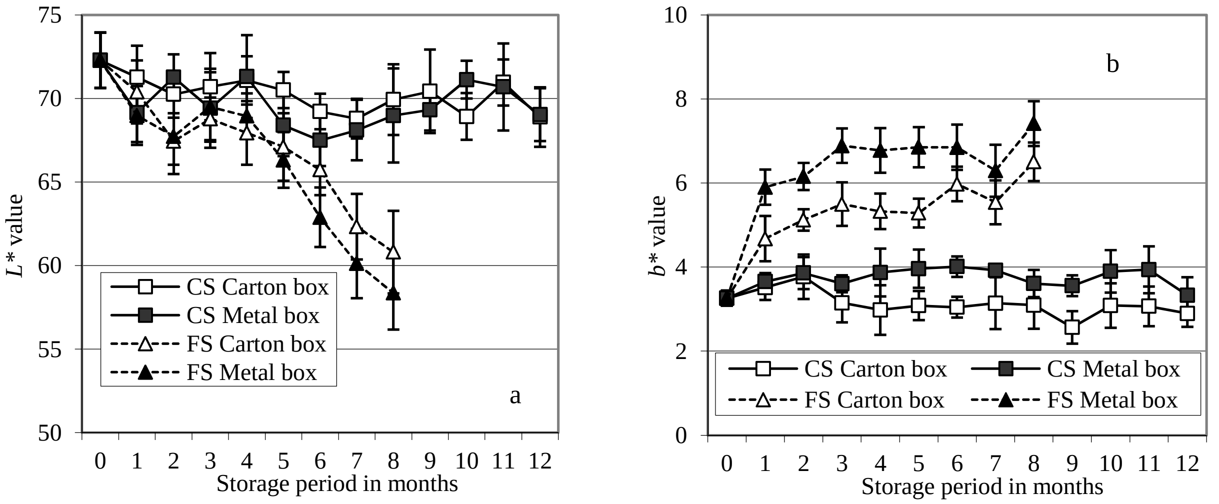

Figure 2. Changes in L^*(a) and b^*values (b) of fig delight packed in metal or carton and stored under cold or ambient conditions. CS, cold storage; AS, ambient storage.

The changes in TA content of fig delight packed in carton or metal boxes stored in cold conditions displayed similar trends. The TA content increased significantly ($P<0.05$) in both packaging materials after 6 months of storage under ambient conditions (Fig. 3).

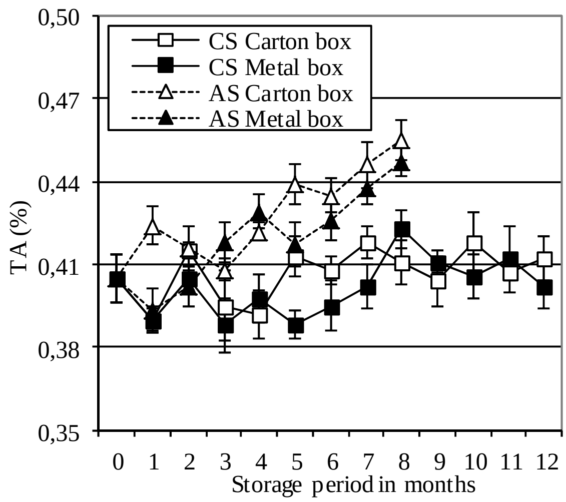

Figure 3. Changes in TA content of fig delight packed in metal or carton and stored under cold or ambient conditions. CS, cold storage; AS, ambient storage.

The overall acceptability of cold stored fig delight decreased during the latter half of storage significantly ($P<0.05$). Despite the decrease of scores during the storage period, the overall acceptability of fig delight packed in both the metal and carton boxes remained at reasonable levels (Table 1). All the other parameters evaluated by sensory analyses were quite high and ranked above 3.8 (data not shown). On the other hand, under ambient storage, the acceptability scores remained constant for 2 months in both packaging types however major ($P<0.01$) reductions happened starting from the 6th month and onward (Table 1). The color changes in grated coconut and fig delight started after 7 months of storage and became significant on the 8th month leading to reduced acceptability scores. In addition to this, the taste scores decreased noticeably (data not shown). Thus, reduced taste and discoloration resulted in extremely low acceptability scores at 7th and 8th months of storage under ambient conditions therefore fig delight was evaluated as not suitable for further consumption. The results were similar in both packaging types.

Table 1. Changes in overall acceptability of fig delight packed in metal or carton and stored under cold or ambient storage conditions.

Storage period in months	Cold storage		Ambient storage	
	Carton box	Metal box	Carton box	Metal box
0	5.0 a[a*]	5.0 a[*]	5.0 a[**]	5.0 a[**]
1	5.0 a	5.0 a	5.0 a	5.0 a
2	5.0 a	5.0 a	5.0 a	5.0 a
3	5.0 a	5.0 a	4.7 ab	4.5 ab
4	4.7 ab	4.5 ab	4.3 ab	4.7 ab
5	4.5 ab	4.7 ab	4.5 ab	4.3 ab
6	4.7 ab	4.3 b	4.2 b	4.0 b
7	4.3 b	4.2 b	3.2 c	3.0 c
8	4.2 b	4.3 b	2.3 d	2.0 d
9	4.3 b	4.2 b		
10	4.0 b	4.2 b		
11	4.2 b	4.0 b		
12	4.0 b	4.3 b		

[a]Means for each storage condition were separated within columns by Duncan's multiple range test, $P<0.05$

[*], [**] Significant at $P<0.05$, or $P<0.01$, respectively

The initial oil and fatty acid contents, peroxide value and fatty acid composition of walnut and coconut and the occurring changes under both tested storage conditions are displayed in Tables 2 and 3. Quality of walnut stored at cold conditions stayed rather stable however under ambient storage conditions the fatty acid content increased significantly ($P<0.01$) starting from March, and peroxide values increased ($P<0.01$) from May and onwards. The changes in oil composition of walnut during storage were limited under both conditions (Table 2). Palmitoleic (C16:1), arachidic (C20:0) and eicosenoic acid contents were minor and did not exceed the following values 0.07%, 0.10% and 0.16%, respectively.

The peroxide value of coconut displayed marked ($P<0.01$) increases under both storage conditions, on the other hand, the oil content and fatty acid content changes were not significant (Table 3). Under cold storage, the variation in coconut oil composition was stable however under ambient storage conditions oleic acid content decreased significantly ($P<0.05$) whereas there were no noticeable changes in other fatty acids (Table 3). Caproic (C16:0), lineloic (C18:2), ecosenoic (C20:1) and ecosadienoic acid (C20:2) contents were quite low and the maximum levels were found as 0.60%, 0.95%, 0.16%, 0.43% and 0.14%, respectively.

Table 2. Effect of storage period under cold or ambient conditions and packaging type on oil content, fatty acid content, peroxide value and fatty acid composition of walnut used in fig delight[a].

Storage	Months	Oil content (% dry weight)	Fatty acid content (%)	Peroxide value (meq/kg)	Fatty acid composition (% of total oil)				
					C16:0	C18:0	C18:1	C18:2	C18:3
Cold	0	63.22±1.18^{NS}	0.56±0.01^{NS}	1.39±0.11^{NS}	6.06±0.03^{NS}	2.23±0.03^{NS}	17.81±0.03^{NS}	61.35±0.04^{NS}	12.36±0.03^{NS}
	2	62.90±1.13	0.67±0.07	1.19±0.22	6.67±0.02	2.44±0.04	16.78±0.02	61.23±0.05	12.59±0.05
	4	60.44±1.12	0.62±0.06	1.29±0.10	6.46±0.11	2.30±0.06	17.14±0.08	61.22±0.05	12.64±0.00
	6	63.32±1.26	0.81±0.06	1.55±0.16	6.64±0.09	2.22±0.10	16.92±0.14	61.09±0.43	12.97±0.15
	8	62.87±0.98	0.73±0.04	1.29±0.09	6.93±0.13	2.48±0.12	17.12±0.21	61.06±0.54	12.32±0.15
	10	64.80±1.05	0.77±0.05	1.41±0.27	6.61±0.05	2.38±0.01	17.77±0.05	61.00±0.05	12.17±0.09
	12	62.62±0.73	0.63±0.08	1.20±0.18	6.67±0.22	2.56±0.05	17.69±0.28	60.61±0.35	12.40±0.34
Ambient	0	63.22±1.18^{NS}	0.56±0.01 b^{b**}	1.39±0.11 b**	6.06±0.03^{NS}	2.23±0.03^{NS}	17.81±0.03^{NS}	61.35±0.04^{NS}	12.36±0.03^{NS}
	2	62.81±0.76	0.65±0.16 b	1.99±0.03 b	6.39±0.25	2.18±0.18	17.47±0.24	61.36±0.28	12.40±0.67
	4	64.58±0.64	0.76±0.07 ab	1.63±0.29 b	6.91±0.28	2.27±0.06	16.50±0.30	61.49±0.30	12.65±0.13
	6	63.50±0.98	0.72±0.04 ab	2.22±0.17 ab	6.52±0.09	2.27±0.03	17.38±0.08	61.37±0.21	12.30±0.17
	8	64.49±1.09	1.05±0.09 a	2.30±0.23 a	6.69±0.31	2.30±0.16	16.98±0.25	61.48±0.34	12.41±0.36
	10	64.04±0.16	0.98±0.05 a	2.28±0.12 a	6.63±0.14	2.35±0.12	17.06±0.04	61.59±0.06	12.27±0.08

^{NS}, **, Nonsignificant or significant at $P \leq 0.01$, respectively.

[a]Results are the means of four replicate samples ±*SD*.

[b]Means were evaluated separately for each storage condition and separated within columns by Duncan's multiple range test, P <0.05.

Table 3. Effect of storage period under cold or ambient conditions and packaging type on oil content, fatty acid content, peroxide value and fatty acid composition of grated coconut used in coating fig delight[a].

Storage	Months	Oil content ((% dry weight)	Fatty acid content (%)	Peroxide value (meq/kg)	Fatty acid composition (% of total oil)						
					C8:0	C10:0	C12:0	C14:0	C16:0	C18:0	C18:1
Cold	0	49.17±1.10^{NS}	0.17±0.01^{NS}	0.11±0.01 c^{b**}	6.21±0.03^{NS}	5.89±0.02^{NS}	49.29±0.19^{NS}	18.99±0.03^{NS}	8.92±0.06^{NS}	3.55±0.08^{NS}	5.66±0.04^{NS}
	2	50.38±0.99	0.18±0.01	0.14±0.01 c	7.37±0.36	6.38±0.27	49.47±0.59	18.10±0.19	8.35±0.29	3.26±0.27	4.93±0.20
	4	48.55±0.40	0.16±0.01	0.56±0.02 bc	7.95±0.25	6.71±0.13	49.85±0.21	18.03±0.19	8.00±0.17	3.19±0.10	4.79±0.11
	6	47.73±0.63	0.17±0.01	0.36±0.02 c	7.57±0.12	6.58±0.05	49.89±0.37	18.42±0.10	8.16±0.17	3.17±0.11	4.82±0.14
	8	47.55±0.86	0.20±0.02	0.91±0.04 b	7.46±0.42	6.06±0.31	50.01±0.53	18.69±0.10	8.22±0.13	3.56±0.21	4.86±0.07
	10	48.35±1.29	0.20±0.01	1.22±0.05 ab	6.57±0.13	6.21±0.08	49.82±0.47	18.96±0.23	8.55±0.17	3.63±0.22	5.02±0.15
	12	48.78±0.91	0.17±0.01	1.45±0.07 a	7.27±0.48	6.58±0.24	50.08±0.53	18.74±0.26	8.59±0.29	3.19±0.38	4.97±0.32
Ambient	0	49.17±1.10^{NS}	0.17±0.01^{NS}	0.11±0.01 c**	6.21±0.03^{NS}	5.89±0.02^{NS}	49.29±0.19^{NS}	18.99±0.03^{NS}	8.92±0.06^{NS}	3.55±0.08^{NS}	5.66±0.04 a*
	2	49.19±1.22	0.20±0.01	0.41±0.02 bc	7.54±0.07	6.41±0.03	49.60±0.15	18.09±0.03	8.08±0.05	3.22±0.04	5.14±0.05 a
	4	48.83±0.33	0.16±0.01	0.92±0.04 b	5.66±0.18	6.26±0.20	51.94±0.31	20.97±0.22	7.98±0.39	2.92±0.22	3.43±0.15 b
	6	48.59±1.05	0.15±0.01	1.39±0.03 ab	5.56±0.28	5.84±0.18	51.87±0.21	20.27±0.24	8.71±0.22	3.19±0.12	3.93±0.11 b
	8	48.95±0.77	0.18±0.02	1.11±0.02 b	7.08±0.15	6.45±0.08	50.78±0.27	18.73±0.15	8.02±0.10	3.08±0.09	4.55±0.13 b
	10	49.42±0.86	0.21±0.01	1.86±0.08 a	6.59±0.36	6.23±0.17	50.17±0.25	19.45±0.25	8.55±0.22	3.43±0.12	4.25±0.17 b

^{NS}, **, Nonsignificant or significant at $P \leq 0.01$, respectively.

[a]Results are the means of four replicate samples ±*SD*.

[b]Means were evaluated separately for each storage condition and separated within columns by Duncan's multiple range test, P <0.05.

DISCUSSION

The major quality decreases that occurred under ambient storage conditions were namely discoloration. In the experiment, the quality and overall acceptability of fig delight decreased after 6 months of storage under ambient conditions primarily due to higher temperatures starting in March (>12.7ºC). The increases in temperature and decreases in relative humidity under ambient storage conditions triggered moisture loss in fig delight. Since these two parameters exert significant effects on moisture content of the stored product, a decrease is expected as a consequence of these changes (Cemeroglu and Ozkan, 2009). On the other hand, due to the narrow variation in storage temperature and relative humidity levels, the reduction in moisture content was much more limited under cold storage. A negative correlation exists between the moisture content of dried fig fruit and tissue hardening (Sen *et al.,* 2008). Thus, reduced moisture content of fig delight enhanced hardening of the product. Gabas et al. (2002) also report that when products are air-dried, their structure collapses which in turn hardens the texture and increases chewiness. This condition was observed in fig delight stored under both cold and ambient temperatures.

The color of the coconut coating changed (*L** value decreased and *b** value increased) at the 7th and 8th months of storage under ambient conditions revealing that white color has turned into a yellowish color. This change was promoted by higher temperatures since non-enzymatic browning (Maillard reaction) are both speeded up at higher temperatures. On the contrary, lower temperatures are known to slow down these reactions (Karacali, 2002; Kader *et al.,* 2002; Cemeroglu *et al.,* 2009). The darkening of fig delight and the test scores of sensory evaluation support each other. On 7th and 8th months of storage under ambient conditions, the overall acceptability was reduced considerably as a result of discoloration.

Carton packaging material was slightly more affected by the prevailing conditions and the fig delight moisture contents were lower compared to those in metal boxes especially during the latter part of the storage period. The moisture loss of the product is influenced largely by the water tightness of the packaging material (Aksoy and Dokuzoguz, 1984). The reductions in moisture content and similarly in water activity were more limited in metal boxes. However the firmness and TA values did not vary significantly according to the packaging material.

The compositional changes in walnut and coconut during storage were more evident under ambient storage conditions due to accelerated oxidation at higher temperatures (Kader and Thompson, 2002). On the contrary, cold storage conditions have slowed down the reaction and have helped to preserve the quality (Olsen *et al.,* 1998). Lower temperatures reduce lipid oxidation which causes rancidity. For tree nuts, Kader and Thompson (2002) recommend storage temperatures between 0 and 10ºC according to the expected storage duration. The results also proved that taste, color, texture and aroma were preserved better under cold conditions supporting the recommendation for 12 months storage.

CONCLUSION

Under ambient conditions, fig delight cannot be stored for more than 6 months because of significant losses in some quality attributes. During winter, the ambient conditions (mean 9.2ºC) were close to the recommended cold storage conditions which may have delayed quality deterioration. The shelf life of fig delight will be shorter than 6 months in case of summer months (mean 30.6ºC) or in regions with higher temperatures. Cold conditions allow storage of fig delight successfully for 12 months without leading to significant quality or microbial problems. The quality of fig delight stored at cold conditions were retained even at the end of 12 months thus the storage period can be extended to the early new dried fig season when necessary.

ACKNOWLEDGEMENTS

This study was partially funded by the TARIS Research and Development Center, İzmir, Turkey.

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