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Research Article

Effect of Cold Storage and Packing Type on Khalas and Sukkary Dates Quality

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Abstract: With the introduction of cold storage in date palm cultivation areas, cold storage has been gaining popularity as it allows for dates consumption at any time of the year. In this study, the quality of two date cultivars, ‘‘Khalas’’ and ‘‘Sukkary’’, commonly grown in Saudi Arabia, were studied under cold storage. The chosen storage conditions were 12 months at 5°C. Data of fruit quality were collected at harvest, after 3, 6, 9 and 12 months, respectively of storage. Physicochemical characteristics of stored date fruits, such as moisture, Total Soluble Solids (TSS), tannins, pH, water activity, firmness, color, fruit weight, length and width, were measured. The results showed that cold storage and packing type could significantly affect physical and chemical quality of date fruits. Significant differences in fruit length, width and date seed width, were observed. Physical attributes such as fruit weight, length, width and date seed length, were significantly reduced due to storage period. Firmness of date fruits increased with the increase of storage time. There was significant effect of package type on TSS and water activity of Sukkary date. However, packing type had no significant effect on chemical characteristics for Khalas date. Storage time significantly affected moisture content and pH of date fruits. Water activity and pH of date fruits decreased during storage period. Packing type significantly affected color properties of Sukkary date compared with Khalas. Lightness, redness and yellowness showed significant differences during storage period. Lightness and yellowness increased significantly during storage time, while redness decreased significantly at same conditions. Cold storage is capable of being a viable alternative that allows for long term storage of date fruits.

Keywords: Cold storage, date, date quality, physicochemical characteristics

INTRODUCTION

Date palm is grown extensively in arid and semiarid regions of the world, such as North Africa, the Arabian Peninsula and South Asian countries. It is one of the oldest plants cultivated by human beings and has been used as food for around 6,000 years. Date palm plays an important role in the economic and social life of the people in date producing regions (Besbes *et al*., 2004; Sahari *et al*., 2007; Tang *et al*., 2013). The world production of date fruits has increased from about 4.6 million tons in 1994 to 7.68 million tons in 2010 and expectations are that their production yield will continue to increase (Al-Farsi and Lee, 2008; Ashraf and Hamidi-Esfahani, 2011; Tang *et al*., 2013). This indicates that the consumption and demand for date fruits are increasing every year and the production of date fruits is also increased to meet the increasing demands. There is a large demand on Saudi dates in the international market. However, cold storage for date fruit at full mature stage to extend shelf life is of great importance (Al-Redhaiman, 2005). Cold storage of date fruits has received more attention in recent years in the major date producing countries. Date industries usually store dates at 3°C up to a year (Aleid, 2013; Ismail *et al*., 2008; Al-Yahayai and Al-Kharusi, 2012). Many storage technologies are available and being used throughout the world to prolong the market life, maintain a high quality product and add value to dates in order to enhance the market competitiveness and economic value of edible product (Al-Yahayai and Al-Kharusi, 2012; Din *et al*., 2011). When stored at some specific conditions, date fruits can be subject to various quality degradation phenomena such as sugar crystallization at the surface of the dates, drying of soft dates, hydration, fermentation or surface color change and biological alterations due to the development of micro-organisms. Temperature is one of the most important factors, which affect the shelf life and the quality of date fruits. Temperatures which are low, but not low enough to cause chilling-injury, can slow down physiological activity. The Food and Agriculture Organization (FAO) has conducted several activities to prolong the storage of date fruits using refrigeration. The process is mainly based on slowing down of fruit maturity.

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Since quality parameters of date fruits are affected by storage, it is very important to understand the effect of storage conditions on the characteristics of date fruits. The literature contains many studies on the effect of storage on different fruit and vegetable attributes (Ismail *et al*., 2008; Harker *et al*., 2003). Unfortunately, few studies are focused on the effect of storage conditions on date quality parameters. Further research is needed to investigate the effect of storage conditions on date quality. Therefore, the aim of this study was to assess the effect of cold storage and packing type Khalas and Sukkary dates quality.

MATERIALS AND METHODS

Dates sampling and handling: Date samples were collected in 2011 season from two specialized orchards of date palms in the Alahsa region (Khalas cultivar) and Qassim region (Sukkary cultivar), Saudi Arabia. Dates were packaged in flexible plastic sacks and in a secondary carton boxes containing about 10 kg fruits, respectively. Packaged dates were preserved in a cold store at 5±0.5°C. A 2-way factorial experimental design with five replicates was employed with two types of packing boxes (Carton and Plastic) and two date cultivars (Khalas and Sukkary) as variables. Dates were stored for 12 months and tested each 3 months. Physicochemical characteristics including moisture, Total Soluble Solids (TSS), tannins, pH, water activity, firmness, color, weight, length and width of date fruits and seed, were measured.

Physical analysis: Date fruit weight was estimated using a sensitive balance with sensitivity of 0.1 mg (Model 204, Metter, Toledo, Switzerland). Length and width of date fruits and seed were estimated using a micrometer caliper (Model CD-15CW, Mitutoyo Corp., Japan). The volume of date fruits was determined by the water displacement method. Fruit firmness was determined according to Aleid and Dogan (2004), using a penetrometer (Stanhope-Seta Setamatic Penetrometer, Surrey, UK) with a cone weight of 102.3 g and a 45° cone angle. Measurements were conducted on five individual fruit per replicate. Firmness assessment for date fruits occurred prior to treatment application and thereafter at 3, 6, 9 and 12 months of storage, respectively. The results were expressed as penetration distance travelled in (mm) at room temperature.

Physicochemical analysis: Water activity (a_w) was determined according to AOAC (1995) methods using an AquaLab apparatus (Decagon Devices, Pullman Inc., Washington, USA). pH was measured according to AOAC (1992) methods. Color measurements for date fruit were measured using a color difference meter (Quest-45/0 LAV, Hunter Associates Laboratory, USA) standardized with black and green tiles. Relative brightness of stored dates was made at spectral range (400-700 nm), reporting interval every 10 nm and photometric range 0-150% reflectance. Sample color was reported in HunterLab color values. The color coordinates were determined: Lightness (L), redness (a, ±red-green) and yellowness (b, ±yellow-blue). D*E* (Delta *E*) which gives the value of the absolute difference of the three coordinates (*L*, *a* and *b*) was also determined. Measurements were conducted on fifty individual fruit per replicate (Aleid *et al*., 2012).

Chemical analysis: Moisture content was determined according to AOAC (1995) method. Moisture (g water/100 g sample) was determined by drying date fruits (5 g) under vacuum at 70°C until constant weight. TSS was measured according to AOAC (1992) method. Tannins content was determined according to Markkar *et al*. (1993).

Statistical analysis: Data were subjected to analysis of variance. Mean comparisons were performed using Duncan's multiple-range test to examine differences ($p<0.05$) among treatments. All analyses were carried out with SAS Ver. 6.02.

RESULTS AND DISCUSSION

Effect of cold storage time and packing type on physical properties of date fruits: Packing type could affect the physical properties of date fruits (Table 1). The influence degree depended on the cultivar. The significant differences were observed, especially in date fruits, width and date seed width. For Sukkary date, packing type could affect fruit length, fruit width, seed weight, seed width, fruit volume and fruit firmness significantly. However, packing type could affect fruit weight, length and width, seed length and width of date Khalas significantly. The reasons for these different results could be due to the difference of the collecting origin and cultivar of date fruits.

The results also in Table 1 indicated that storage time affected physical properties of date fruits significantly. Fruit weight was reduced from 11.92 to 8.74% for date Sukkary and from 8.64 to 7.82% for date Khalas, respectively. Furthermore, fruit length and width decreased significantly during storage period. Also, the change of fruit volume depended on the cultivar. Fruit volume of date Khalas was reduced from 9.0 to 8.0 cm^3 significantly due to storage time. However, fruit volume of Sukkary date decreased progressively. Storage time had not significant effect on fruit volume of Sukkary date. These results were similar with the results reported by Al-Yahayai and Al-Kharusi (2012). No change in fruit volume occurred after 10 months of storage in their study. In present study, no significant change in date seed weight occurred during the storage period for both date cultivars. Change of length and width of date seed depended on the cultivar. For Sukkary date, length and width of date seed were reduced significantly during 12-month storage time. However, only seed length of Khalas date was reduced significantly at the same conditions.

Table 1: Effect of cold storage time and packing type on physical properties of Sukkary and Khalas dates

Characters/ treatments	Fruit weight (g)	Fruit length (cm)	Fruit width (cm)	Seed weight (g)	Seed length (cm)	Seed width (cm)	Fruit volume (cm^3)	Firmness (mm)
Sukkary								
A: type of packing								
Carton	9.71	33.33	32.32	1.41	19.13	8.21	8.4	21.63
Basket	9.91	31.89	25.09	1.17	18.45	9.35	9.4	24.48
F-test	NS	**	**	*	NS	**	*	**
B: storage time								
Control	11.92	33.28	27.03	1.35	19.66	9.37	9.5	11.20
3 months	8.54	27.09	24.95	1.24	19.21	9.43	9.0	17.25
6 months	9.41	29.13	23.94	1.23	17.65	8.37	9.0	25.78
9 months	10.46	31.88	22.35	1.46	18.04	8.74	8.5	29.30
12 months	8.74	31.68	22.75	1.17	19.47	7.97	8.5	31.75
F-test	**	**	**	NS	*	**	NS	**
Khalas								
A: type of packing								
Carton	9.51	34.94	22.15	0.72	20.91	6.71	8.4	30.56
Basket	8.67	32.53	20.05	0.83	19.92	8.10	8.6	30.56
F-test	**	**	**	NS	**	**	NS	NS
B: storage time								
Control	8.64	37.33	23.05	0.83	22.75	7.15	9.0	26.10
3 months	9.84	36.24	20.24	0.85	22.97	7.24	9.5	29.80
6 months	10.12	33.69	22.53	0.69	20.14	7.76	8.0	28.15
9 months	9.02	31.33	20.58	0.73	18.43	7.17	8.0	39.90
12 months	7.82	30.10	19.11	0.77	17.78	7.69	8.0	28.85
F-test[a]	**	**	**	NS	**	NS	*	**

[a]: Significant terms (F-values) from analysis of variance procedure; *: Significant at $p \le 0.1$; **: Significant at $p \le 0.05$; NS: Not significant

Table 2: Effect of cold storage time and packing type on chemical proprieties of Sukkary and Khalas dates

Characters treatments	Sukkary Water content (%)	Sukkary TSS (%)	Sukkary Water activity	Sukkary Tannin (g/kg)	Sukkary pH	Khalas Water content (%)	Khalas TSS (%)	Khalas Water activity	Khalas Tannin (g/kg)	Khalas pH
A: type of packing										
Carton	12.56	82.96	0.626	0.00	5.53	17.11	80.32	0.504	0.004	5.42
Basket	12.64	85.10	0.542	0.00	5.38	17.54	79.94	0.497	0.005	5.43
F-test	NS	**	**	-	NS	NS	NS	NS	NS	NS
B: storage time										
Control	11.89	85.80	0.620	0.00	5.61	14.97	77.85	0.550	0.008	5.96
3 months	11.77	83.40	0.592	0.00	5.43	15.08	75.35	0.551	0.003	5.42
6 months	12.05	85.15	0.578	0.00	5.44	17.65	83.70	0.493	0.002	5.33
9 months	14.15	82.95	0.586	0.00	5.39	21.80	79.90	0.441	0.008	5.21
12 months	13.14	82.85	0.543	0.00	5.39	17.13	83.85	0.467	0.002	5.18
F-test[a]	**	**	**	-	NS	**	**	NS	**	*

[a]: Significant terms (F-values) from analysis of variance procedure; *: Significant at $p \le 0.1$; **: Significant at $p \le 0.05$; NS: Not significant

The observed firmness of date fruits increased with the increase of storage time. Generally, high negative correlation coefficients were found between firmness and moisture content of date fruits. Afoakwa and Sefa-Dedeh (2001) reported that the moisture and starch contents of the tuber were reversely related to the hardening phenomenon occurring in the tubers after harvesting. However, in our study, water content of date fruits increased with the increase of storage time (Table 2). Therefore, these are other reasons for these results in our study. Afoakwa and Sefa-Dedeh (2001) indicated that the plant cell wall polysaccharide constituents had high positive correlation with firmness of the samples. The main reason for the change of firmness of date fruits during storage period was probably due to the increase in cell rigidity and subsequent strengthening of cell wall bonding. Low temperature storage could therefore be used to effectively strength the firmness of date fruits.

Effect of cold storage time and packing type on chemical properties of date fruits: Packing type could affect TSS and water activity of Sukkary date significantly. However, for Khalas date, there was no significant effect of packing type on chemical properties (Table 2). TSS is a parameter significantly correlated with the perception of sweetness, date flavor and aroma intensity. TSS of Sukkary date was 82.96 and 85.10% for packing type (carton and basket) respectively. This difference could be due to the different conversion of some insoluble compounds into soluble compounds (such as the conversion of proto pectin into pectin) in date samples. Water activity of Sukkary date was reduced from 0.63 for carton packing type to 0.542 for basket packing type. This difference might be due to higher respiration rate of Sukkary date in the basket package compared to that of carton package.

Significant differences in TSS were observed between the two cultivars under different storage times (Table 2). TSS of Sukkary date significantly decreased from 85.80 to 82.85% after 12 months storage. The present results were in agreement with Lee *et al*. (2008). Abu-Goukh *et al*. (2003) also showed that Barakawi and Gondeila dates harvested by the traditional method had a significant reduction in TSS during storage. However, in present study, TSS of Khalas date significantly increased from 77.85 to 83.85% under the same storage conditions. Many similar results have been reported. Al-Kahtani *et al*. (1998), Afoakwa and Sefa-Dedeh (2001) and Azelmat *et al*. (2005) reported that TSS content in date increased gradually with the increase of storage time. This significant increase in TSS content could be due to the degradation in insoluble compounds present in date fruit. Differences between our study and the reported data could be attributed to cultivar variations and storage temperature (Wills *et al*., 1998; Ismail *et al*., 2008).

Tannins are water-soluble poly-phenol compounds that are reported to serve as a natural defense mechanism against microbial infection. Tannins also are reported to possess anti-carcinogenic and anti-mutagenic activity. The more advanced stage of ripening, the lower the fruit tannin contents. Tannins content in Khalas date decreased significantly during 12 months at cold storage (Table 2). The reason might be due to non-enzymatic activity (Al-Ogaidi and Mutlak, 1986; Abu-Goukh *et al*., 2003).

In this study, moisture contents of Sukkary and Khalas dates significantly increased from 11.89 to 13.14% and from 14.97 to 17.13%, respectively (Table 2). Many studies on the change of moisture contents in date fruits have been reported. Ihsanullah *et al*. (2005) suggested that moisture content of date fruits packed in white polythene decreased from 14.1 to 9.7% over 5 months period. Recently, Khan *et al*. (2008) reported that moisture content of dry date fruits decreased from 12.8 to 14.2% after 12 months storage at ambient temperature. Ismail *et al*. (2008) reported that storage time had no effect on moisture content of Khalas date, while Barhee's date had higher moisture content. Moisture levels of fruits have been reported to remain more or less constant under low temperature storage, but prolonged storage often leads to a decrease in moisture content (Afoakwa and Sefa-Dedeh, 2001; Omoigho and Ikenebomeh, 2000; Zare *et al*., 2002). However, in present study, significant increases in moisture content of both cultivars were observed, which could be attributed to the initially low level of moisture and the high TSS content in date fruits that would bound water leaving very little if free water to be lost.

pH of date fruits decreased during the storage period (Table 2). The reduction of pH of Sukkary date was from 5.61 to 5.39. Compared to that of Sukkary date, pH of date Khalas significantly decreased from 5.96 to 5.18. Similar observations have been reported in case of Dhakki date (Baloch *et al*., 2006). Baloch *et al*. (2006) studied the effect of controlled atmosphere on the stability of Dhakki date and found that a gradual decline in pH from 6.3 to 3.58 was observed during storage period. In this study, the continuous fall in pH during storage period demonstrated that both oxidative and non-oxidative mechanisms might be the cause for pH changes.

It is generally accepted that water activity is more closely related to physical, chemical and biological properties of foods and other natural products than to its total moisture content. Specific changes in color, aroma, flavor, stability and acceptability of raw and processed food have been associated with relatively narrow water activity ranges. Water activity of date fruits also played a vital role in governing pH changes and samples with reduced water activity displayed greater resistance against date fruits deterioration (Baloch *et al*., 2006). In this study, water activity of Sukkary date significantly decreased from 0.62 to 0.543. Also, water activity of Khalas date decreased from 0.55 to 0.467 (Table 2). Thus, date samples studied in this study might show higher resistance against contamination microorganism after 12 months storage.

Effect of cold storage time and packing type on color properties of date fruits: Color Measurements is important for classifying raw materials and knowing how technological processes affect the stored fruits. Instrumental color measurements using a spectrophotometer or colorimeter are the most used methods because of their close relationship with the visual perception of the human eye. Furthermore, such measurements are made on the surface of the product, are non-destructive, accurate and fast, allowing a better interpretation of color difference (Sanchez-Zapata *et al*., 2011). Packing type could significantly affect the color properties of date fruits, except redness of Khalas date (Table 3). Date fruits in carton packages showed higher lightness, redness and yellowness values compared to those in basket packages. The reason for these results might be due to the higher inhibition of oxidant reactions in carton packing.

Lightness, redness, yellowness and D*E* (Delta *E*) values which gives the total color difference showed significant differences during storage period. Lightness values increased during storage period. L values increased from 41.33 to 45.38 for Sukkary date and from 26.52 to 38.47 for Khalas date respectively. Lightness is related to moisture content. As shown in Table 2, water content increased with storage time. Therefore, lightness increased significantly after 12-months storage. Several authors have reported that lightness increased in different meat and meat products during refrigerated storage (Kusmider *et al*., 2002; Fernandez-Lopez *et al*., 2006, 2008). Redness of date fruits significantly decreased during storage time (Table 3). The reduction of redness could be due to the reduction of anti-oxidant compounds (poly-phenols). During storage period, the reduction of pH of date samples was observed (Table 2). This acid also might

Table 3: Effect of cold storage time and packing type on color properties of Sukkary and Khalas dates

Characters treatments	Sukkary				Khalas			
	(L) lightness	(a) redness	(b) yellowness	(DE)	(L) lightness	(a) redness	(b) yellowness	(DE)
A: type of packing								
Carton	48.14	11.05	34.02	60.68	33.12	12.18	22.99	42.35
Basket	39.42	9.91	27.60	49.60	31.44	12.10	18.97	39.06
F-test	**	**	**	**	**	NS	**	**
B: storage time								
Control	41.33	13.34	28.54	52.13	26.52	13.71	20.37	36.65
3 months	36.35	11.62	21.41	43.73	26.15	12.74	15.87	33.17
6 months	47.61	10.15	37.41	61.60	33.15	10.90	23.49	42.02
9 months	48.22	6.81	29.98	57.61	37.11	11.71	22.28	45.04
12 months	45.38	10.45	36.71	60.63	38.47	11.63	22.89	46.45
F-test[a]	**	**	**	**	**	**	**	**

L scale: Light vs. dark where a low number (0-50) indicates dark and a high number (51-100) indicates light; a scale: Red vs. green where a positive number indicates red and a negative number indicates green; b scale: Yellow vs. blue where a positive number indicates yellow and a negative number indicates blue; D*E* (Delta *E*): Value gives the total color difference; [a]: Significant terms (F-values) from analysis of variance procedure; *: Significant at $p \le 0.1$; **: Significant at $p \le 0.05$; NS: Not significant

partially or totally decompose red pigment. Some authors have reported that acidity could decrease redness values (Feranadez-Lopez, 1998; Perez-Alvarez *et al*., 1999). Yellowness of date fruits significantly increased during storage period (Table 3). The observed changes in yellowness were probably due to the oxidation reactions during storage and so the increase in yellow pigment which was greatly contributed to yellowness values. Fernandez-Lopez (1998) reported that lactic acid concentration increased yellowness co-ordinate in dry-cured sausage model system. In this study, pH of date samples decreased during storage period (Table 2). pH of date fruits might be another reason for the increase in yellowness. The color of date fruits was also influenced by water activity. In this study, water activity of date fruits showed a decreasing profile. Baloch *et al*. (2006) reported that the stability of date samples increased by adjusting water activity at low level. Date fruits in this study exhibited low water activity and storage stable which was in accordance with the reported observations by Baloch *et al*. (2006) and Mutlak and Mann (1984).

CONCLUSION

Overall, our results showed that cold storage and packing type could affect the quality of both tested date cultivars, although to varying degrees. Even though the results indicated that significant changes in the studied attributes were associated with cold storage, Sukkary and Khalas dates still had comparable good quality after 12 months storage. This study provides some basic results that could be helpful in future development of short- and long-term preservation methods for better handling and industrialization of date fruits. Cold storage is an essential practice for dates storage. Further research on date fruits quality parameters such as appearance, texture and sensory properties is highly recommended.

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