

Effect of Smart Packaging on Physical and Chemical Characteristics of Zaghoul Date Palm Fruits During Cold Storage

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Abstract: The present study was carried out during the two successive seasons (2016/2017 and 2017/2018) on date palm fruits cultivar Zaghoul to investigate the effect of some types of passive modified atmosphere packaging such as smart bags imported from Canada. Prime Pro® bag is a polyethylene plastic film produced to extend the shelf life of fresh fruits, micro perforated low density Polyethylene bags (LDPE) and micro perforated Punnets (PET) compared with control (Carton boxes) under cold storage conditions ($0\pm 1^{\circ}\text{C}$ with RH. 85-90%) and exposed to the ambient air (passive MAP). The quality changes of fresh fruits were studied by determining weight loss%, decay%, rutab %, firmness, total soluble solids contents (TSS), total acidity (TA), TSS /acid ratio, total tannins and respiration rate (O_2 , CO_2 and ethylene production) during cold storage period. The obtained results revealed that, the percentage of fruit weight loss, decay, rutab, total soluble solids (TSS) and TSS /acid ratio were increased with the increasing of storage period; however firmness, acidity and tannins contents relatively were reduced by prolonging the storage period. Fruits which stored in smart Prime Pro® bags, (PET) were the best package type compared with the other packages in physical and chemical characteristics. The lowest percentage of weight loss, decay and rutab was recorded in smart Prime Pro® bags; (PET) followed by micro perforated Punnets (PET) followed by micro perforated low density Polyethylene bags (LDPE) and control (Carton boxes). This is due to the permeability rate of package. The lowest respiration rate was recorded in the smart Prime Pro® bags, (PET) compared with the other treatments.

Key words: Date palm • Postharvest • Packaging • Fruit quality • Cold storage

INTRODUCTION

Date palm (*Phoenix dactylifera* L.), considered one of the ancient domestic fruit trees in the world, especially in the Middle East countries and their fruits play an important role in the nutritious pattern of many people. The total production of date fruits in Egypt amounted to 1, 501, 799 tons/year [1]. In Egypt, many cultivars such as Zaghoul, Samany, Halaway and Hayany are grown in different regions. They are the earliest ripening varieties of soft date grown in Egypt. Zaghoul date is the most important commercial cultivar in Egypt and highly demanded in the Arab markets.

The process of storing dates may be necessary, since the marketing of dates according to market requirements and for a period longer than normal season, achieving a good return and the optimal temperature to store the fruits of dates is from $0-4^{\circ}\text{C}$ and relative humidity 85-90 % to be stored for a month depending on the cultivar [2, 3].

The development and use of alternative postharvest control options involving natural plant extracts have become important, since it is perceived as being environmentally safer and more acceptable to the general public [4]. Recently, researchers have shown an interest in the application of packaging system should maintain the optimal storage, transport and handling throughout the market chain for a specific commodity [5].

The main goal of this work was to study the effect of using some types of Passive MA packaging materials and smart packaging materials to preserve the quality of Zaghoul date palm fruits under cold storage conditions.

MATERIALS AND METHODS

Date palm (*Phoenix dactylifera*, L.) fruits cv. Zaghoul were harvested at mid-September during two successive seasons (2016/2017 and 2017/2018). Fruits were harvested at maturity stage from fourteen

years old palms that similar in growth and received common horticultural practices from a private orchard at Abo-Rawash region, El-Giza Governorate, Egypt. Fruits were uniform in size, appearance, free from visible physical and pathological defects. Fruits were transported to the laboratory of Agricultural Development System (ADS) project, Cairo University. Fruits were thoroughly washed with chlorine water for 3-5 minutes as sanitizing agents for inhibiting micro-spoilage according to Sapers [6] Then washed with tap water only and left to dry completely aerobically.

Packaging Materials: Date palm fruits Zaghloul were packaged using three types and control of application packages produced by Food Engineering and Packaging Department, Food Technology Research Institute (FTRI), in the frame work of the National Project on “Production and Evaluation of Smart and Modified Atmosphere Packaging of Horticulture crops for Export”, funded by Science and Technological Development Fund (STDF).

- Smart Prime Pro® bags (dimension of (25* 35 cm) WVP (1 gm/bag/day OTR (15 cm³/bag/day)) with thickness 30 ± 2 µm,
- Local micro perforation punnet rigid plastic (PET) average size 420g / punnet with dimensions of (L 15cm x W 15cm x D 8 cm), 8 pores/ punnet 20 µm, (W.V.L) Water Vapor Leakage (1 gm/ punnet/day) (O.T.R) Oxygen transmission Rate (10 cm³/ punnet/day),
- Local Micro perforation Low density polyethylene bags dimensions (25 x 30 cm with thickness 30±2 µm, 8 pores / punnet 20 µm WVP Water Vapor permeability 5gm/bags/day OTR 10 cm³/bag/day)
- Carton boxes as a control.

The Fruits Were Divided into Three Groups:

- Group one contained three packages from each kind (in total twelve packages) to measured weight loss, decay and rutab.
- Group two contained three packages from each kind (in total twelve packages) to measured respiration rate (O₂, CO₂ and ethylene)
- Group three contained three packages from each kind (in total twelve packages) to measured both of them texture, TSS, Acidity, TSS/Acid ratio, color (hue angel) and tannins.

The total number of packages was thirty six and each simple for three replicates have fifteen fruits (R1= 5 fruits,

R2 = 5 fruits and R3 = 5 fruits) for each kind of packaging and each package contains twenty five fruits were stored at 0±1°C, with 85-90% RH. Three replicates of each treatment were taken and fruits were examined for quality parameters at day 0, 10, 20, 30 and at 40 days.

Fruit Quality Assessments

Physical Properties

Weight Loss (%): Fruits were weighed at the beginning of the experiment and every 10 days during 40 days of storage. The fruit weight loss percent was calculated by standard procedure as following equation.

Fruit weight loss % = Initial weight – Weight at time of sampling / Initial weight x 100

Decay Incidence (%): Fruits, which decayed by different physiological and pathological factors were periodically counted and discarded. Then percentages of decayed fruits were calculated in relation to total number of fruits.

Decay percentage was calculated as follows:

Decay (%) = Number of decayed fruits at time of sampling / Initial fruit number X 100

Firmness (g/cm²): Fruit firmness was recorded by Lira texture analyzer instrument using a penetrating cylinder of 1 mm of diameter, to a constant distance (3 and 5 mm) inside the fruits pulp and by a constant speed 2 mm per sec. and the peak of resistance was recorded per g.

Rutab Percentage (%): All fruits that showed visual change in color to dark brown and softening of about 20% of its surface were considered rutab. Percentage of rutab was calculated according to the following equation:

Rutab % = Number of rutab fruits / Initial fruit number X 100

Fruit Color (Hue Angle): (l* value, c* value,) (L c / h value) surface color of fruit was measured using a colorimeter ((Model CR-400, Minolta, Japan) which provided CIE L*, a* and b* value. Negative a* values indicate green and higher positive a* values red color. Higher positive b* value indicate a more yellow skin color and negative b* values color .The values were then used to calculate hue degree (h0 =arctangent b/ a*) where 0° = red-purple, 90° = yellow, 180° = bluish- green and 270° = blue [7].

Respiration Rate: Bags head space gas concentrations (CO₂, O₂ and ethylene) were measured using respiration rate analyzer (Model 902D O₂/ CO₂ Headspace Analyzer). O₂, CO₂ and ethylene values were expressed as percentage [8].

Chemical Properties

Total Soluble Solids Percentage (TSS %): It was estimated by abbey digital refractometer. Three different readings for each replicate were recorded and the average was calculated according to A.O.A.C. [9].

Total Acidity Percentage: It was determined as malic acid by titration with a solution of 0.1 N. (Na OH), using phenolphthalein as an indicator. The average amount of sodium hydroxide used in each titration was recorded and total acidity was calculated as gm / 100 gm fresh weight [9].

Total Soluble Solids / Total Acidity Ratio: It was calculated by dividing TSS (%) by total acidity (%), as the methods described by A.O.A.C. [9].

Total Tannins Percentage (g/ 100g f.wt): It was evaluated according to the method of Yeshajahu and Clifton [10] the results were calculated as g/ 100 g fresh weight.

Statistical Analysis: The obtained data were statistically analyzed as a factorial Randomized Complete Block Design with two factors (factor A: packaging treatments and factor B: storage period) by analysis of variance (ANOVA) using Statistical Analysis System (Co Stat) program. The means of treatments were compared using LSD at 0.05 according to Snedecor and Cochran [11].

RESULTS AND DISCUSSION

Physical Properties

Weight Loss Percentage: Data presented in Table (1) show the effect of different packaging on weight loss percentages of Zaghoul dates during cold storage at (0±1° C and 85-90% R.H.). It was shown a gradual increase in weight loss until the end of the storage period (40 days). The lowest weight loss % was obtained by smart prime pro bags. These results due to the action of Prime Pro® bags are active polyethylene plastic film containing a proprietary as ethylene absorber and anti fungi additive. This additive is specially designed to

remove ethylene from the air around fresh produce. As ethylene is removed, the process of ripening and decay can be slowed, dramatically extending the shelf life of fresh produce. On the other hand, control treatment showed the highest weight loss value (16.24 & 16.53%) in the two seasons, respectively. the interaction between the different packaging and storage period obtained significant differences in the first and second seasons respectively. The Prime Pro bags seemed to efficiency in controlling weight loss, packaged with Prime pro bags, micro perforation punnet PET and polyethylene bags in the first and second season as well as packaged with control in packaged with significantly differences. Weight loss increased as cold storage proceeded Significant weight loss reductions compared to control fruits (Carton box) were recorded for all packages at the end of storage period. Such significant effect was detected throughout the whole trial in all fruits packaged with smart prime pro bags in both investigated seasons. Fruit packaged by smart prime pro bags in the first and second seasons showed significant lower weight loss as compared to other used packages and the control as the weight loss increased gradually during storage period. Generally, all packaged were effective in reducing the rate of weight loss percentage as compared to control (carton box). Mean while, the highest fruit weight loss percentage was recorded for fruit packaged in carton box. These data are in line with, Thompson and Abboodi [12]; Vicente, *et al.* [13]; Abd EL-Samad, [14]; Abbasi, *et al.* [15]; Mpho, *et al.* [16] and El-Hadidy, *et al.* [17].

Decay Percentage: Data in Table (2) indicated that, fruit decay percentage was gradually increased as a function of cold storage period up to 40 days either packaged or unpackaged fruits of Zaghoul date palm under study in both seasons. Meanwhile, all packages were effective in reducing decay percentage compared to the control but the effect was more pronounced with Prime Pro bags compared with the other packaging and control (carton box). Control treatment showed the highest decay values in both seasons, respectively. On the other hand, the lowest decay were obtained by smart prime pro bags and showed the lowest decay% than other treatments in the two seasons. This result due to the action of Prime Pro® bags is an active polyethylene plastic film containing a proprietary as ethylene absorber and anti fungi additive. This additive is specially designed to remove ethylene from the air around fresh

Table 1: Effect of smart packaging on weight loss % of Zaghoul date palm fruits during cold storage at (0±1°C and 85-90% R.H.) in (2016/2017 and 2017/2018) seasons

Treatments	Storage Periods (Days)					Mean (A)
	Season (2016-2017)					
	0	10	20	30	40	
Carton box "Control"	0	16.33	17.76	22.88	24.25	16.24
Prime Pro bags	0	1.80	4.52	6.22	8.45	4.20
Micro. Punnet PET	0	4.81	6.60	9.74	11.06	6.44
Micro. P Polyethylene bags	0	6.05	8.46	11.84	13.45	7.96
Mean (B)	0	7.25	9.34	12.67	14.30	
LSD at _{0.05}	Treatments (A): 0.03 Storage Periods (B): 0.03 Interaction (A×B): 0.07					
Treatments	Storage Periods (Days)					Mean (A)
	Season (2017-2018)					
	0	10	20	30	40	
Carton box "Control"	0	14.66	18.08	23.99	25.93	16.53
Prime Pro bags	0	2.30	6.00	7.62	9.65	5.11
Micro. Punnet PET	0	4.81	6.90	9.84	12.00	6.71
Micro. P Polyethylene bags	0	6.55	9.36	12.34	13.95	8.44
Mean (B)	0	7.08	10.09	13.45	15.38	
LSD at _{0.05}	Treatments (A): 0.03 Storage Periods (B): 0.03 Interaction (A×B): 0.07					

Table 2: Effect of smart packaging on decay % of Zaghoul date palm fruits during cold storage at (0±1° C and 85-90% R.H.) in (2016/2017 and 2017/2018) seasons

Treatments	Storage Periods (Days)					Mean (A)
	Season (2016-2017)					
	0	10	20	30	40	
Carton box "Control"	0	11.83	20.61	23.2	35.76	18.28
Prime Pro bags	0	3.27	5.20	6.60	10.50	5.11
Micro. Punnet PET	0	3.70	5.96	7.26	11.93	5.77
Micro. P Polyethylene bags	0	4.27	6.36	8.18	12.47	6.26
Mean (B)	0	5.77	9.53	11.31	17.67	
LSD at _{0.05}	Treatments (A): 0.03 Storage Periods (B): 0.03 Interaction (A×B): 0.07					
Treatments	Storage Periods (Days)					Mean (A)
	Season (2017-2018)					
	0	10	20	30	40	
Carton box "Control"	0	12.63	19.61	22.2	34.76	17.84
Prime Pro bags	0	3.97	6.00	7.10	11.50	5.71
Micro. Punnet PET	0	4.00	6.16	8.26	12.93	6.27
Micro. P Polyethylene bags	0	5.10	7.10	9.08	13.47	6.95
Mean (B)	0	6.43	9.72	11.66	18.17	
LSD at _{0.05}	Treatments (A): 0.03 Storage Periods (B): 0.03 Interaction (A×B): 0.07					

produce. As ethylene is removed, the process of ripening and decay can be slowed, dramatically extending the shelf life of fresh produce. Chantler Packages <http://primepro.com/>. The interaction between the different packaging and storage period obtained significant differences in two seasons. These data are in line with, Thompson and Abboodi, [12]; Vicente, *et al.* [13]; Abd EL-Samad, [14]; Abbasi, *et al.* [15]; Mpho, *et al.* [16] and El-Hadidy, *et al.* [17].

Fruit Firmness: Data in Table (3) showed that fruit firmness for all packages in this study gradually decreased by increasing storage periods in both seasons.

The lowest fruit firmness was obtained with sample unpacked in carton box as a control packaged in the first and second seasons respectively during 40 days storage period. However, the highest fruit firmness was recorded for smart packaging Prime Pro bags fruits in both seasons. There was no significant difference in all packaged under these study. Fruit softening is normally attributed to the destruction of cell structure and the deterioration in cell wall composition and intracellular materials. It is a biochemical process that involves the hydrolysis of pectin and starch by enzymes, for example, wall hydrolyses. These results confirm the finding of Mortazavi, *et al.* [18] they found that fruit packaged with

Table 3: Effect of smart packaging on fruit firmness (g/cm²) of Zaghoul date palm fruits during cold storage at (0±1°C and 85-90% R.H.) in (2016/2017 and 2017/2018) seasons

Treatments	Storage Periods (Days)					
	0	10	20	30	40	Mean (A)
	Season (2016-2017)					
Carton box "Control"	16.96	15.23	13.96	12.03	9.56	13.55
Prime Pro bags	16.96	16.36	16.2	14.83	13.80	15.63
Micro. Punnet PET	16.96	16.43	15.13	14.70	11.83	15.01
Micro. P Polyethylene bags	16.96	15.44	14.14	13.60	11.54	14.34
Mean (B)	16.96	15.87	14.86	13.79	11.68	
LSD at _{0.05}	Treatments (A): 0.10 Storage Periods (B): 0.11 Interaction (A×B): 0.21					
	Season (2017-2018)					
Carton box "Control"	16.35	15.12	13.99	11.35	9.69	13.30
Prime Pro bags	16.35	16.15	15.92	14.49	13.32	15.25
Micro. Punnet PET	16.35	15.89	14.95	13.65	11.32	14.43
Micro. P Polyethylene bags	16.35	15.75	14.85	13.19	10.15	14.06
Mean (B)	16.35	15.73	14.93	13.17	11.12	
LSD at _{0.05}	Treatments (A): 0.10 Storage Periods (B): 0.11 Interaction (A×B): 0.22					

Passive Modified atmosphere almost half of the fruits to turn into low quality rutab, while the best quality and longest shelf-life of khalal fruits was gained with 5% CO₂ concentration. Also, passive MAP compared with control samples, showed acceptable results by extending the shelf-life of khalal date fruits, The quality changes of fresh fruit were studied under modified atmosphere packaging date fruits was packed in barrier bags and exposed to ambient air passive MAP and different concentrate of CO₂ (5, 15 and 30 %). These data are in line with, Thompson and Abboodi, [12]; Vicente, *et al.* [13]; Abd EL-Samad [14] Abbasi, *et al.* [15]; Mpho, *et al.* [16] and El-Hadidy, *et al.* [17].

Rutab %: Data illustrated in Table (4) show that the fruit which turned from fresh to rutab in all packages in this study gradually increased by increasing the storage periods in both seasons. The fruits changed in color to brown or black and become soft. The softening of the date fruit is mainly influenced by polygalacturonase, beta-galactosidase and cellulose enzymes [19, 20]. During softening, the tannins which led under the skin are precipitated in an in soluble form, so that the fruit loses astringency with an increase in the reducing sugars and total sugars and total solids concentrations [19, 20]. Fruit softening is normally attributed to the destruction of cell structure and the deterioration in cell wall composition and intracellular materials.

It is a biochemical process that involves the hydrolysis of pectin and starch by enzymes, for example, wall hydrolyses. These results confirm the finding of Mortazavi, *et al.* [18] they found that fruit packaged with

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Results presented in Table (4) clarify that all treatments significantly enhanced the transformation of fruits from the fresh color to rutab this persisted throughout the whole storage period. The increase in rutab % was insignificant compared to control fruits during 40 days under cold storage. The packaging by Prime Pro bags fruits recorded the lowest fruit turned to rutab compared with control.

Fruit Color % (Hue Angle): The effect of different packaging treatments on date palm cv. Zaghoul fruit color hue angle (h°) of both seasons is presented in Table (5). The results revealed that, hue angle of fruits was significantly decreased gradually with the increasing cold storage period till the end of storage. Fruits packaged in Prime Pro bags a significant higher hue angle compared with the control fruits in both seasons.

Concerning the interaction between passive packaging condition and storage duration, data clear that prime pro bags maintained highest value of fruit hue angle at 40 storage days during 1st and 2nd seasons,

Table 4: Effect of smart packaging on rutab% of Zaghoul date palm fruits during cold storage at (0±1°C and 85-90% R.H.) in (2016/2017 and 2017/2018) seasons

Treatments	Storage Periods (Days)					Mean (A)
	0	10	20	30	40	
Season (2016-2017)						
Carton box "Control"	0	47.90	62.4	91.90	93.30	59.10
Prime Pro bags	0	39.60	36.00	57.70	85.10	43.68
Micro. Punnet PET	0	41.70	41.50	81.10	93.40	51.54
Micro. P Polyethylene bags	0	44.37	53.00	84.30	92.20	54.77
Mean (B)	0	43.39	48.23	78.75	91.00	
LSD at _{0.05}	Treatments (A) 0.30: Storage Periods (B) 0.35: Interaction (A×B): 0.67					
Season (2017-2018)						
Carton box "Control"	0	50.94	56.70	84.50	97.10	57.85
Prime Pro bags	0	47.06	51.50	62.40	83.00	48.79
Micro. Punnet PET	0	47.82	53.90	75.70	88.10	53.10
Micro. P Polyethylene bags	0	49.62	55.30	78.80	95.50	55.84
Mean (B)	0	48.86	54.35	75.35	90.93	
LSD at _{0.05}	Treatments (A): 0.30 Storage Periods (B):0.35 Interaction (A×B): 0.67					

Table 5: Effect of smart packaging on fruit color % (Hue angle) of Zaghoul date palm fruits during cold storage at (0±1°C and 85-90% R.H.) in (2016/2017 and 2017/2018) seasons

Treatments	Storage Periods (Days)					Mean (A)
	0	10	20	30	40	
Season (2016-2017)						
Carton box "Control"	31.13	28.49	25.67	25.42	30.65	28.27
Prime Pro bags	31.13	30.67	29.13	28.87	34.78	30.92
Micro. Punnet PET	31.13	30.54	27.42	26.54	33.21	29.77
Micro. P Polyethylene bags	31.13	31.21	28.17	26.16	30.92	29.52
Mean (B)	31.13	30.23	27.60	26.75	32.39	
LSD at _{0.05}	Treatments (A): 0.31 Storage Periods (B): 0.35 Interaction (A×B): 0.69					
Season (2017-2018)						
Carton box "Control"	31.36	28.72	25.9	25.65	30.88	28.50
Prime Pro bags	31.36	30.9	29.36	29.1	35.01	31.15
Micro. Punnet PET	31.36	30.77	27.65	26.77	33.44	30.00
Micro. P Polyethylene bags	31.36	31.44	28.4	26.39	31.15	29.75
Mean (B)	31.36	30.46	27.83	26.98	32.62	
LSD at _{0.05}	Treatments (A): 0.31 Storage Periods (B): 0.35 Interaction (A×B): 0.69					

compared with control carton box. These data are in line with, Thompson and Abboodi [12]; Vicente, *et al.* [13]; Abd EL-Samad [14]; Abbasi, *et al.* [15]; Mpho, *et al.* [16] and El-Hadidy, *et al.* [17].

Respiration Rate: Modified Atmosphere Packaging, known as MAP Passive gas analysis technology and controlled atmosphere storage (CAS) are novel techniques that are widely applied for preservation of agricultural products especially fruits and vegetables.

Data in Table. (6 & 7 and 8) clearly showed that, in both seasons of study, all used treatments greatly decreased gases concentrations than control during cold storage durations. However, Smart Prime Pro® bags exhibited the lowest concentrations of O₂, CO₂ and ethylene production than the others. At the end of cold storage period (40 days) at 0°C and 90% RH, Smart Prime Pro® bags recorded the lowest O₂, CO₂ and ethylene

concentrations, while control fruits had the highest concentrations in both seasons. These data illustrated that cold temperature reduced gases productions, fruit deterioration and extend fruit life. All packages showed reduce in O₂ and an increased CO₂ and ethylene level. These data are in line with Mortazavi [21] and Hameed, *et al.* [22].

According to the O₂ and CO₂ data, differences between passive Packaging kinds were seen during storage period, then, drawing near and steady state was obtained.

These results are in agreement with those obtained by Mortazavi [21] on date fruit and Hameed, *et al.* [22] on green slender chilies.

For fresh endives, it was evident from this study that the rutab spots area (RSA) that appeared during storage was correlated significantly with CO₂ concentration within packages.

Table 6: Effect of smart packaging on O₂% gas content MAP of Zaghoul date palm fruits during cold storage at (0±1°C and 85-90% R.H.) in (2016/2017 and 2017/2018) seasons

Treatments	Storage Periods (Days)					Mean (A)
	0	10	20	30	40	
Season (2016-2017)						
Carton box "Control"	22	21	21	20	20	20.8
Prime Pro bags	22	11	6	5	3	9.4
Micro. Punnet PET	22	16	11	8	6	12.6
Micro. P Polyethylene bags	22	17	15	16	16	17.2
Mean (B)	22.00	16.25	13.25	12.25	11.25	
LSD at _{0.05}	Treatments (A) 2.31; Storage Periods (B) 1.01; Interaction (A×B): 2.99					
Season (2017-2018)						
Carton box "Control"	20	19	19	18	18	18.8
Prime Pro bags	20	9	4	3	1	7.4
Micro. Punnet PET	20	14	9	6	4	10.6
Micro. P Polyethylene bags	20	15	13	14	14	15.2
Mean (B)	20.00	14.25	11.25	10.25	9.25	
LSD at _{0.05}	Treatments (A):0.99 Storage Periods (B):1.09 Interaction (A×B): 1.97					

Table 7: Effect of smart packaging on CO₂% gas content MAP of Zaghoul date palm fruits during cold storage at (0±1° C and 85-90% R.H.) in (2016/2017 and 2017/ 2018) seasons

Treatments	Storage Periods (Days)					Mean (A)
	0	10	20	30	40	
Season (2016-2017)						
Carton box "Control"	0.2	0.4	0.5	0.6	0.9	0.52
Prime Pro bags	0.2	22.1	27.1	29.1	35.1	22.72
Micro. Punnet PET	0.2	18.1	20.1	26.1	32.1	19.32
Micro. P Polyethylene bags	0.2	15.1	22.1	21.1	23.1	16.32
Mean (B)	0.20	13.93	17.45	19.23	22.80	
LSD at _{0.05}	Treatments (A): 1.89 Storage Periods (B): 3.80 Interaction (A×B): 1.75					
Season (2017-2018)						
Carton box "Control"	0.3	0.5	0.6	0.7	1	0.62
Prime Pro bags	0.3	22.2	27.2	29.2	35.2	22.82
Micro. Punnet PET	0.3	18.2	20.2	26.2	32.2	19.42
Micro. P Polyethylene bags	0.3	15.2	22.2	21.2	23.2	16.42
Mean (B)	0.30	14.03	17.55	19.33	22.90	
LSD at _{0.05}	Treatments (A): 1.72 Storage Periods (B): 1..27 Interaction (A×B): 2.22					

Also, when the storage period prolonged, greater part of fruits changed to rutab in bags. The gas content changed rapidly during the first ten days and then the change was slowing during 40 days storage. Gases content was negligible for other packaged after 20 days of storage and the lowest value was recorded in fruit packed in (carton box) as control package which a large part of fruit turned to rutab. Appearing rutab spots and wrinkled surface are the two main disorders restricting marketing, storage and exports of khalal dates after harvest. However, turning fruit surface color to brown considered as rutab spot, comparing obtained rutab fruits in this study, with those ripened naturally on the tree, showed

some major differences. Rutab spots in the fruits coming out of storage can be described as CO₂ injury similar to that reported by Serrano, *et al.* [20] for sweet cherry at high CO₂ concentrations. Elevated CO₂ can prove to be fruit damage, often inducing fermentation, particularly when fruit is sealed in packaging film of insufficient permeability [21, 22].

Chemical Properties

Total Soluble Solids (TSS %): Data of fruit total soluble solids percentage indicated that all packages type used increased with prolonging period of fruit storage in both seasons (Table 9). However, most packages of Zaghoul

Table 8: Effect of smart packaging on ethylene% gas content MAP of Zaghoul date palm fruits during cold storage at (0±1°C and 85-90% R.H.) in (2016/2017 and 2017/2018) seasons

Treatments	Storage Periods (Days)					Mean (A)
	0	10	20	30	40	
Season (2016-2017)						
Carton box "Control"	0	3	5	5	7	4
Prime Pro bags	0	1	1.5	1.5	2	1.2
Micro. Punnet PET	0	1	1.5	2	2.5	1.4
Micro. P Polyethylene bags	0	2	4	5	6	3.4
Mean (B)	0	1.25	2.50	3.00	3.75	
LSD at _{0.05}	Treatments (A):0.15 Storage Periods (B): 0.17 Interaction (A×B): 0.35					
Season (2017-2018)						
Carton box "Control"	0	3	4	5	7	3.8
Prime Pro bags	0	1	1.5	2	2.5	1.4
Micro. Punnet PET	0	1	2	3	3	1.8
Micro. P Polyethylene bags	0	2	5	6	6	3.8
Mean (B)	0	1.25	3.25	4.00	4.25	
LSD at _{0.05}	Treatments (A):0.15 Storage Periods (B):0.17 Interaction (A×B):0.35					

Table 9: Effect of smart packaging on total soluble solids% (TSS) of Zaghoul date palm fruits during cold storage at (0±1° C and 85-90% R.H.) in (2016/2017 and 2017/2018) seasons

Treatments	Storage Periods (Days)					Mean (A)
	0	10	20	30	40	
Season (2016-2017)						
Carton box "Control"	10.9	11	11.13	11.14	9.16	10.67
Prime Pro bags	10.9	11.25	11.53	11.87	10.5	11.21
Micro. Punnet PET	10.9	11.23	11.36	11.67	10.83	11.20
Micro. P Polyethylene bags	10.9	11.07	11.27	11.31	10.38	10.99
Mean (B)	10.9	11.14	11.32	11.50	10.22	
LSD at _{0.05}	Treatments (A): 0.05 Storage Periods (B): 0.06 Interaction (A×B): 0.11					
Season (2017-2018)						
Carton box "Control"	10.51	11.2	11.4	11.25	10.42	10.96
Prime Pro bags	10.51	11.58	11.71	12.82	11.91	11.71
Micro. Punnet PET	10.51	11.41	11.5	12.61	11.68	11.54
Micro. P Polyethylene bags	10.51	11.33	11.47	12.49	11.55	11.47
Mean (B)	10.51	11.38	11.52	12.29	11.39	
LSD at _{0.05}	Treatments (A): 0.10 Storage Periods (B): 0.11 Interaction (A×B): 0.22					

particularly recorded the highest values of fruit total soluble solids percentage content in the second season took nearly the same trend in the first one. In addition, after 40 days storage fruit packaged by smart Prime Pro bags in the first season and fruit packaged by micro perforation Punnet PET as well as fruit packaged by Polyethylene in the second season showed significantly higher TSS % as compared to the control (carton box).

The gradual increase of total soluble solids with increasing of storage period and could be due to the degradation of complex in soluble compounds like starch to simple soluble compounds like sugar which are the major component of soluble solids content in the fruits.

Meanwhile, the changes increased with the progress of storage period, where it allowed the accumulation of soluble solids in fruits. Our results are in agreement with the findings of Hameed, *et al.* [22] they found that, the total soluble solids were significantly higher in control sample as compared to Zaghoul dates fruits packaged in smart Prime Pro bags. It must be noted that the lowest TSS % were detected with fruit packaged in Prime Pro bags at the 10, 20 and 30 days of storage.

Beside this, the findings of the present study also revealed that micro perforation Punnet PET packaged also lowered the TSS value in comparison to Polyethylene bags fruit, which indicate that Prime Pro bags delay the softening process in fruit.

Table 10: Effect of smart packaging on total acidity% (TA) of Zaghloul date palm fruits during cold storage at (0±1° C and 85-90% R.H.) in (2016/2017 and 2017/2018) seasons.

Treatments	Storage Periods (Days)					Mean (A)
	0	10	20	30	40	
Season (2016-2017)						
Carton box "Control"	0.74	0.74	0.60	0.34	1.21	0.72
Prime Pro bags	0.74	0.54	0.40	0.34	1.01	0.60
Micro. Punnet PET	0.74	0.67	0.47	0.34	1.14	0.67
Micro. P Polyethylene bags	0.74	0.67	0.54	0.34	1.01	0.66
Mean (B)	0.74	0.65	0.50	0.34	1.09	
LSD at _{0.05}	Treatments (A): 0.01 Storage Periods (B): 0.01 Interaction (A×B): 0.03					
Season (2017-2018)						
Carton box "Control"	0.70	0.77	0.64	0.37	1.24	0.74
Prime Pro bags	0.70	0.57	0.44	0.37	1.04	0.62
Micro. Punnet PET	0.70	0.70	0.50	0.37	1.17	0.69
Micro. P Polyethylene bags	0.70	0.70	0.57	0.37	1.04	0.68
Mean (B)	0.70	0.69	0.54	0.37	1.12	
LSD at _{0.05}	Treatments (A): 0.01 Storage Periods (B): 0.01 Interaction (A×B): 0.03					

Table 11: Effect of smart packaging on TSS/Acid ratio of Zaghloul date palm fruits during cold storage at (0±1° C and 85-90% R.H.) in (2016/2017 and 2017/2018) seasons

Treatments	Storage Periods (Days)					Mean (A)
	0	10	20	30	40	
Season (2016-2017)						
Carton box "Control"	14.8	14.9	18.5	33.3	7.6	17.80
Prime Pro bags	14.8	21.0	28.7	35.4	10.4	22.07
Micro. Punnet PET	14.8	16.8	24.2	34.8	9.5	20.02
Micro. P Polyethylene bags	14.8	16.5	21.0	33.8	10.3	19.29
Mean (B)	14.79	17.30	23.10	34.32	9.47	
LSD at _{0.05}	Treatments (A): 0.01 Storage Periods (B): 0.01 Interaction (A×B): 0.09					
Season (2017-2018)						
Carton box "Control"	14.9	14.5	17.9	30.5	8.4	17.26
Prime Pro bags	14.9	20.3	26.9	34.8	11.5	21.68
Micro. Punnet PET	14.9	16.2	22.9	34.2	10.0	19.65
Micro. P Polyethylene bags	14.9	16.1	20.1	33.9	11.1	19.24
Mean (B)	14.94	16.80	21.96	33.36	10.24	
LSD at _{0.05}	Treatments (A):0.01 Storage Periods (B):0.01 Interaction (A×B): 0.07					

These data are in line with, Thompson and Abboodi [12]; Vicente, *et al.* [13]; Abd EL-Samad [14]; Abbasi *et al.* [15]; Mpho, *et al.* [16] and El-Hadidy, *et al.* [17].

Titrateable Acidity: Data in Table (10) showed that, all packaging greatly decreased fruit acidity than control during cold storage durations in both seasons.

In this respect Zaghloul fruits packaged in smart Prime Pro bags gave lower acidity values than those obtained from fruits packaged in micro perforation Punnet PET this effect was more obviously noticed in the first season. Where packaging Zaghloul fruits in

micro perforation Polyethylene lowered acidity than those packaging in carton box. However, the different between all combination packaged were lacking from statistical stand point in both seasons.

These data are in line with, Thompson and Abboodi [12]; Vicente, *et al.* [13]; Abd EL-Samad [14]; Abbasi *et al.* [15]; Mpho, *et al.* [16] and El-Hadidy, *et al.* [17].

TSS/Acidity Ratio: TSS/acidity ratio as affected by postharvest treatments on the average under cold storage conditions (0±1°C, with 85-90% RH) during the two seasons are presented in Table (11). By the extension of

Table 12: Effect of smart packaging on tannins % of Zaghoul date palm fruits during cold storage at (0±1°C and 85-90% R.H.) in (2016/2017 and 2017/2018) seasons

Treatments	Storage Periods (Days)					Mean (A)
	0	10	20	30	40	
Season (2016-2017)						
Carton box "Control"	3.33	2.28	1.86	0.92	0.93	1.86
Prime Pro bags	3.33	2.08	0.92	0.67	0.57	1.51
Micro. Punnet PET	3.33	2.13	1.21	0.72	0.65	1.61
Micro. P Polyethylene bags	3.33	2.16	1.8	0.85	0.73	1.77
Mean (B)	3.33	2.16	1.45	0.79	0.72	
LSD at _{0.05}	Treatments (A): 0.01 Storage Periods (B): 0.01 Interaction (A×B): 0.04					
Season (2017-2018)						
Carton box "Control"	3.34	2.33	1.9	0.94	0.57	1.82
Prime Pro bags	3.34	2.13	0.96	0.69	0.65	1.55
Micro. Punnet PET	3.34	2.18	1.25	0.74	0.64	1.63
Micro. P Polyethylene bags	3.34	2.21	1.84	0.87	0.6	1.77
Mean (B)	3.34	2.21	1.49	0.81	0.62	
LSD at _{0.05}	Treatments (A): 0.01 Storage Periods (B): 0.01 Interaction (A×B): 0.04					

cold storage period, TSS/acidity ratio was increased till 30 days and then decreased after 40 days during both seasons. Prime Pro bags raised TSS/acidity ratio to the highest magnitude in comparison with the other packaging in both seasons. The current results of postharvest treatments and storage periods are in line with, Thompson and Abboodi, [12]; Vicente, *et al.* [13]; Abd EL-Samad [14]; Abbasi, *et al.* [15]; Mpho, *et al.* [16] and El-Hadidy, *et al.* [17].

Tannins Fruit Contents: Data in Table (12) show that the effect of different packaging types on a tannin of Zaghoul dates during two seasons. Fruit tannins content decreased significantly with prolonging the storage periods in both seasons. The current data clearly indicate that, the storage duration significantly affected fruit tannins content of Zaghoul fruits during both seasons.

Tannins content was decreased gradually during cold storage period compared with the initial time (zero) throughout the both seasons. Fruits packaged in Prime Pro bags had the least content of tannins in both seasons compared with the other treatments.

Tannins, which take part in non-enzymic oxidative browning thus insoluble leucoanthocyanidin decrease during storage period and Zaghoul date fruits Prime Pro bags and micro perforated Punnet PET helped to delay ripening and preserve fruit quality.

These data are in line with, Thompson and Abboodi [12]; Vicente, *et al.* [13]; Abd EL-Samad [14]; Abbasi *et al.* [15]; Mpho, *et al.* [16] and El-Hadidy, *et al.* [17].

CONCLUSION AND RECOMMENDATIONS

It is clear from the results that keeping date palm fruits in Passive modified atmosphere packages were best results in Prime Pro bags, then micro perforation PET punnet and micro perforation polyethylene packaging with all the characteristics of date palm according to the OTR of packaging and breathing rate of the type of fruit under cooling to preservation by the minimize oxygen concentrate in packages to reduce breathing to increase the shelf life of products during storage in local and export market.

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