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Influence of Polyethylene Perforation on the Storability of Apricot (*Prunus armeniaca L.* var. Canino) Fruits

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ABSTRACT

The effect of different perforation treatments on the quality of stored "Canino" apricot was studied. Fruit were unwrapped (control) and wrapped with high-density polyethylene (HDPE) or low-density polyethylene (LDPE) plastic bags with 0, 20, 40, 60, 80 or 100 holes/bag, and stored at 0°C and 85-90% RH for four weeks. At weekly intervals, fruit samples were removed from the storage and weight loss, firmness, respiration rate, soluble solids content (SSC), treatable acidity and ascorbic acid (Vitamin C) content were measured. Weight loss, firmness, SSC, acidity and ascorbic acid in all plastic-wrapped fruit were better than control. Weight loss was significantly reduced in fruit stored in HDPE and LDPE bags as compared to control that had higher respiration rate, SSC and acidity. Perforated Polyethylene bags significantly delayed ripening, maintained quality parameters and extended storability of "Canino" fruit.

Keywords: Postharvest, Polyethylene perforation, Storage, Fruit quality, Apricot.

INTRODUCTION

Apricot (*Prunus armeniaca* L.) is one of the most important fruit crops in Egypt. The total apricot cultivation area is 6.445 ha and total apricot production is 156.465 tons (FAO 2012). Apricots are cultivated worldwide mainly for high nutritional value of fruit. This fruit can be consumed as fresh, dried or processed. Fruit quality is a combination of physical and chemical characteristics accompanied with sensory properties (appearance, texture, taste and aroma) and nutritional value (Kramer & Twigg 1966; Velisek & Cejpek 2007).

Apricots ripe in few weeks (70-80 days after full bloom) and fruit are highly perishable. Their storage life is limited with 2 and 4 weeks. This period depends on ripening stage at harvest. Short storage life is due to rapid degradation processes (high metabolic activity and ethylene biosynthesis) that begin shortly after commercial ripening (Agar & Polate 1995; Egea *et al*., 2007). Fruit rapidly ripe and become senescent at ambient temperatures, and therefore require careful and rapid handling after harvest (2-4days) to avoid substantial loss for fresh market. Storage at modified atmosphere (MA) conditions delays fruit senescence, and extends storage life of horticultural crops through reducing postharvest loss (Kader 2002). MA reduces respiration rate and associated biochemical processes such as ethylene production and cell-wall enzyme activity. In addition, it reduces fruit sensitivity to ethylene action (Kolev 1977; Wills *et al*., 1983).

Using plastic-perforated bags had increased the demand to achieve modified atmosphere conditions (Kader 2002). It extended the storability of apples and pears compared to other storage methods (Elkashif *et al*., 2005). Somboonkaew & Terry (2010a) reported that perforated polyethylene bags were used to extend the storability of litchi fruit cv. Mauritius through reducing abrasion damage, minimizing weight loss and delaying of ripening and senescence processes. They are also maintaining the organoleptic properties of the fruit (Ramin & Khashbakhat 2008). The high humidity within the bags slows down the drying process and reduces weight loss (De-Souza *et al*., 1999) through restricted rates of respiration and transpiration (Kader 2002).

The objective of this research is to study the effect of perforated polyethylene bags on the storability of "Canino" apricot fruit stored at 0±1°C and 85-90% RH.

MATERIAL AND METHODS

Harvest

Generally growers' harvest fruit in before ripening stage (yellow-greenish skin color). This study was carried out during the 2009 and 2010 harvest seasons on apricot trees (*Prunus armeniaca* var. Canino) grown in a private orchard, Kafr El-Sheikh Governorate, Egypt. Fruit were harvested at maturity (70 days after full bloom) and were sorted to a similar size (3.05cm length and 3.01cm width) being free from any injuries or mechanical damages. Fruit were washed with tap water, dipped in hypochlorite solution (0.02%) for 2 minutes (surface-sterilized) and dried using an electrical fan.

Packing

Fruit were packed in foam plates (30 fruit [1000g] per plate) and divided into three groups; control fruits (without wrapping), fruit wrapped with high-density polyethylene (HDPE) bags, and fruit wrapped with low-density polyethylene (LDPE) bags.

Polyethylene bags (36 × 19 cm) were perforated at 0, 20, 40, 60, 80 or 100 holes per bag. The area of each hole was 50 mm^2. Treatments were labeled based on the type of plastic and the number of holes. Experiment was designed in a complete randomized blocks (3 replicates per treatment) (Little & Hills 1972); where fruit were kept in plastic boxes (60×40×18cm). Each box contained four foam plates, with a total of 60 fruit per treatment. All boxes were stored in a cold room at 0±1°C with 85-90% RH for four weeks. Fruit of each treatment and the control were examined at harvest day and weekly intervals during cold storage period, until the percentage of injured fruit (fruit in senescence stage, decayed…etc.) reached ≥ 50%.

Physico-Chemical Analyses

Seven fruit/replicate were used to determined chemical character as follows: Weight loss was measured using a digital balance according to A.O.A.C. (1991). Fruit firmness was determined by an Effegi penetrometer (diameter point = 1 mm) and expressed as Newton (N) according to A.O.A.C. (1991). Soluble solids content (SSC) was determined using a hand-held refractometer (Model K-0032, Cosmo, Japan) at room temperature according to A.O.A.C. (1991). Titratable acidity was calculated with the titrated volume of standard NaOH (0.1 N) to pH 8.1 and expressed as mg of malic acid according to A.O.A.C. (1991). Ascorbic acid content was determined using 2, 6 Dichlrophenol indophenols for the titration of juice and presented as mg/100 cc of fruit extract according to A.O.A.C. (1991).

Respiration rate one kilogram of fruit was placed in a desiccator and connected to a tube containing 25 ml of KOH (1.0 N). CO_2-free air was drawn into the desiccator and passed through the KOH tube for 1 hour, then KOH titrated with HCl (1.0 N) using thymol blue indicator. Released CO_2 was calculated as mg CO_2/kg fresh weight/h.

Statistical Evaluation

Data were analyzed using SPSS Statistics 17.0 software (Statistical Packages for the Social Sciences, released 23 August 2008). Means were compared using Duncan's new multiple-range test (DMRT) (Duncan, 1965) at P value ≤ 0.05 as a limit of significance.

RESULTS

Weight loss (%)

A significant variation was recorded in fruit wrapped with HDPE and LDPE in comparison to the control (Fig. 1). The highest significant fruit weight loss was recorded in control fruit (0.18 %) after 28 days during 2010. The average of fruit weight loss in all treatments of wrapped with high density (LDPE) holes 20, 40, 60. 80 and 100 recorded higher weight loss than HDPE, whereas treatments HDPE 0 and LDPE 0 recorded the lowest weight loss during 7, 14, 21 and 28day of intervals of storage in 2009 and 2010 seasons, respectively but the differences among treatments not significant in most intervals of storage.

Fruit firmness (Newton)

HDPE and LDPE treatments (0, 20, 40, 60, 80 and 100 holes/bag) had a pronounced effect than the control on fruit firmness (Fig. 2). HDPE treatments recorded higher fruit fermness than LDPE treatments in all holes/treatment but the differences were not significant between treatments in most periods of storages. Control treatment showed the lowest significant fruit firmness; 2.43 and1.35 N after 28 days of storage in 2009 and 2010 seasons, respectively.

Soluble Solids Contents (SSC)

SSC in control fruit increased gradually from 13.0% at harvest date to 21.0% after 28 days of storage, compared to the other treatments (Table 1). Treatment LPDE 20 showed the lowest percent of SSC (14.47 %) compared to the control (21.00%) after 28 day of cold storage in 2010 seasons. LPDE (40 and 60) recorded the lowest significant SSC content in most periods of storage compared to HPDE and control.

Table 1: Effect of polyethylene perforation bags on SSC (%) of 'Canino' apricot fruit during 2009 and 2010 seasons

No.	Treat.	7 day		14 day		21 day		28 day	
		2009	2010	2009	2010	2009	2010	2009	2010
1	Cont.	17.33a	15.73a	18.00a	16.93a	16.20a	20.00a	17.20a	21.00a
2	HD 0	13. 33ef	14.00gh	14.87b	14.60ef	15.13b	15.20d	15.47c	15.47de
3	20	14.00c	14.80c	14.20c	14.87d	15.20b	14.80f	15.67b	15.00g
4	40	13. 33ef	14.07g	13.93de	14.40g	14.53d	15.00e	14.73fg	15.30ef
5	60	13.47def	14.40e	13.93de	14.40g	14.87c	14.93ef	15.20d	15.20f
6	80	14.00c	14.47e	14.33c	15.20b	14.80c	15.40c	15.00e	15.73bc
7	100	14.00c	14.60d	14.13cd	15.00cd	14.40d	15.80b	14.60g	15.80b
8	LD 0	14.73b	14.87b	14.80b	15.07bc	14.33d	15.53c	14.33h	15.60cd
9	20	13.67cde	14.03gh	13.80e	14.10h	14.00e	14.47g	14.80f	14.47i
10	40	13.33ef	13.93h	14.67b	14.07h	14.80c	14.60g	15.07de	14.80h
11	60	13.80cd	14.20f	13.80e	14.67e	13.80e	14.80f	14.00i	15.00g
12	80	13.13f	13.40i	13.27f	13.73i	13.80e	13.80h	14.13h	15.00g
13	100	14.00c	15.00b	14.20c	14.47fg	14.33d	14.47g	14.40h	15.00g

H.D= Plastic sheet thickness ≤ 0.03mm; L.D =Plastic sheet thickness =17μ; 0,20,40,60,80 and 100 holes/bag. Means followed by a common letter in the same column are not significantly different by DMRT (P ≤ 5%).

Titratable Acidity (% Malic Acid)

A general trend of acidity reduction over storage time was noticed in all treatments and the control (Table 2); however, there were no specific significant difference among all treatments and the control. Some treatments showed some significant values during storage with no specific trend of acidity percentage compared to the control.

Ascorbic Acid (Vitamin C) Content (Mg/100g Fresh Weight)

Vitamin C content varied in all treatments and the control (Table 3). Treatment HPDE 80 showed the highest content of vitamin C (13.94 and 16.5) compared to the control (12.37 and 12.74) in 2009 and 2010 seasons, respectively; however, the difference was only significant during the second season. Treatment LPDE 0 showed the lowest content of vitamin C (10.77 and 12.45) compared to the control (12.74 and 12.74) in 2009 and 2010 seasons, respectively, and the differences were significant during both seasons.

Table 2: Effect of polyethylene perforation bags on acidity (%) of 'Canino' apricot fruits during 2009 and 2010 seasons

No.	Treat.	7 day		14 day		21 day		28 day	
		2009	2010	2009	2010	2009	2010	2009	2010
1	Cont	0.432a	0.351a	0.452a	0.340a	0.339a	0.361a	0.326b	0.295d
2	H.D 0	0.329d	0.326cd	0.327f	0.303bcd	0.309d	0.353b	0.215b	0.240h
3	20	0.366c	0.339b	0.279h	0.252f	0.333b	0.315e	0.308b	0.259g
4	40	0.317e	0.320de	0.303g	0.290cde	0.296e	0.340c	0.320b	0.370a
5	60	0.322e	0.339b	0.328ef	0.328ab	0.315c	0.296f	0.320b	0.283e
6	80	0.317e	0.326cd	0.363c	0.265ef	0.247h	0.290g	0.345a	0.308c
7	100	0.281h	0.332c	0.334e	0.315abc	0.273g	0.277h	0.289b	0.259g
8	L.D 0	0.390b	0.308f	0.388b	0.265ef	0.296e	0.315e	0.345a	0.314b
9	20	0.366c	0.289g	0.333e	0.301bcd	0.286f	0.277h	0.295b	0.283e
10	40	0.273i	0.258h	0.339d	0.340a	0.284f	0.277h	0.259b	0.259g
11	60	0.293g	0.320de	0.333e	0.277def	0.271g	0.334d	0.308b	0.259g
12	80	0.372c	0.314e	0.327f	0.252f	0.296e	0.277h	0.320b	0.259g
13	100	0.310f	0.289g	0.303g	0.303bcd	0.296e	0.277h	0.316b	0.271f

H.D = Plastic sheet thickness ≤ 0.03mm; L.D =Plastic sheet thickness =17µ; 0,20,40,60,80 and 100 holes/bag. Means followed by a common letter in the same column are not significantly different by DMRT (P ≤ 5%).

Table 3: Effect of polyethylene perforation bags on vitamin C (mg/100g fw) of 'Canino' apricot fruit during 2009 and 2010 seasons

No.	Treat.	7 day		14 day		21 day		28 day	
		2009	2010	2009	2010	2009	2010	2009	2010
1	Cont	19.98a	11.35cd	8.05bc	8.27g	7.95f	10.74d	7.89f	13.47cd
2	H.D 0	14.56b	13.40b	9.00ab	10.83de	14.93ab	15.64a	9.87de	15.43ab
3	20	8.32e	13.40b	9.00ab	10.88de	10.95d	12.73bc	10.88cd	14.43bc
4	40	14.56b	12.37bc	8.00bc	9.89ef	8.96ef	12.73bc	8.88ef	13.47cd
5	60	10.40d	12.37bc	6.00d	15.83a	10.95d	13.68b	9.90de	11.53e
6	80	14.56b	15.45a	6.00d	16.16a	15.93a	16.62a	11.84bc	14.43bc
7	100	10.36d	12.37bc	10.00a	11.88cd	9.95de	13.68b	10.85cd	12.53de
8	L.D 0	7.28e	9.29e	6.00d	8.90fg	10.95d	8.78e	9.87de	15.43ab
9	20	10.36d	12.74bc	9.50a	11.88cd	13.93bc	12.73bc	8.88ef	12.53de
10	40	11.44cd	15.40a	7.00cd	10.83de	12.94c	11.72cd	12.83ab	15.43ab
11	60	11.42cd	10.32de	7.00cd	12.21cd	10.95d	12.73bc	13.81a	11.53e
12	80	11.44cd	12.37bc	9.00ab	12.87bc	10.95d	13.68b	9.87de	16.37a
13	100	12.48c	10.32de	7.00cd	13.86b	13.93bc	15.64a	12.83ab	16.37a

H.D = Plastic sheet thickness ≤ 0.03mm; L.D =Plastic sheet thickness =17µ; 0,20,40,60,80 and 100 holes/bag. Means followed by a common letter in the same column are not significantly different by DMRT (P ≤ 5%).

Respiration Rate (mg CO_2/kg fw/h)

Compared with the control, HDPE and LDPE bags significantly decreased the respiration rate of 'Canino' fruit (Fig. 3). The highest recorded respiration rates were 19.55 and 21.00 mg CO_2 /kg fw/h in control fruit, and 15.99 and 16.02 mg CO_2 /kg fw/h in fruit wrapped with LDPE 100 in 2009 and 2010 seasons, respectively. The lowest rate of respiration were 2.25 and 4.69 mg CO_2 /kg fw/h recorded in fruit wrapped with HDPE 0 in 2009 and 2010 seasons, respectively.

DISCUSSION

Through the obvious results, postharvest handling is the final and important stage in the process of producing high quality fresh produce (Abu-Goukh *et al*., 1995; Bashir & Abu-Goukh 2003; Murthy *et al*.,., 2004). Compared to the other methods of fruit packaging, the improved method of HDPE and LDPE reduced respiration rate, weight loss, soluble solids content and titratable acidity; improved fruit firmness and ascorbic acid content; and extent fruit storability (Adamicki 2001; Aharoni *et al*., 2008). In the present study, HDPE 0 and HDPE 20 treatments significantly decreased respiration rate and weight loss percentage during storage in comparison with the control (Fig. 1 and 3). Similar findings of decreasing respiration rate and delay the climacteric peak using polyethylene film (MA) have been reported by Abu-Goukh (1986), Elamin &Abu-Goukh (2006); Somboonkaew & Terry (2010b). Weight loss of control fruit were ranged from 0.17 to 0.19% compared to 0.02 and 0.063% in HDPE and LDPE after 28 days of cold storage (Fig 1). Wills *et al*., (1983) found that water loss from the fruit to the surrounding air affect the physical characteristics of the fruit negatively. Polymeric film packaging can reduce water loss and improve fruit physical characters (Purvis 1983; Elkashif *et al*., 2005; Elamin & Abu-Goukh, 2006; Soomboonkaew & Terry 2010a; 2010b; Sug Choi *et al*., 2012). Fruit firmness of control declined gradually during storage from 6.2 and 5.09 N at harvest date to 2.43 and 1.35 N after 28 days of cold storage in 2010 and 2011, respectively, whereas it was 4.86 and 4.46 N in fruit wrapped with HPDE 20 in the 2010and 2011 seasons, respectively. Similar results were reported in apples, peaches, apricot and dates (Salunkhe & Wu 1973; Barrevelled 1993). The liner effect of polyethylene film is due to the effect of modified atmosphere storage conditions inside the package (high CO_2 and low O_2) (Illeperuma & Jayasuriya 2002; Kader 2002; Elkashif *et al*., 2005; Elamin & Abu-Goukh 2006). Soluble solids content was significantly affected by all HDPE and LDPE treatments in both seasons; however, all treatments caused lower SSC as compared to the control. Agar and Polate (1995) stated that the increase in SSC might be due to the conversion of carbohydrates, organic acids and other soluble materials into sugars during storage. They also observed that SSC increased in different varieties of apricot from 10.6 to 14% due to an increase in both respiration rate and the conversion of sugars to carbon dioxide and H_2O in the late stages of storage (Elamin & Abu-Goukh 2006; Amaros *et al*., 2008; Bayram *et al*., 2009). Also observed that vitamin C content increased significantly with some different perforated polyethylene bags treatments (HDPE or LDPE) than control, but there were no specific significant difference among all treatments and the control in acidity content (Mohamed & Abu-Goukh 2003; Arthey & Philip 2005).

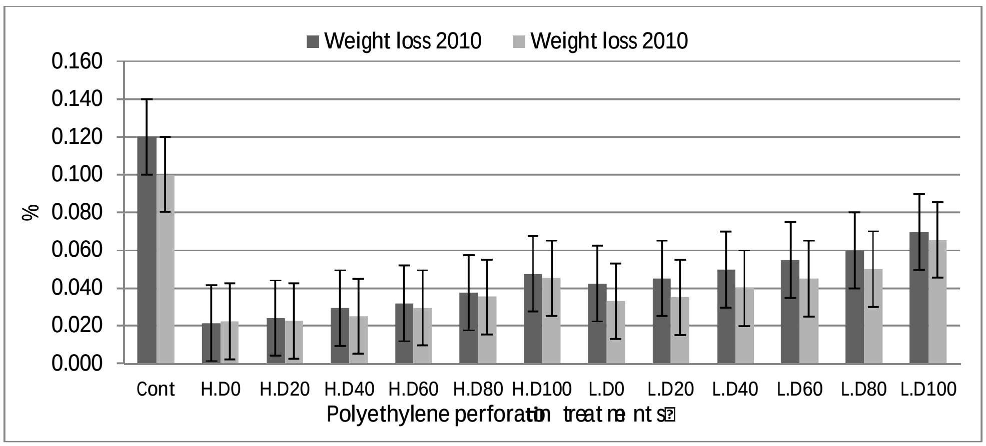

Fig. 1: Effect of polyethylene perforation bags on weight loss (%) of 'Canino' apricot fruit during cold storage in 2009 and 2010 seasons

H . D= Plastic sheet thickness ≤ 0.03mm; L .D =Plastic sheet thickness =17µ; 20, 40, 60, 80 or 100 holes/bag

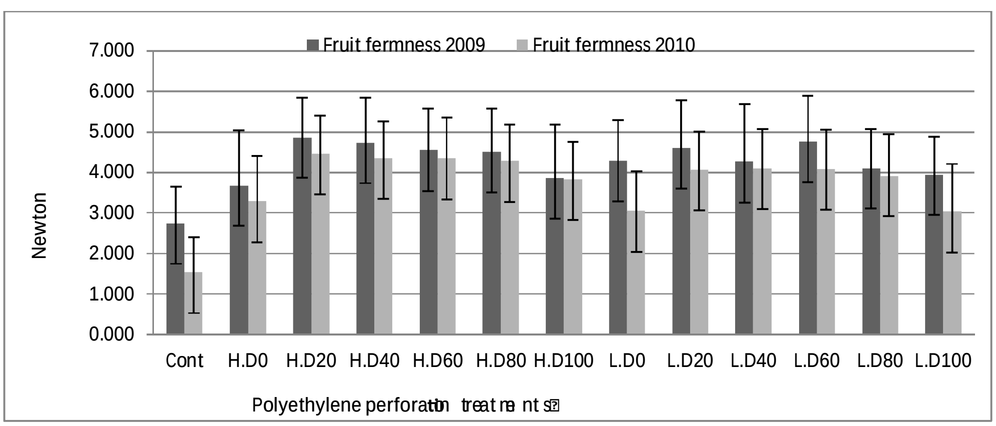

Fig. 2: Effect of polyethylene perforation bags on firmness (Newton) of 'Canino' apricot fruit during cold storage in 2009 and 2010 seasons

H . D= Plastic sheet thickness ≤ 0.03mm; L .D =Plastic sheet thickness =17µ; 20, 40, 60, 80 or 100 holes/bag

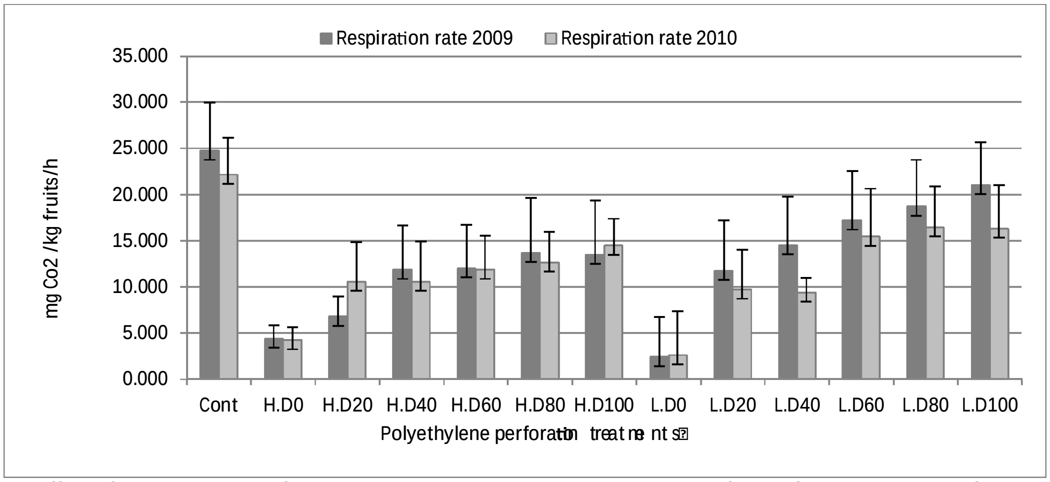

Fig. 3: Effect of polyethylene perforation bags on respiration rate (mg CO_2 /kg fw/h) of 'Canino' apricot fruit during cold storage in 2009 and 2010 seasons

H . D= Plastic sheet thickness ≤ 0.03mm; L .D =Plastic sheet thickness =17µ; 20, 40, 60, 80 or 100 holes/bag

CONCLUSIONS

Perforated polyethylene bags are useful in the storability of apricot fruit, as they delay fruit ripening, maintain quality and extend cold storage period. "Canino" apricot fruit could be stored for four weeks in 20 holes-high density polyethylene bags (HDPE 20) with the optimal quality parameters than perforated with low density polyethylene bags (LDPE) treatments or control.

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