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# Effects of Microperforated Polyethylene Bags and Temperatures on the Storage Quality of Acid Lime Fruits

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**Abstract:** The potential of 30 µm thickness High Density Polyethylene (HDPE) bags with, 1x40, 2x40,3x40 microperforations and no-bags (control) for maintaining the quality of "Key"acid lime fruits during storage has been investigated. The influence of storage temperatures (10 and 20°C) and storage periods (5 and 10 weeks) was evaluated. The greenest and firmest fruits were found in microperforated polyethylene bags compared with no polybags when stored at 10°C. At 20°C, fruit were less green and firm, although fruit kept in microperforated polybags were consistently greener than fruit without polybags. The benefit of using microperforated polybags declined with increasing storage periods. However, vitamin C and color value ($a^*$ value) of fruits was supper ($p<0.05$) with 1X40 microperforation polyethylene bags, compared to the other treatment. Microperforation polyethylene bags reduced remarkable weight loss and decay in fruits stored at the both room temperature (20°C) and 10°C. Maximum weight loss and decay observed in control (non-bag) and minimum in polybags with 40 microperforation. The incidence of decay, particularly in fruits stored at 20°C, is a major limitation to the use of microperforation polybags for long-term storage. There was not significant differences in juice quality of fruit (SSC, pH and acid) stored in polybags or no-bags (control).

**Key words:** *Citrus aurantifolia* L. · Postharvest · Temperature · Microperforated polyethylene bags

## INTRODUCTION

Citrus fruit are non-climacteric, with persistently low respiration and ethylene production rates, do not undergo any major softening or compositional changes after harvest therefore, can normally be stored for relatively long periods [1]. However, two major problems limit facing the long-term storage capability of citrus fruit: the first is pathological and physiological breakdown leading to decay and rind disorders; the second is weight loss especially in acid lime fruits [2]. However, it is practicable to sole the problem of decay development and weight loss, either by the application of fungicide or by alternative environmental safe methods [3]. Apart from decay, the deterioration of citrus fruit during storage results mainly from transpiration and respiration. Traditionally, waxes have been used on citrus fruits to retard transpiration. However, excessive wax coatings restricted the respiratory gas exchange of citrus, causing them to accumulate high levels of ethanol and develop distinct off-flavors [4]. Recently, interest has been shown in the use of plastic films as an alternative to waxing [5].

The permeances of films used for modified atmosphere packing which modify $CO_2$ and $O_2$ levels around fruit, have been tested for retail packing of citrus and application of these films may also have potential for storage and transport of citrus [6]. This would provide a relatively low cost alternative to controlled atmosphere storage, especially for Iran which supplies fruit for short to long term storage to market. Control of atmosphere within MA packages is not precise, however, being a function of product respiration rates, film permeability and external factors such as temperature [5].

The limits for the development of MA packaging science fruit damage may occur due to very high $CO_2$ or very low $O_2$ resulting from temperature fluctuations during commercial handling. One strategy to decrease the risk of developing of injurious gas concentrations is to place pin holes, or microperforations, in the plastic film [7]. Ben-Yehoshua [5] found that polyethylene bags with microperforations (microperforated polybags) reduced the incidence of deterioration as measured by peel shrinkage, softening, deformation and loss of flavor in oranges, grapefruit and lemons. Benefits to background color, flesh

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firmness and eating quality of citrus were also observed using recommended number of microperforations per bag [8]. Film packaging has been extensively tried to restrict weight loss, 15 µm thick high density polyethylene sheets greatly reduced fruit weight loss under uncontrolled room conditions [9]. The weight loss was significantly reduced by seal packaging with low density polyethylene film ranging from 20-40 µm thickness [10]. Poly ethylene bags maintained good organoleptic properties of melon study the storage in a modified atmosphere [11]. The ascorbic and citric acid content loss in un-wrapped and un-waxed fruits whereas, sugar content and sugar acid ratio increased [12].

The objectives of the present study were to evaluate the use of microperforated polybags for acid lime fruits in relation to storage temperatures and storage periods.

## MATERIALS AND METHODS

This Experiment was carried out using fruit from citrus trees acid lime “Kay” grown at the southern part of Iran (Darab). Fruit were washed, dipped in a 500 ppm benomil solution and air dried. Fruits were graded to required sizes. The fruits were then randomized into lots for microperforation polybags film sealing and the control fruit received no polybags. Polybags (polyethylene bags) 25X20 cm with a 30 µm film thickness containing 1X40 (40), 2X40 (80) and 3X40 (120) microperforation (Save Selfresh, Sought Korea) were used for the experiment. Seal-packaged fruit were sealed with Edgeseal machine. Ten fruits from each treatment were numbered and used for weight loss determination. The remainder of each lot was used for other analysis. All microperforated polybags including controls were stored at 10 and 20°C for 5 and 10 weeks. Storage room temperatures were maintained within±1°C. Relative humidity of storage rooms ranged from 85-95%. The bags were removal from cold store and fruit assessed for quality after 24h at ambient air temperatures. Background skin color was assessed using a Minolta CR-200 Chromameter, Japan and calibrate with a white reference plate (Y = 94.3, X = 0.3142 and Y = 0.3211). The $a^*$ value being determined, the more negative the value, the greener the color. Fruit firmness was evaluated on two opposite of the equator with a fruit pressure tester with a 9 mm probe tip. Juice squeezed and Soluble Solid Content (SSC) were measured with a hand refractometer. Titratable acidity was measured by titration of 5-ml juice sample with 0.1 mol NaOH to an endpoint of pH=8.1. Percentages of decay, vitamin C and weight loss were recorded. Randomized complete block design was used for the experiment with three replication for each treatment with 10 fruits each. All statistical procedures were performed using Mstat. Data were subject to ANOVA and Least Significant Differences (LSDs) were determined at $p<0.05$ to compare means. The value presented in the figures was means of three replications.

## RESULTS

An important consequence of seal microperforation with polyethylene bags film is its effect on fruit appearance. The fruit maintained its fresh appearance for 10 weeks even under storage conditions of 20°C (Fig. 1). At the end of the storage periods, a highly significant difference in $a^*$ values occurred between the two storage temperatures with the greener fruit resulting from 10°C storage Fig. 1. The greenest fruit was found in microperforated polybags at both temperatures. The $a^*$ value of 10 and 20°C storage after 10 weeks ranged from 4.6 to 12 in control and -6 to -0.9 in 40 microperforation bags, respectively. Both 80 and 120 microperforation sample maintained their inherent color at 10°C storage. The difference in color between fruit from 1X40 (40) microprforated poly-bags and control (no bag) was significant ($P<0.05$). Also, the difference in color between fruit from 10 and 20°C storage was less in microperforated poly-bags than in ones stored in no bag.

Visible wilt was found only in fruits stored at 20°C without polybags and the average incidence of wilt for fruits in this treatment was 17% Fig. 2. Seal packaging of fruit in microperforation polyethylene bags film markedly reduced the loss of weight in acid lime even stored at 20°C (Fig. 2). 40 and 80 or even 120 microperforated bags reduced the loss in weight by no more than 0.6, 3 and 4.1% at 10°C, respectively, while the reduction of weight

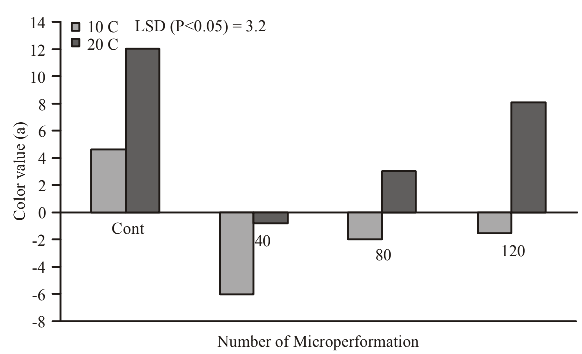


Fig. 1: Effect of microperforated polybags on color value (a) in acid lime lemon after 5 weeks storages

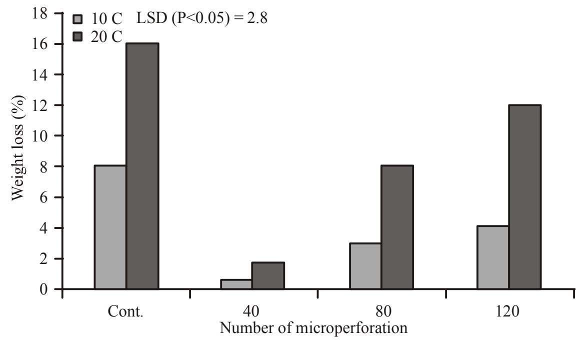


Fig. 2: Effect of microperforated polybags on weight loss of acid lime lemon after 5 weeks storage

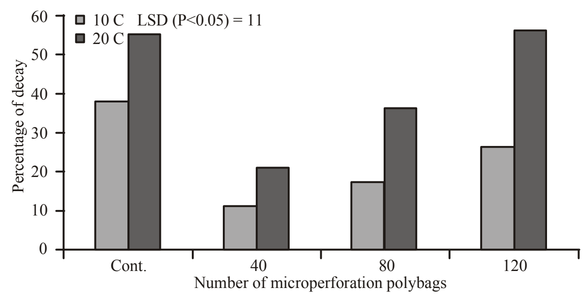


Fig. 3: Effect of microperforated polybags on decay of acid lime lemon after 5 weeks storage

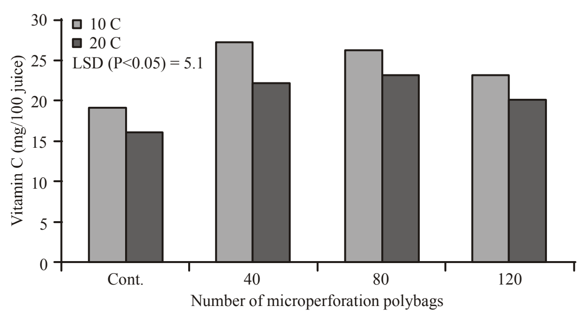


Fig. 4: Effect of microperforated polybags on vitamin C content of acid lime lemon after 5 weeks storage

loss in acid lime in control non-packaged was 8%. About the same reduction was obtained with fruit stored at 20°C. Fig. 2 shows that sealed fruits kept for 10 weeks at 20°C lost less weight (12%) than non-sealed control fruit.

Fruits were stored at 20°C indicated highly quality loss even stored into microperforated polybags Fig. 3. The main cause of quality loss was the occurrence of decay which was very high in the control and microperforated polybags (80 and 120 microperforation). However, after 10 weeks of storage at 20°C, overall loss

Table 1: Firmness and juice quality in seal packaged with microperforation polyethylene (HDPE) and non-sealed in acid lime fruit after 10 weeks storage at 10°C

| Polyethylene film types | Firmness (kg) | SSC* (%) | Acid (%) | pH |
|---|---|---|---|---|
| Control (no-Polybag) | 1.9 | 6.8 | 8.38 | 2.05 |
| 40 microperforation | 2.2 | 7.55 | 8.76 | 1.95 |
| 80 microperforation | 2.1 | 7.39 | 8.55 | 1.98 |
| 120 microperforation | 2.08 | 7.32 | 8.44 | 2.1 |
| LSD (p<0.05) | 0.02 | ns | ns | ns |

* = Soluble solid content

of quality at this temperature resulted in unmarketable fruit. At 10°C, decay did not exceed 38% and was associated primarily with no polybag, compared to 40 microperforation polybag that was 11%. The influence of microperforation polybag types on the occurrence of decay was quite clear Fig. 3. The microperforation of poly-bags did not affect on juice quality of fruit (SSC, acid content and pH) during storage and stimulated marketing and no significant differences were found among the type of microperforation bag Table. However, amount of vitamin C and fruit firmness was greater than other treatments in fruit packaged in 40 microperforation polyethylene bags Fig. 4 and Table 1.

## DISCUSSION

Seal packaging citrus fruits with a thin microperforated film of High Density Polyethylene (HDPE) have more than doubled their life. Microperforated of HDPE bags inhibited weight loss and softening even more than cooling, which is accepted as the best treatment for extending fruit life.

Among the various techniques development to extend fruit life after harvest is the use of plastic films, which maintain the freshness and quality of fruits and vegetables during storage [8, 13]. The results for 10 weeks of storage at 10°C support those report by Hewett and Thompson [14] and Watkins and Thompson, [15] with benefits of microperforated polybags on fruit quality when compared with quality of fruit from no polybags. After 10 weeks storage at 10°C might allow use of microperforated polybags without development of low temperature disorders. The studies reported here indicated that microperforation polyethylene film is of less importance than storage temperature in the keeping quality of seal-packaged fruit. However, polyethylene bag permeability to water vapor and respiratory gases is influenced by chemical composition of the film as well as by number of microperforation [16]. Most of the water loss from citrus fruit during storage is lost from the peel tissue rather than from pulp [5]. Sealing lemon in microperforation polyethylene bags was superior to a conventional solvent wax treatment in reducing transpiration during storage. In contrast to transpiration, microperforated of polyethylene bags did not alter the rate of $CO_2$ and $O_2$ exchange by grapefruit. Vines and Oberbacher [17] found that although respiratory rates of oranges and grapefruit were not appreciably affected by thicker than normal wax coating, the internal $CO_2$ nevertheless increased and the $O_2$ decreased in relation to thickness of applied wax. Porat *et al*. [6] reported that the microperforated XF10 liner enabled a modified atmosphere to form inside the package, with elevated $CO_2$ and decreased $O_2$ levels, whereas the gas atmosphere composition inside the macroperforated XF10 film hardly changed and remained more or less similar to that of ambient air. However, Hewett and Thompson [14] also, reported that concentration of $CO_2$ increase while those of $O_2$ decrease when apples fruit cv. "Cox Orange Pippin" are stored in microperforated polybags; values of 6.2% $CO_2$ and 14.7% $O_2$ after 6 weeks at 1°C.

The microperforated polyethylene bags used in this study did not appear to have any deleterious effect on the juice quality factors determined; however storage temperatures did not alter juice quality. Science the microperforated polyethylene bags were effective in maintaining fresh fruit appearance at temperatures up to and perhaps higher than 20°C, one might be tempted to store warped citrus fruits at non-refrigerated temperatures. Sealing acid lime fruit in microperforated polyethylene bags can extend their storage life, but only when the temperature is properly controlled.

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