prevented. A further advantage of the folded film is that it isolates these problems into individual layers of fruit. One adverse aspect of film use is the problem of disposal at the consumer end. In the case of some European markets, the seller may be responsible for the cost of disposal.

**Literature Cited**


**INDIVIDUAL SHRINK FILM WRAPPING OF MANGOS**

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Additional index words. Mangifera indica, respiration, ethylene, fruit quality, postharvest.

**Abstract.** The effects of individual shrink film wrapping of mangos on shelf life and fruit quality were evaluated. Mango fruit were either shrink film wrapped in RD 106 film (W.R. Grace and Co., Duncan, S.C.) or left nonwrapped. One set of wrapped and nonwrapped fruit was held at 21°C constantly and used to determine the in-package concentrations of carbon dioxide, oxygen, and ethylene as well as carbon dioxide and ethylene evolution from fruit following removal of the wrap. A second set of fruit was stored at 12°C for 1 or 2 weeks after which they were transferred to 21°C for ripening and subsequently evaluated for quality. Carbon dioxide concentration within the wrap ranged from about 5 to 8% and oxygen concentration was about 12% at 21°C. Following removal of the film, respiration rates of the fruit were similar to nonwrapped controls; however, ethylene evolution increased with increased duration of wrapping. The increased ethylene was most different between wrapped and nonwrapped fruit. Wrapped fruit had more decay and lower fruit quality when compared with nonwrapped fruit. Based on the results of this study, individual shrink film wrapping of mangos does not appear to be beneficial.

Mangos (Mangifera indica) are an important tropical fruit crop with good potential for expanded markets outside of the growing regions. However, ripe mangos are highly perishable, and in order to withstand transportation to distant markets, the fruit are typically harvested mature but preripe and ripened during handling and distribution (Chaplin, 1988). Because mangos are sensitive to chilling injury, distribution at low temperature in order to slow ripening is not an option. Treatments which would reduce the rate of mango ripening during distribution and allow the development of good quality in ripe fruit could help expand markets for mangos.

**Materials and Methods**

Mango (cv. Tommy Atkins) fruit were obtained from J. R. Brooks and Sons packing house, Homestead, Fla. The fruit were mature green with full shoulders weighing about 600 g each. The fruit were divided into two groups at random and either not wrapped (control) or wrapped in RD 106 plastic film (60 guage). Transmission rates of water vapor, O2, and CO2 through RD-106 film are 22.9 g/m2/24 h, 8,900 cc/m2/24 h, and 24,000 cc/m2/24 h, respectively. The plastic film was applied using a Weldontron se-
ler (model 6001) and was shrunk tightly around the fruit using a Weldotron heat tunnel (model 7001).

Forty nonwrapped and 40 wrapped fruit were held at 21°C to determine the gas composition of the in-package atmosphere as well as rates of carbon dioxide and ethylene production from the fruit following removal of the wrap. A drop of silicone sealant was placed on the wrap in order to serve as a septum for repeated gas sampling from the atmosphere between the fruit and the wrap. Gas samples were removed daily and analyzed for O₂, CO₂, and C₂H₄ by gas chromatography. The plastic film was removed from 10 fruit following 3, 6, or 10 days and the production of CO₂ and C₂H₄ were determined using a static sampling system (McCollum et al., 1999).

The remainder of the fruit were divided into lots of 6 fruit with 3 lots constituting a replication. There were three replications per treatment. These fruit were placed into storage at 12°C and RH of 85% to 95%. Samples were removed following storage for 7 or 14 days and transferred to 21°C for ripening. Following one week of storage at 12°C plus 5 days at 21°C the wraps were removed from one half of the wrapped fruit. This treatment was not included for the fruit stored for 2 weeks due to the rapid rate of ripening.

At the time of transfer to 21°C, all fruit were weighed and rated subjectively for firmness, color, and decay. The fruit were monitored daily for ripeness, and when they reached the soft ripe stage (subjective determination) they were weighed, color was measured (Minolta CR-200), puncture resistance of the flesh was determined (Instron Universal testing instrument), and soluble solids were measured (refractometer). Pulp samples were stored frozen for later determination of pH and titratable acidity.

Results and Discussion

In-package CO₂ and O₂ concentrations for film-wrapped mangos are presented in Fig. 1. Carbon dioxide concentration averaged from 5 to 7%, and oxygen concentration between 11 to 15% during 9 days. Ethylene was not detected in the in-package atmosphere.

Respiratory rates of mango fruit following the removal of wrap are presented in Fig. 2A. Respiratory rates ranged from 22 to 40 mL/kg h⁻¹ and were not affected by the duration of wrapping. Ethylene production rates following unwrapping are presented in Fig. 2B. Ethylene production was influenced by duration of wrapping with fruit wrapped for greater durations having increasing rates of C₂H₄ production. Although fruit showing visible signs of decay were not used for gas analyses, it is possible that the increase in ethylene that was observed resulted from incipient decay.

The incidence of decay was higher in wrapped than nonwrapped fruit. Following 1 week of storage at 12°C, 9.2% of the nonwrapped fruit were discarded due to decay compared with 13.0% of the wrapped fruit. Following 2 weeks at 12°C, 15% of the nonwrapped fruit were discarded due to decay compared with 29.6% of the wrapped fruit.

Weight loss was reduced significantly by film wrapping (Table 1). Following 1 week of storage, nonwrapped fruit lost approximately 1.8% of their initial weight compared with 0.2% for wrapped fruit. At the ripe stage, nonwrapped fruit had lost 6.6% of their initial weight whereas the wrapped fruit had lost 0.6%. Weight loss from fruit which had the wrap removed was intermediate.

The number of days to ripen following 1 week at 12°C was reduced by film wrapping (Table 1). Fruit ripened in the wrap did not differ significantly from unwrapped fruit in the number of days to ripen. Following 2 weeks at 12°C, the effect of wrapping on the number of days to ripen was not significant. Apparently, some ripening took place at 12°C.

Nonwrapped fruit were significantly firmer than wrapped fruit following both one and two weeks of storage (Table 1). The loss of firmness in wrapped compared to nonwrapped fruit is surprising due to the greater weight loss of nonwrapped fruit. Softening in mangos may be

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Figure 1. Carbon dioxide and oxygen concentrations in the atmosphere between mango fruit and polyethylene film at 21°C.

Figure 2. Rates of carbon dioxide (A) and ethylene (B) production at 21°C from mango fruit that had not been wrapped in polyethylene film (O) or wrapped for 3 (●), 6 (△), or 10 (▲) days.
Table 1. Effects of shrink film wrapping on percent weight loss, days to ripen, resistance to puncture, °Brix, titratable acidity and pH of 'Tommy Atkins' mango fruit following storage at 12°C for 7 or 14 days.

<table>
<thead>
<tr>
<th>Time at 12°C (days)</th>
<th>Treatment</th>
<th>Weight loss (%)</th>
<th>Resistance to puncture (N)</th>
<th>°Brix</th>
<th>Titratable acidity (% citric)</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>at transfer</td>
<td>ripe</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>None</td>
<td>1.8 a</td>
<td>6.6 a</td>
<td>15.3 a</td>
<td>6.1 a</td>
<td>4.6 a</td>
</tr>
<tr>
<td></td>
<td>Wrapped/unwrapped</td>
<td>0.2 b</td>
<td>0.6 b</td>
<td>14.4 b</td>
<td>5.1 b</td>
<td>12.3 b</td>
</tr>
<tr>
<td></td>
<td>Wrapped</td>
<td>0.2 b</td>
<td>0.6 b</td>
<td>14.0 b</td>
<td>5.4 ab</td>
<td>12.0 b</td>
</tr>
<tr>
<td>14</td>
<td>None</td>
<td>3.2</td>
<td>5.7</td>
<td>19.8</td>
<td>6.6</td>
<td>14.0</td>
</tr>
<tr>
<td></td>
<td>Wrapped</td>
<td>0.3</td>
<td>1.3</td>
<td>19.8</td>
<td>5.7</td>
<td>12.5</td>
</tr>
</tbody>
</table>

*Values followed by the same letter are not significantly different at the 5% level.

Values significantly different at the 5% level (*) or not significantly different (ns).

more related to degradation of cell wall polymers than to water loss.

Total soluble solids were significantly higher in non-wrapped fruit than in wrapped fruit following both one and two weeks of storage (Table 1). The higher soluble solids content of the nonwrapped fruit may have been the result of the greater water loss. These results are in contrast with those reported by Miller et al., 1983, and Miller et al., 1986, who found that shrink film wrapping had no significant effect on soluble sugars in mangos, but in agreement with Dhalla and Hanson's (1988) finding that treatment of mangos with Pro-Long resulted in lower total soluble solids.

Following one week of storage, the wrapped fruit were significantly more acid than were the nonwrapped fruit as indicated by the lower pH and the higher titratable acidity (Table 1). Following two weeks of storage, the effects of film wrapping were not significant; however, the same trend of greater acidity in wrapped than nonwrapped fruit was observed as with the fruit stored for one week. Although a formal taste evaluation was not conducted, informal tasting of the fruit indicated a tendency for more off-flavors in the wrapped fruit. In addition, darkened vascular strands in the absence of decay were observed in the wrapped fruit. CIE L, a, and b values of ripe mango fruit flesh were not influenced by film wrapping (data not shown).

Although shrink film wrapping reduced weight loss of mangos, the effects of the treatment were more detrimental than beneficial. Based on the results of this study, we conclude that individual shrink film wrapping of mango fruit is not a beneficial treatment for improvement of shelf-life.

Literature Cited


LIMONIN CONTENT OF FLORIDA PACKED GRAPEFRUIT JUICE

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Additional index words. commercial processing, immunoassay.

Abstract. Samples of Florida grapefruit juice packed at commercial processing plants were obtained as part of the Florida Department of Citrus' (FDOC) commercial juice surveys. During the 1985-86 through 1989-90 processing seasons, limonin was determined using an enzyme immunoassay (EIA) procedure. Samples packed in cans as well as those packed in other containers (glass, plastic and cartons) were evaluated for comparison. Samples were also evaluated based on the type of juice, i.e. reconstituted or direct packed (not from concentrate (NFC)). Results of the investigations showed that non canned grapefruit juice from concentrate generally had the lowest limonin content.

Limonin is one of the bitter compounds which can strongly affect the organoleptic properties of grapefruit juice (Citrus paradisi). Its importance to the flavor of grape-