Evaluation of Shrink-Wrap Packaging for Maintaining Quality of Apples

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ABSTRACT

Changes in quality of unwrapped and shrink-wrapped Starkrimson cultivar apples were monitored during a 38-week storage period (26°C, 40-42% relative humidity). Shrink-wrapped apples were subjectively judged to have acceptable qualities throughout storage. Changes in Gardner a and b values for skin color of apples suggest that shrink-wrap film allows accumulation of ethylene which stimulates yellow color development in less mature apples. Observations indicate that top quality apples benefit from shrink-wrapping, with loss of crispness being the primary limiting factor to extended storage life.

The primary reason for storing apples is to extend the marketing season. Controlled refrigeration temperature and modified atmosphere are commonly used to partially accomplish this objective. To maintain quality for extended periods, the Refrigeration Research Foundation recommends storage at -1 to 0°C under an atmosphere of 1 to 8% CO₂ and 2 to 3% O₂, depending upon the cultivar.

Considerable research has been reported on controlling ripening and senescence of fruits and vegetables (2,5,6,11-14). Attempts to circumvent or minimize controlled storage periods, the Refrigeration Research Foundation recommends storage at -1 to 0°C under an atmosphere of 1 to 8% CO₂ and 2 to 3% O₂, depending upon the cultivar.

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Description of packaging and storage conditions

The purpose of this study was to gain information on changes in quality of Starkrimson cultivar apples individually shrink wrapped and stored at 26°C. This relatively high storage temperature would simulate ambient temperature in roadside markets, especially in the U.S., and also in tropical countries where apples are not traditionally grown, i.e., countries in which increased markets for shrink-wrapped apples might be developed.

MATERIALS AND METHODS

Description of packaging and storage conditions

Orchard run Starkrimson cultivar apples were harvested at random from trees in the University of Georgia Experiment Station orchard and subjectively graded prior to pretreatment or shrink wrapping. Apples were packaged within one day after harvest, before any substantial postharvest changes occurred. Fruits were shrink wrapped in Cryovac D955 (60 gauge) film (Cryovac Division, W. R. Grace and Co., Duncan, SC). The Cryovac D955 film is a biaxially oriented high density polyethylene (O₂ and H₂O transmission rates: 8,900 cm²/m²/24 h and 1.48 g/100 in.²/h, respectively). The CO₂ transmission rate is about 14% that of O₂. Shrink wrapping was achieved by sealing fruits in loose pouches, then passing them through a shrink tunnel at 177°C for 10 sec.

A minimum of six fruits was examined at each analysis time unless otherwise stated.

Procedures for analysis

External color of apples was determined over a 38-h storage period using a Gardner XL-800 color meter with an XL-845 circumferential sensor. Readings were taken at four locations on each apple, about 90° apart around the equatorial circumference.

Texture (Newtons of penetration force) of apples was measured with an Instron Model 1122A food testing system fitted with a 11 mm diameter Magness-Taylor puncture probe penetrating a depth of 7 mm beneath the skin. Crosshead speed was 100 cm per min, chart speed was 100 cm/min, and the full scale load was 10 kg. Measurements were made at two locations about 90° apart on the equatorial circumference of each fruit.

Sensory evaluation of apples consisted of preference ratings for color, aroma, texture, and flavor by a 10-member trained panel.
Statistical analysis

Data were subjected to the Statistical Analysis System (SAS Institute, Cary, NC) for analysis of variance and Duncan's multiple range test.

RESULTS AND DISCUSSION

Instron penetration values for full red and less mature unwrapped and shrink-wrapped Starkrimson apples are summarized in Table 1. A highly significant loss in firmness occurred during the first week of storage, irrespective of maturity level or type of packaging, followed by a more gradual change. There was very little difference between firmness of fully red and less mature partially red fruit.

TABLE 1. Firmness of unwrapped and shrink-wrapped Starkrimson apples at two maturities stored at 26°C for up to 13 weeks.

<table>
<thead>
<tr>
<th>Storage time (wk)</th>
<th>Unwrapped</th>
<th>Shrink-wrapped</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Instron penetration force (N)</td>
<td>Instron penetration force (N)</td>
</tr>
<tr>
<td></td>
<td>Full red</td>
<td>Less mature Av.</td>
</tr>
<tr>
<td>0</td>
<td>59.7</td>
<td>59.2 a</td>
</tr>
<tr>
<td>1</td>
<td>43.5</td>
<td>43.1 b</td>
</tr>
<tr>
<td>2</td>
<td>32.9</td>
<td>35.5 c</td>
</tr>
<tr>
<td>13</td>
<td>36.0</td>
<td>35.6 c</td>
</tr>
</tbody>
</table>

Values in the same column not followed by the same letter are significantly different (P<0.05).

Gardner color measurements on unwrapped and shrink-wrapped Starkrimson apples were monitored for 13 weeks (Table 2). Measurements (not shown) on shrink-wrapped apples were made for an additional 25 weeks, but no significant changes were observed during this period. Gardner L (lightness) values for the fully red apples were only slightly lower than values for less mature fruit. Gardner a values were highly variable over time. The red color of less mature fruits that were unwrapped continued to increase, while the red color of shrink-wrapped changed very little during the storage period. Gardner b values, a measurement of yellowness, were influenced, by fruit maturity and shrink-wrapping. The less mature fruits attained higher b values, i.e., became more yellow, than fully red fruits, and values for shrink-wrapped fruits were higher than for unwrapped fruits. These changes in a and b values suggest that shrink-wrap film allows accumulation of ethylene which stimulates yellow color development in less mature apples.

Fully red unwrapped and shrink-wrapped apples retained brighter color than less mature fruits. The less mature fruit began browning more quickly and discoloration was more pronounced than in fully red fruit. Furthermore, the fully red apples retained superior color for a longer time than did less mature apples. Gardner a values indicate that redness of apples at both levels of maturity increased at 26°C irrespective of whether they were wrapped or unwrapped. In the less mature "green" apples, the increased a values were associated with browning more than with development of redness. By 13 weeks, unwrapped apples had substantially deteriorated. Shrink-wrapped apples had begun to develop brown discoloration. Color changes as related to maturity, packaging, and storage time at 26°C are clearly shown in other Gardner values (C, H, and hue angle). Large differences exist between fully red and less mature apples and between unwrapped and shrink-wrapped apples.

Although color of Starkrimson apples was changing at a rate that could be easily measured instrumentally, sensory panel scores for color remained in the range of 6 to 7 during a 13-week storage period. Values showing the effect of maturity and packaging on sensory qualities during storage are shown in Table 3. Texture was the first quality attribute to be downgraded. Although apples had high turgidity, they were considered to be overripe by panelists. Observations indicate that top quality apples benefit from shrink-wrapping, with loss of crispness being the predominant quality change.
samples were removed at 16 sec from a high temperature short time production pasteurizer at the temperatures indicated and assayed in triplicate for ALP activity by the Fluorophos test method.

This procedure provides a rapid and easy to use method for low levels of ALP in a wide variety of dairy products. The correlation with current methods is good. Using a single working reagent and 3 min read time, a detection limit of 0.006% raw milk is achieved.

ACKNOWLEDGMENTS

Thanks are due to Linda Bates for her technical assistance in the laboratory and to R. L. Bradley, Jr. at the University of Wisconsin for his critical suggestions and for providing the skim milk samples for the pasteurization temperature study.

REFERENCES


TABLE 3. Sensory preference ratings on a hedonic scale (9 = excellent; 1 = very poor) for Starkrimson apples stored at 26°C for 13 weeks.

<table>
<thead>
<tr>
<th>Parameter effect</th>
<th>Storage time (wk)</th>
<th>Color</th>
<th>Texture</th>
<th>Flavor</th>
<th>Sensory characteristic*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>- fully red -</td>
<td></td>
<td>- less mature -</td>
<td></td>
</tr>
<tr>
<td>Maturity*</td>
<td>0</td>
<td>7.2 a</td>
<td>7.9 a</td>
<td>7.2 a</td>
<td>7.2 a</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>7.2 a</td>
<td>7.9 a</td>
<td>7.2 a</td>
<td>7.2 a</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>7.2 a</td>
<td>6.4 b</td>
<td>6.8 a</td>
<td>7.1 a</td>
</tr>
<tr>
<td></td>
<td>13</td>
<td>7.0 a</td>
<td>5.6 c</td>
<td>6.7 a</td>
<td>7.0 a</td>
</tr>
<tr>
<td>Packaging*</td>
<td>0</td>
<td>7.4 a</td>
<td>7.7 a</td>
<td>7.5 a</td>
<td>7.0 a</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>7.4 a</td>
<td>7.7 a</td>
<td>7.5 a</td>
<td>7.0 a</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>7.0 a</td>
<td>6.6 b</td>
<td>6.9 a</td>
<td>7.2 a</td>
</tr>
<tr>
<td></td>
<td>13</td>
<td>6.6 a</td>
<td>6.6 b</td>
<td>6.4 b</td>
<td>7.4 a</td>
</tr>
</tbody>
</table>

*Values in the same column within the same parameter (maturity or packaging) not followed by the same letter are significantly different (P<0.05).

**Includes values for unwrapped and wrapped apples.

***Includes values for fully red and less mature apples.

REFERENCES


