Edible Fruit Coating Reduces Rate of Moisture Loss in Refrigerated Purple Pitanga (Eugenia uniflora ‘Zill Dark’) Fruits

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Like numerous other crops, fresh purple pitanga fruits have a short shelf-life since the fruits quickly ripen and lose moisture, such that they become unattractive and unmarketable within a few days of harvest. Edible fruit coatings have been applied to a number of fruits and vegetables to enhance appearance and extend the shelf-life of the products. For these trials, we evaluated two readily available JBT fruit coatings often applied to tropical fruits. Sta-Fresh® 2952 and Endura-Fresh™ 6100 were diluted to two different concentrations as dips for ripe ‘Zill Dark’ pitanga fruits. After air drying, the fruits were placed in standard plastic berry clamshells; each clamshell containing twelve fruits was weighed and placed in refrigerated storage at 10 °C. Once every 24 hours, the clamshells were weighed to measure overall moisture loss of the fruits. Although the fruit weight decreases of the various treatments were not different after one or two days of refrigeration, after more than three days of refrigeration, fruits dipped in the Endura-Fresh™ 6100 at the 50/50 dilution rate retained moisture better than either fruits only dipped in deionized water or fruits dipped in any of the other treatments.

Some edible fruits have relatively long shelf lives after they are harvested, but many others do not, quickly become over-ripe and unmarketable after a short period of storage. To increase the shelf life and to also improve the appearance of many fruits, edible fruit coatings of various types have been routinely applied to fruits such as apples, pineapples, mangoes, oranges, pomegranates, and others (Olivas, et al., 2008). Some of these fruits, when coated and refrigerated, have a lengthy shelf life where they remain both palatable and marketable for weeks or months (Galus and Kadiński, 2015). It is unlikely that the application of edible fruit coatings onto purple pitanga fruits would extend the shelf life of these soft, tropical fruits for months. However, just extending the marketable shelf life of the fruits from fewer than 7 days up to 10 days would greatly increase the ability of growers to get the fruits to market. There have not been many published research reports on either refrigerated storage (Griffis, et al., 2015; Mélo, et al., 2000; Santos, Silva and Alves, 2006; Santos, Silva, Mendonça, et al., 2006) or application of various edible food coatings to pitanga (Cerqueira, et al., 2009; Fritz, et al., 2019; Sanches et al., 2017). There does not appear to be any published information about applying the two JBT (John Bean Technologies Corp., Chicago, IL) edible food coatings that were used in this experiment to pitanga, although both Endura-Fresh™ 6100 and Sta-Fresh® 2952 are routinely applied to tropical fruits (Hu, et al., 2011; Nor and Ding, 2020; Razali, et al., 2016) both to reduce fruit weight loss and to inhibit fruit decay in low temperature storage. The objective of this study was to determine if various dilutions of either Endura-Fresh™ 6100 or Sta-Fresh® 2952 applied as a fruit dip would inhibit purple pitanga fruit weight loss during two weeks of low temperature storage.

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Materials and Methods

On 7 May 2021, ripe purple fruits were harvested from ‘Zill Dark’ pitanga plants located on the Florida Southern College campus in Lakeland, FL. The fruits were transported to the laboratory where they were placed on paper towels to check for juice leakage. They were evaluated individually to remove any unmarketable or damaged fruits. Two dilutions of both JBT Endura-Fresh™ 6100 and JBT Sta-Fresh® 2952 were prepared. Endura-Fresh™ 6100 is a dark brown liquid containing a proprietary blend of waxes. It was mixed with deionized (DI) water at two recommended rates: 50 mL Endura-Fresh™ 6100 was stirred into 50 mL of deionized water (50:50) and 25 mL of Endura-Fresh™ 6100 was stirred into 75 mL of deionized water (25:75). Sta-Fresh® 2952 is a gel-like paste containing a proprietary blend of fatty acids, fatty acid salts, and mono- and diglycerides derived from plants. It was weighed out and whisked into deionized water until blended. The two recommended rates were 10 g of Sta-Fresh® 2952 whisked into 110 mL of deionized water (10:110) and 10 g of Sta-Fresh® 2952 whisked into 190 mL of deionized water (10:190). Individual purple pitanga fruits were dipped into either deionized water alone or into one of the four edible fruit coating solutions. Thirty-six fruits were selected for each treatment. Fruits were completely submerged in one of the solutions; each fruit was removed from the solution with a plastic spoon and placed carefully on a plastic rack to air dry for 2 h. A small fan was used to speed up the drying process. The 36 fruits for each treatment were divided into three groups of 12 and were placed in plastic 4-oz berry clamshells so that there were three replicates of each treatment, 15 clamshells in all. The clamshells were then transported to Florida Gulf Coast University (FGCU) in Ft. Myers, FL. At FGCU, the individual clamshells, each containing 12 fruits, were weighed and placed...
in refrigerated storage at 10 °C. Every 24 h for 15 days, the clamshells were removed from the refrigerated storage and weighed. They were then returned to refrigerated storage, but their positions were changed each day to eliminate any effects of being placed on the top or the bottom of a stack of clamshells.

## Results

The weights of the ‘Zill Dark’ pitanga fruit dipped into either DI water or one of four different coatings (Endura-Fresh™ 6100 50:50, Endura-fresh™ 6100 25:75, Sta-Fresh® 2952 10:110, Sta-Fresh® 2952 10:190) were measured using three clamshell containers per treatment, yielding repeated measurements of the weights per treatment. Each weight variation for a treatment was observed over 16 days with Day 0 corresponding to the original weight of both the fruit and the container. The weight of every container decreased every 24-h period, indicating some water (with some volatile elements) was being lost from the fruits each day. The data with the replicates contained 16 x 5 x 3 = 240 observations corresponding to the number of days, the DI water control and four treatments, and three replicates respectively.

A repeated measures one-way analysis of variance [RM-ANOVA (Girden, 1992)] was used to determine differences between treatments and within treatments (time measurements); essentially not all fruits among the several treatments lost the same percentage of moisture weight at the same rate. Table 1 shows the results of RM-ANOVA. There were differences over time and between treatments at a 0.05 level of significance. A post-hoc analysis (Maxwell, 1980) was conducted to determine the treatments that showed significant differences. Table 2, shows a significant difference between Stay-Fresh 2952® 10:190 and Endura-Fresh™ 6100 25:75 and the control (DI Water). There were no significant differences among other comparisons. The P-values were adjusted to control familywise error rate (FWER) (Lehmann and Rojo, 2012) using Bonferroni correction.

A secondary analysis was performed to determine differences between treatments and within treatments (time measurements) without replicates. The replicates were summed to obtain a total weight per treatment. This analysis allowed us to determine if the variations in total weight among the containers, both between treatments and within treatments, caused any significant distortions in the data. A one-way analysis of variance (ANOVA) (Montgomery, 2017) was used with weight measurements over time starting with the initial total weight. The treatments were measured individually without any overlaps, satisfying the independence assumption of an ANOVA. A Shapiro-Wilks test (Shapiro, et al., 1968) for normality indicated that the normality assumption of an ANOVA was not violated for measurements in the treatment groups. The results of the ANOVA are summarized in Table 3 which shows significant differences between treatments at the 0.05 level. There were also significant differences for average weight measurements as weights decreased over time, an expected outcome. A post-hoc analysis was performed to identify differences in treatments. Differences among Stay-Fresh 2952® 10:190, Endura-Fresh™ 6100 25:75, and DI Water were consistent with the results in Table 2. The total weights (without repeated measurements) showed differences between Stay-Fresh 2952® 10:110, Endura-Fresh™ 6100 50:50 and DI Water (control) and these results are summarized in Table 4. Since the ANOVA analysis (Table 3) revealed there were significant differences between treatments, it seemed reasonable to display the results graphically so that they could more easily be visualized. This was done with the replicates for each treatment combined and the total percentage of weight remaining (after water loss in refrigerated storage) was tracked daily for 15 days (Fig. 1).

## Discussion

Although there were significant differences between various treatments in this experiment, it appears that Endura-fresh™ 6100 at a 50:50 dilution with DI water was better than any of the other treatments evaluated at slowing water loss from the purple pitanga fruits during refrigerated storage at 10°C. Reduced water loss is an important concern when the fruits are evaluated for extended marketability (Bai, et al., 2019), but there are other important concerns as well, including both appearance and taste of the fruits after refrigerated storage. Some fruits in our trials were relatively unchanged in appearance after the first week in refrigerated storage (Fig. 3a) when compared to Day 0 fruits (Fig. 2), whereas others did not appear to be marketable after 7 days in refrigerated storage (Fig. 3b). After 15 days in refrigerated storage at 10 °C, fruits from all treatments evaluated did not appear to be marketable. Additional experiments might test other dilutions of these or other edible fruit coatings for efficacy at reducing fruit water loss and other clamshell containers could be evaluated as well (Bai, et al., 2019). Other refrigerated storage temperatures could also be evaluated, and additional fruit selection efforts might reduce variability in the weights among fruit filled containers. Increasing the number of replicates for each treatment would allow some of the replicates to be terminated each day, so that the fruit color, juice color, acid, brix, and other measurements of stored fruits

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### Table 1. Results of repeated measures one-way analysis of variance (RM-ANOVA) comparing weights measured over time.

<table>
<thead>
<tr>
<th>Effect</th>
<th>$df_1$</th>
<th>$df_2$</th>
<th>F-statistic</th>
<th>P-value</th>
<th>Effect Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td>15</td>
<td>30</td>
<td>35.74</td>
<td>&lt;0.0001</td>
<td>0.672</td>
</tr>
<tr>
<td>Treatment</td>
<td>4</td>
<td>8</td>
<td>4.85</td>
<td>0.0280</td>
<td>0.411</td>
</tr>
<tr>
<td>Treatment:Time</td>
<td>60</td>
<td>120</td>
<td>1.23</td>
<td>0.169</td>
<td>0.217</td>
</tr>
</tbody>
</table>

| Treatment:Time (Interaction) | 60 | 120 | 1.23 | 0.169 | 0.217 |

### Table 2. Post-hoc analysis for RM-ANOVA.

<table>
<thead>
<tr>
<th>Treatment-1</th>
<th>Treatment-2</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>2952 10:190</td>
<td>6100 25:75</td>
<td>0.0137</td>
</tr>
<tr>
<td>--</td>
<td>DI Water</td>
<td>0.0002</td>
</tr>
</tbody>
</table>

### Table 3. Results of one-way ANOVA comparing treatment means and means over time.

<table>
<thead>
<tr>
<th>Effect</th>
<th>df</th>
<th>SS</th>
<th>MS</th>
<th>F-statistic</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment</td>
<td>4</td>
<td>11975</td>
<td>2994</td>
<td>365.6</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Time</td>
<td>1</td>
<td>38915</td>
<td>38915</td>
<td>4572.7</td>
<td>--</td>
</tr>
<tr>
<td>Residuals</td>
<td>74</td>
<td>606</td>
<td>8</td>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>
could be compared to those of fresh fruits harvested that same day to determine if or when measurable differences in parameters that might affect marketability of fruits occur.

**Literature Cited**


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