NATIONAL MANGO BOARD

PACKAGING STUDY

October, 2019
VIDEO HIGHLIGHTING THE NEW MANGO BOX:

Click Here: https://www.youtube.com/watch?v=5p4rqxy2nCk

Mission: Gather insight from mango industry stakeholders (including growers, packers, exporters, importers, and retailers):

- Identify the current packaging and palletization challenges and any other issues affecting the mango supply chain.
- Emphasize the necessary steps to improve the mango industry’s handling practices and reduce shrinkage.
- Advance increased mango movement at the retail level.
• Albertson’s/ Safeway
  Davis Mochizuki, Director of Produce

• Kroger
  Phil Davis, Supply Chain;
  Lyle O’Banion, Assistant Process Change Manager

• Walmart
  Wynn Peterson, Senior Produce Merchant;
  Gary Campisi, Sr. Director, Quality Control

• Wegman’s
  Chris Foos, Produce Ripener

• Whole Foods
  Chris Romano, Global Produce

• Greg Golden, Amazon Produce Network
• Jojo Shiba, GM Produce Sales
• Sergio Palala, Splendid by Porvenir
• Michael Warren, Central American Produce Co.
• Oscar Orrantia, Durexporta (Ecuador)
• Altamir Martins, Finobrasa Agroindustrial S.A. (Brazil)
• Jorge Perez, Perez Orgánico S. A. de C. V. (Mexico)
• Joaquin Balarezo, Sunshine Export (Peru)
• Veny Marti, Martex Farms (Puerto Rico)
• María Guzmán-Sotomayor and Daniel Lopez Silva, International Paper
• Luis Cristerna, Smurfit Kappa
a) Suboptimal designs and materials are being used for pallets and boxes.

b) Mango industry does not use a standard size box and does not consistently utilize the standard 40”x48” size pallets.

c) Majority of the produce industry uses a 5-down standard box footprint, the mango industry utilizes smaller-size boxes (e.g. 12-downs and 14-downs). Resulting challenges include:
   • Mango boxes do not stack well with other produce boxes and can damage other commodities when mixed pallets are consolidated.
   • Pallets with smaller-size boxes are less stable and fall over with more frequency.
   • Current mango box designs and materials are inconsistent and do not hold up well to the humid conditions commonly found in ripening rooms.

d) These deficiencies increase transfer costs, labor, risk and liability, and expenses are commonly passed down to the growers and packers.
The NMB began a palletization and packaging project with researchers and manufacturers:
  • Cal Poly University and Michigan State University researchers
  • Smurfit Kappa and International Paper carton manufacturers

Four box designs were tested:
  • Compression Testing
  • Bottom-face Bowing
  • Forced-Air Cooling
UPDATED PALLET DESIGN

SINGLE USE, 4-WAY, DOUBLE-FACE, NON-REVERSIBLE
UPDATED BOX DESIGN

COMMON FOOTPRINT, 5-DOWN BOX
BENEFITS OF THE UPDATED DESIGNS

1) Ease of Use and Efficacy
   • 3 of the 4 Kg. round mango boxes = 1 common footprint box
   • Less labor involved
   • Filling the box with product
   • Stacking and unstacking boxes
   • More display space

2) Improved Pallet Stability
   • Larger base per box
   • Both the pallets and boxes are stronger as a result of the design and materials
   • No pallet transfer gaps

3) Improved Ventilation
   • Additional side and bottom air vents
   • Optimal alignment of vent holes

4) Better Durability in High-Humidity Environments
   • Improved crushing resistance and less bottom-face bowing

5) Reduce Overall Total Costs
   • Less fruit damaged = reduced shrink
   • Less carton to dispose of at the end
Updated mango box designs are being recommended for a common footprint box:

- Mini-platform on the top of the box provides better support during shipment.
- Less bottom-face bowing which is beneficial in reducing bruising related abuse on mangos during shipment.
- Faster cooling rate.
- Overall improvement in handling.
# 4 KG BOX TO 5-DOWN BOX CONVERSION

## Tommy Atkins

<table>
<thead>
<tr>
<th>Trays per layer</th>
<th>Corrugated Board</th>
<th>*Mango Count</th>
<th>Mangos/Tray</th>
<th>Weight (lbs.)</th>
<th>Weight (Kg)</th>
<th>Average Mango Weight (grams)</th>
<th>Std. Dev Mango Weight(grams)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Double Wall BC-Flute</td>
<td>6</td>
<td>20</td>
<td>32.1</td>
<td>14.6</td>
<td>710.0</td>
<td>57.0</td>
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<tr>
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<td>Double Wall BC-Flute</td>
<td>7</td>
<td>23</td>
<td>30.8</td>
<td>14.0</td>
<td>592.0</td>
<td>51.0</td>
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<tr>
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<td>Double Wall BC-Flute</td>
<td>8</td>
<td>25</td>
<td>28.9</td>
<td>13.1</td>
<td>509.0</td>
<td>35.0</td>
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<tr>
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<td>Double Wall BC-Flute</td>
<td>9</td>
<td>27</td>
<td>28.3</td>
<td>12.8</td>
<td>459.0</td>
<td>39.0</td>
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<tr>
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<td>Double Wall BC-Flute</td>
<td>10</td>
<td>30</td>
<td>28.3</td>
<td>12.8</td>
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<td>43.0</td>
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<tr>
<td>5</td>
<td>Double Wall BC-Flute</td>
<td>12</td>
<td>37</td>
<td>25.6</td>
<td>11.6</td>
<td>303.0</td>
<td>36.0</td>
</tr>
</tbody>
</table>
QUESTIONS & DISCUSSION
APPENDIX:
4-WAY DOUBLE FACE WOODEN PALLET

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**Pallet Analysis**

**Best Pallet Version 3.3.16**

- **Prepared by:** White and Company Inc.
- **Company:** GA Pallet
- **Location:** GA Pallet
- **Date:** Oct 12, 2017
- **Site:** GA Pallet

**Pallet Information**

- **Dimensions:** 48 in x 40 in x 4.5 in, Weight: 47.8 lbs
- **Material:** Solid wood
- **Stacking:** 3 high, 4 long, 1 width
- **Condition:** New, unused, Block pallet, Chemical treated

**Notes:**

1. **Loads:**
   - **Dimensions:**
     - 4-way double face
     - 4-way single face
     - 4-way single face
   - **Thickness:**
     - 2 in
     - 3 in
     - 4 in

**Analysis Summary**

- **Required Pallet:** 2,000 lbs
- **Predicted Maximum Safe Load:** 27.5 lbs
- **Load/Visibility:** Low

**Analysis**

- **Storage and Handling Conditions**
  - **Predicted Maximum Safe Load:**
    - Forklift Parallel to Pallet: 8,221 lbs
    - Forklift Perpendicular to Pallet: 5,581 lbs
  - **Stacking:** 1 high

**Disclaimer:**

The performance of the pallet is based on engineering calculations and testing. However, the quality of the wood, the load data, and the conditions in which the pallet are used may vary. Therefore, White and Company Inc. is not responsible for pallet performance or design accuracy. Performers are advised to take into account the results of testing and to use the pallet accordingly.
Double wall board: B/C Flute
Water resistant adhesive
Board Combination 35lb - 36lb - 26lb - 36lb - 35lb (Liner-medium-Liner-Medium-Liner)
ECT – 73 lb./in
DATA RECORDER INSTRUMENTATION

- To determine the 7/8 cooling time, temperature recorders were placed in layers 1, 10 and 17 of the palletized load of mangos.
- Two ‘TT4’ temperature recorder probes in location T1 and T2 were inserted into the pulp of the mango to monitor temperature of fruit.
- A temperature and humidity recorder was placed in location T4 on layers 1, 7 and 17 to monitor headspace temperature and humidity during transportation.
- A temperature recorder was placed in location T3 on layers 1, 7 and 17 to monitor cooling tunnel temperature.
FORCED AIR COOLING TEST

PALLET LOCATION

- Two cooling tunnels were used to force air cool 6 palletized load.
- Locations of the pallets are indicated on the picture.
- Initial average internal fruit temperature was 91F and the cooling tunnel temperature was 52F.
- Therefore the $\frac{7}{8}$th cooling time will be the time taken to bring down the internal fruit temperature to approximately 56F-$\frac{7}{8}$th cooling temperature.
- Tunnel 1 ran for approximately 4 hours
- Tunnel 2 ran for approximately 2 hrs 20 mins.
COMPRESSSION STUDY

Triple Stack Data
Ambient Condition 23C @ 70%RH

Design B-DW
Design A-DW
Design A-SW
Design B-SW
Design C-DW
Design C-SW

Compression Strength [lbs]

Mean Design Style

Design B-DW
Design A-DW
Design A-SW
Design B-SW
Design C-DW
Design C-SW
COMPRESSION STUDY

Triple Stack Compression Strength
8C @ 70% RH; 24 hrs

![Graph showing compression strength for different designs.](image-url)
Project implementation completed: Chahuites, Oaxaca, Mexico mid-April (from April 14 to 18).

A total of 74 thermometers were installed in 6 different pallets: each box design was set up in a pallet of 17 layers.

Bottom, mid and top layers (pallet) had 4 thermometers each located in 4 different positions (Except for Design A and Design C, where in the middle layer there were only 3 thermometers).

The thermometers were calibrated in house to record temperature of the fruit, temperature of the tunnels, temperature of the containers, humidity of the tunnels, humidity of the box, humidity of the container etc.
A comparative cooling rate study was conducted on pallet loads of the A, B, and C, tray designs in duplicate.

A standardized 40” X 48” wooden block style developed by PIs was used for palletizing the 5-down trays. Pallet Style- Single Use; 4-Way Double-Face Non-reversible.

Six pallet loads (17 high x 5-down) were prepared. Trays were filled with 28 mangos per tray (Tommy size-9 ct./4 Kg tray).
# FORCED AIR COOLING TEST

## RESULTS TUNNEL 1

<table>
<thead>
<tr>
<th>Tray Type</th>
<th>Predicted 7/8th Cooling Time (Hrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>T1 Location</td>
</tr>
<tr>
<td></td>
<td>Layer 17</td>
</tr>
<tr>
<td>Design B</td>
<td>1.60</td>
</tr>
<tr>
<td>Design C</td>
<td>1.52</td>
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<tr>
<td>Design A</td>
<td>1.29</td>
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</table>

<table>
<thead>
<tr>
<th>Tray Type</th>
<th>Predicted 7/8th Cooling Time (Hrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>T3 Location</td>
</tr>
<tr>
<td></td>
<td>Layer 17</td>
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<tr>
<td>Design B</td>
<td>1.42</td>
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<tr>
<td>Design C</td>
<td>2.09</td>
</tr>
<tr>
<td>Design A</td>
<td>1.42</td>
</tr>
</tbody>
</table>
## FORCED AIR COOLING TEST

### RESULTS TUNNEL 2

<table>
<thead>
<tr>
<th>Tray Type</th>
<th>T1 Location</th>
<th>T2 Location</th>
<th>Predicted 7/8th Cooling Time (Hrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Layer 17</td>
<td>Layer 8</td>
<td>Layer 1</td>
</tr>
<tr>
<td>Design B</td>
<td>3.24</td>
<td>9.41</td>
<td>5.25</td>
</tr>
<tr>
<td>Design C</td>
<td>1.55</td>
<td>3.74</td>
<td>3.26</td>
</tr>
<tr>
<td>Design A</td>
<td>3.43</td>
<td>*</td>
<td>*</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Tray Type</th>
<th>T3 Location</th>
<th>T4 Location</th>
<th>Predicted 7/8th Cooling Time (Hrs)</th>
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<tbody>
<tr>
<td></td>
<td>Layer 17</td>
<td>Layer 8</td>
<td>Layer 1</td>
</tr>
<tr>
<td>Design B</td>
<td>1.99</td>
<td>5.27</td>
<td>*</td>
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<tr>
<td>Design C</td>
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<tr>
<td>Design A</td>
<td>0.98</td>
<td>2.90</td>
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</table>
• Mango Variety Tommy 8 Count (4 Kg Tray).
• Mangos Conditioned at $8^\circ\text{C}$ and 70% RH in trays for 24 hrs.
• Vibration Test- ASTM 4169; Assurance Level II; 60 minutes.
• Quantified bottom face bowing.

**BOTTOM FACE BOWING – POST VIBRATION STUDY**
The average bottom face bowing for Design A was 0.14 inches versus Design B was 0.52 inches.
BOTTOM FACE BOWING – POST VIBRATION STUDY

Average Bowing at Different Points on Box

<table>
<thead>
<tr>
<th>Bow Measurement Points As Marked on Box</th>
<th>Design B-DW Average</th>
<th>Design A-DW Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bow 1</td>
<td>0.51</td>
<td>0.13</td>
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<tr>
<td>Bow 2</td>
<td>0.53</td>
<td>0.19</td>
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<tr>
<td>Bow 3</td>
<td>0.43</td>
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<tr>
<td>Bow 4</td>
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<tr>
<td>Bow Center</td>
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<td>0.34</td>
</tr>
<tr>
<td>Bow Average</td>
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