NATIONAL MANGO BOARD

PACKAGING STUDY

October, 2019

VIDEO HIGHLIGHTING THE NEW MANGO BOX:

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

PURPOSE OF THE PROJECT

The National Mango Board (NMB) organized a Packaging Task Force in 2016.

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.

ORIGINAL TASK FORCE

- 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

DISCOVERY

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.

WHAT DID WE DO…

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

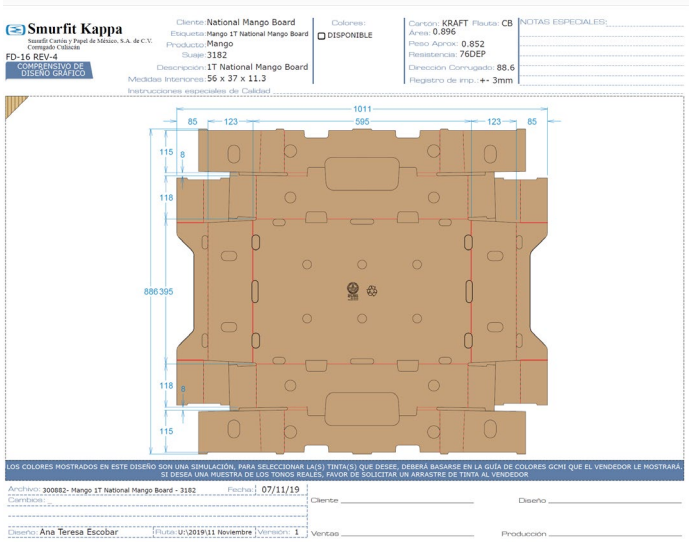
SINGLE USE, 4-WAY, DOUBLE-FACE, NON-REVERSIBLE

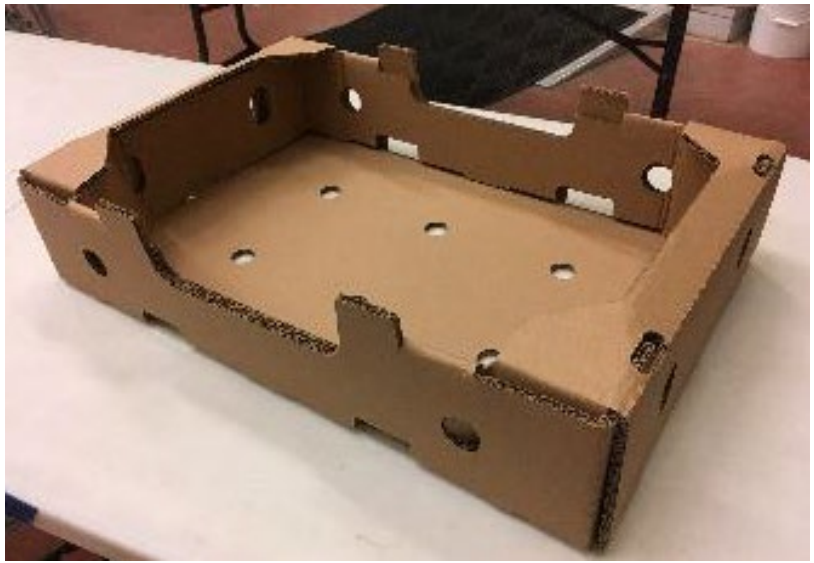
New

UPDATED BOX DESIGN

COMMON FOOTPRINT, 5-DOWN BOX

New





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

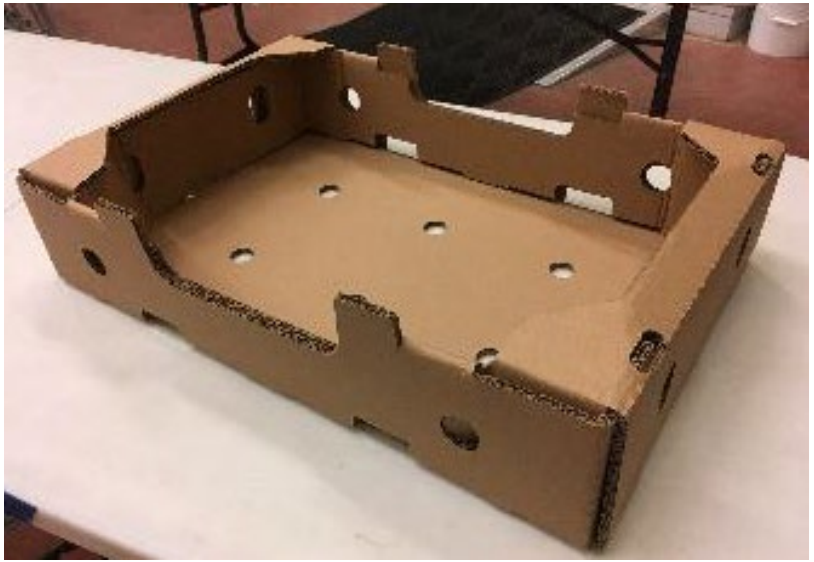
4) Better Durability in High-Humidity Environments
   - Improved crushing resistance and less bottom-face bowing

5) Reduce Overall Total Costs
   - Less fruit damaged = reduced shrink
   - Less carton to dispose of at the end

SUMMARY OF FINDINGS

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

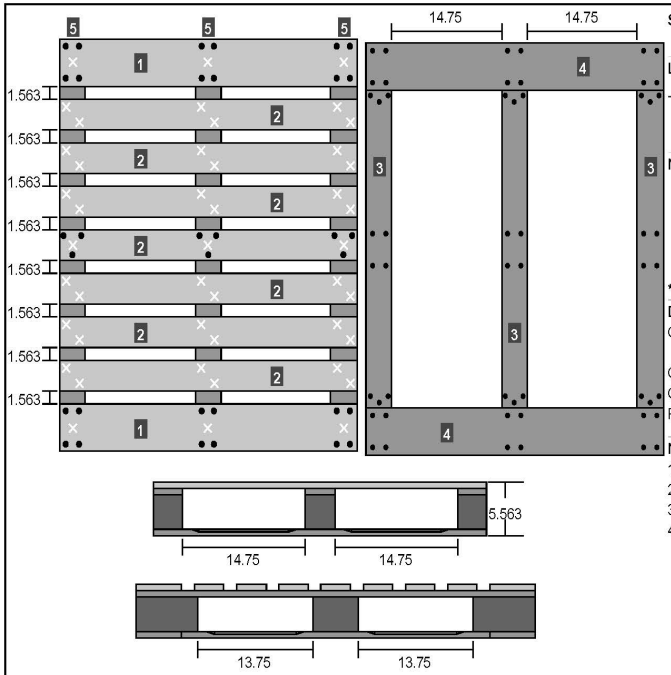
Tommy Atkins

Trays per layer	Corrugated Board	*Mango Count	Mangos/Tray	Weight (lbs.)	Weight (Kg)	Average Mango Weight (grams)	Std. Dev Mango Weight(grams)
5	Double Wall BC-Flute	6	20	32.1	14.6	710.0	57.0
5	Double Wall BC-Flute	7	23	30.8	14.0	592.0	51.0
5	Double Wall BC-Flute	8	25	28.9	13.1	509.0	35.0
5	Double Wall BC-Flute	9	27	28.3	12.8	459.0	39.0
5	Double Wall BC-Flute	10	30	28.3	12.8	414.0	43.0
5	Double Wall BC-Flute	12	37	25.6	11.6	303.0	36.0


Mango.org
QUESTIONS &
DISCUSSION

APPENDIX:

4-WAY DOUBLE FACE WOODEN PALLET



Style: Single-Use, 4Way
DoubleFace Non-reversible, Perimeter Base

Lumber: **Acceptable Lumber Species:**
100% Ponderosa Pine

Min Part Grade: Standard And Better

Max Moisture Content: 19%

Nails: (45 Mat fastener, 87 nails)
See notes below

Length:
Gauge:
Type:
Point:

* or equivalent

Dimensional Tolerance:
Out of Square deviation 1/4"
(1/2" Difference in diagonals).
Overall Length & Width deviation + or - 3/16".
Overall pallet height deviation + or - 1/8".
Pallets shall lie flat at all points within 1/2".

Notes: (lengths in inches)
1. Species - ponderosa, radiata, carribean, loblolly pines
2. Nail TD 3 X 0.120 Inches annular thread.
3. Nail BD 2.5 X 0.120 inches annular thread
4. Clinch nail 1.75 X 0.105 plain clinched or 1.5 inch screw

Deckboards

Item	Qty.	Dimensions
1	2	40.0L x 5.5W x 0.69T
2	7	40.0L x 3.5W x 0.69T
3	3	37.0L x 3.5W x 0.69T
4	2	5.5L x 40.0W x 0.69T

Stringer Boards

Item	Qty.	Dimensions
5	3	48.0L x 3.5W x 0.69T

Blocks

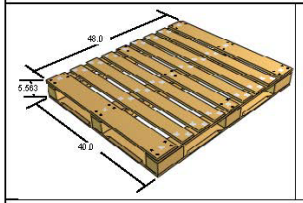
< W >	Qty.	Dimensions
	6	7.5L x 3.5W x 3.5H
	3	5.5L x 3.5W x 3.5H

Approved Pending
Version No. 1
ID. Mango Pallet
Drawing No. 1

Pallet Analysis — Best Pallet Version 3.3.1o*

Prepared By: White and Company LLC
Company: Cal Poly
Analysis ID: SA pine mango pallet V 2
Address:
Date: Oct 12, 2017
San Luis Abispo

Pallet Information: 48.0 in L x 40.0 in W, Weight - 47.8 lbs, HT for Export, Single-Use
Pallet Description: 4Way, DoubleFace , Non-reversible, Block pallet, Chamfered
Pallet Lumber: Ponderosa Pine



Analysis Summary

Required Payload:	2600 lbs
Predicted Maximum Safe Load:	2746 lbs
LoadVariability:	Low

Analysis

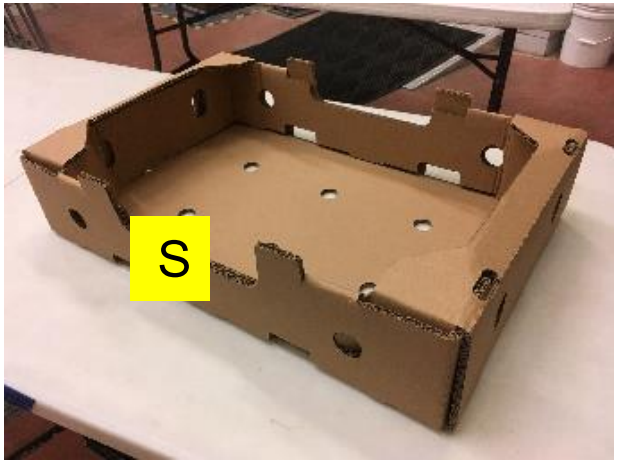
Storage and Handling Conditions	Predicted Maximum Safe Load (lbs)lbs)	Initial Average Deflection (in)in)	Critical Members
Forktine Parallel to Length	8221	0.3	Top Deckboard
Forktine Perpendicular to Length	2746	0.55	Top Stringer
Stacked 1 High	6757	0.14	Top Stringer

Forktine spacing = 14.25, length = 42.0, and width = 5.0

Disclaimer: The performance estimates of Best Pallet represent the best available engineering information compiled to date. However, the quality of workmanship, the input data, and the conditions in which pallets are used may vary widely. Therefore, White & Company, LLC cannot accept responsibility for pallet performance or design as actually constructed. Performance estimates from Best Pallet should be verified by testing of prototypes prior to implementation.

CORRUGATED BOARD SPECIFICATIONS

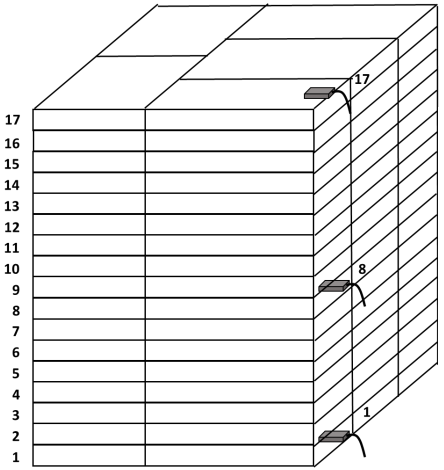
- Double wall board: B/C Flute
- Water resistant adhesive
- Board Combination 35lb - 36lb - 26lb - 36lb - 35lb (Liner-medium-Liner-Medium-Liner)
- ECT – 73 lb./in

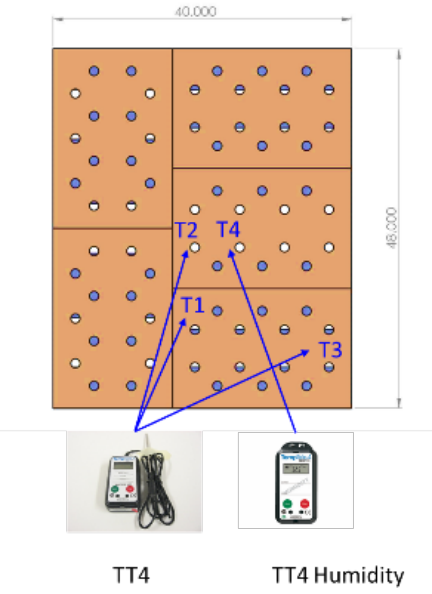


FORCED AIR COOLING TEST

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.





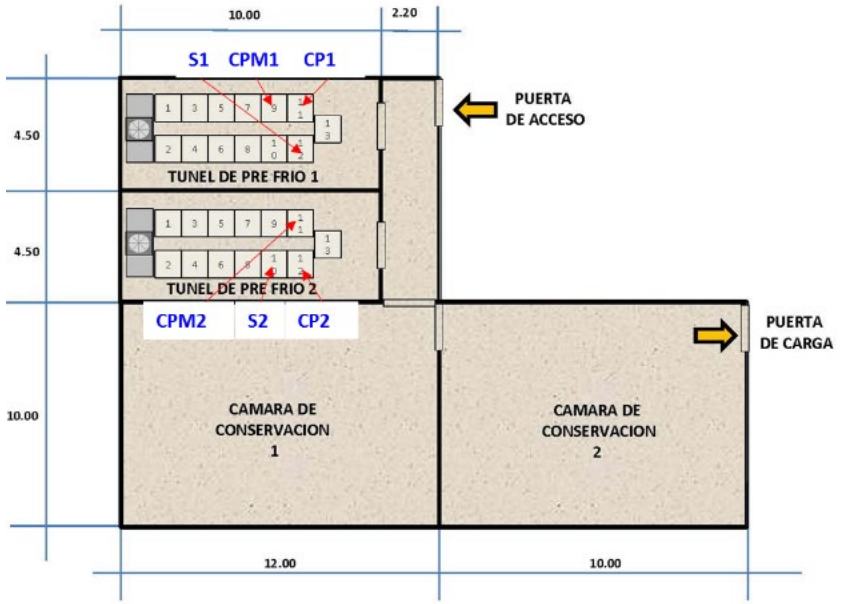
TT4 TT4 Humidity

FORCED AIR COOLING TEST

PALLET LOCATION

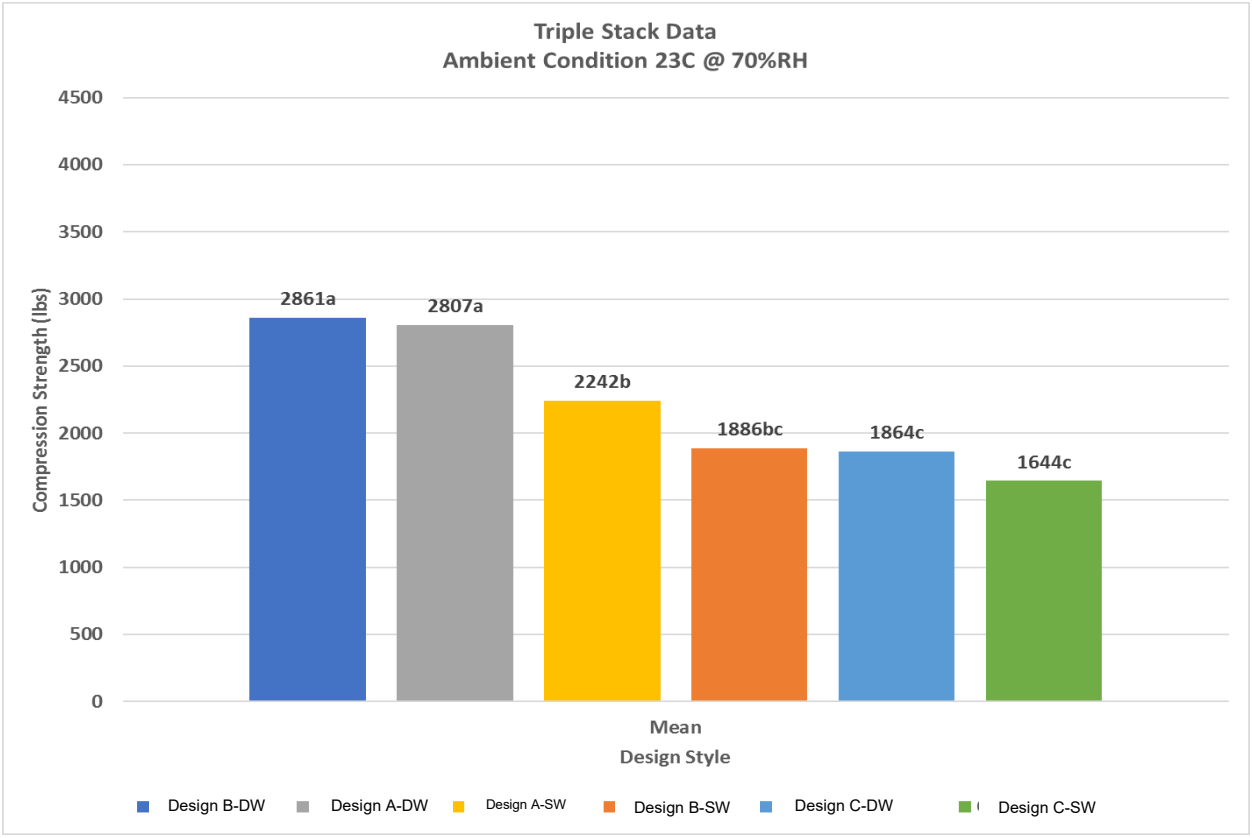
- Two cooling tunnels were used to force air cool 6 palletized load.
- Locations of the pallets are indicated on the picture.
- Initial average internal fruit temperature was 91F and the cooling tunnel temperature was 52F.
- Therefore the 7/8th cooling time will be the time taken to bring down the internal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

LAYOUT CUARTOS FRIOS GRUMAN

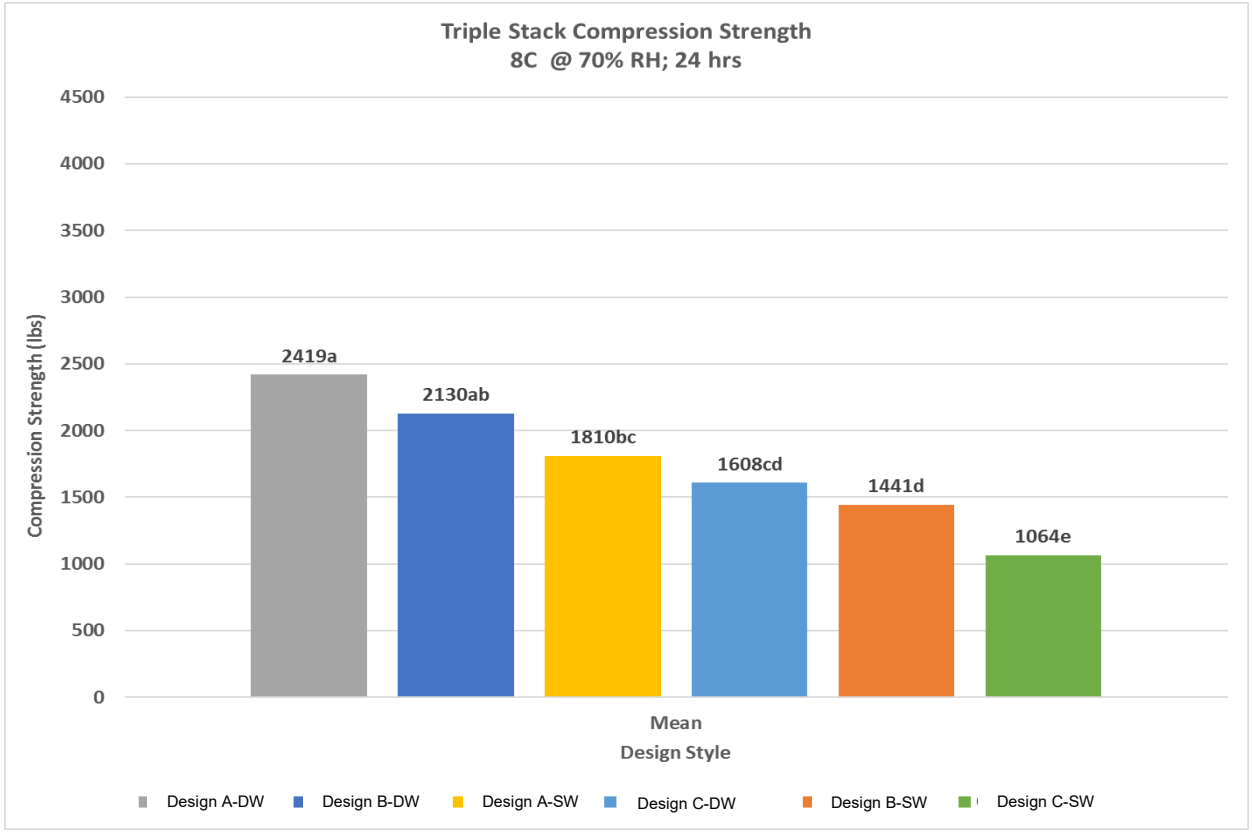


Capacidad de pallets por tunel: 13 pallets
Tipo de caja: Display 4 kg
Temperatura de entrada: 80 -84 F°
Temperatura de salida: 48 -52 F°
Tiempo promedio de pre enfriado: 2 horas 45 minutos

COMPRESSION STUDY



COMPRESSION STUDY



FORCED AIR COOLING TEST

- 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.

FORCED AIR COOLING TEST

- 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

Tray Type	Predicted 7/8th Cooling Time (Hrs)					
	T1 Location			T2 Location		
	Layer 17	Layer 8	Layer 1	Layer 17	Layer 8	Layer 1
Design B	1.60	3.54	4.74	1.64	*	4.91
Design C	1.52	3.95	4.04	2.14	*	*
Design A	1.29	*	*	1.92	2.79	2.50

Tray Type	Predicted 7/8th Cooling Time (Hrs)					
	T3 Location			T4 Location		
	Layer 17	Layer 8	Layer 1	Layer 17	Layer 8	Layer 1
Design B	1.42	2.93	2.30	0.37	*	*
Design C	2.09	*	3.92	0.78	2.82	*
Design A	1.42	2.93	2.30	0.43	1.63	1.25

FORCED AIR COOLING TEST

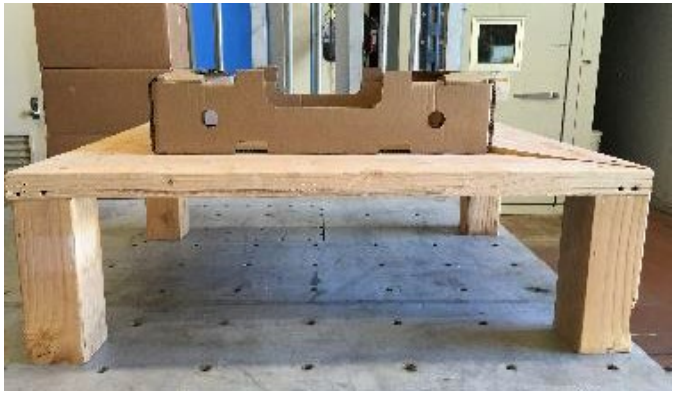
RESULTS TUNNEL 2

Tray Type	Predicted 7/8th Cooling Time (Hrs)					
	T1 Location			T2 Location		
	Layer 17	Layer 8	Layer 1	Layer 17	Layer 8	Layer 1
Design B	3.24	9.41	5.25	1.96	6.49	3.80
Design C	1.55	3.74	3.26	1.77	7.86	8.45
Design A	3.43	*	*	1.73	2.93	3.55

Tray Type	Predicted 7/8th Cooling Time (Hrs)					
	T3 Location			T4 Location		
	Layer 17	Layer 8	Layer 1	Layer 17	Layer 8	Layer 1
Design B	1.99	5.27	*	1.48	2.44	0.88
Design C	1.99	5.27	*	0.39	7.37	3.58
Design A	0.98	2.90	*	0.24	1.93	1.76

BOTTOM FACE BOWING – POST VIBRATION STUDY

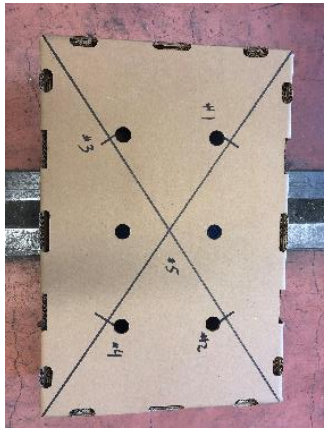
- Mango Variety Tommy 8 Count (4 Kg Tray).
- Mangos Conditioned at 8^{o}C* and 70% RH in trays for 24 hrs.
- Vibration Test- ASTM 4169; Assurance Level II; 60 minutes.
- Quantified bottom face bowing.

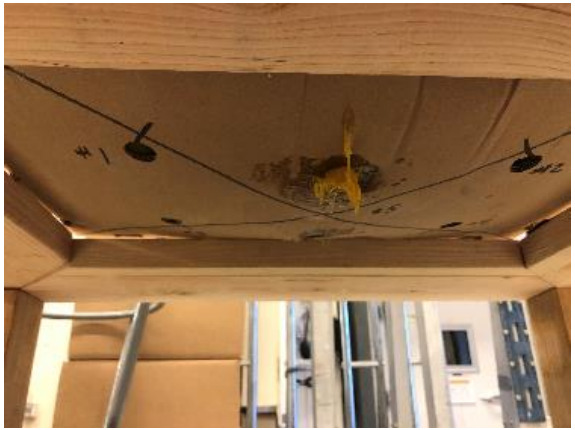


BOTTOM FACE BOWING – POST VIBRATION STUDY

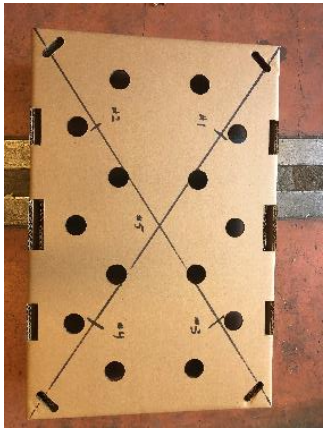
- The average bottom face bowing for Design A was 0.14 inches versus Design B was 0.52 inches.

Design “A”





Design “B”



BOTTOM FACE BOWING – POST VIBRATION STUDY