The use of mini-containers in fresh food supply chains: the small grower perspective

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Schematic of Current Fresh Produce Supply Chain

1. Farm, Farming Practices and harvesting
2. First mile logistics: Routing
3. Consolidation, pre-cooling and introduction to cold chain
4. Packaging and storage at origin
5. Long Haul Transportation
6. Transportation to retailer
7. Storage at distribution Center
8. Local Transportation
9. Warehouse picking and preparation for local transportation
10. Storage at broker's or wholesaler's warehouse
11. Transportation to Consumer's premises
12. Storage at consumer's premises
13. Display at retailer shelf
14. Preparation and Consumption
Current Situation of Local Logistics: Small Grower, first mile Perspective

• Lack of logistics capacity and service providers with focus on small growers
• Lack of open-access facilities for processing, packing, pre-cooling, and cold storage
• Lack of critical mass for an individual grower to access efficient logistics (full truck loads, processing, etc.)
• Aggregation of products from different growers in a vehicle made difficult because of regulation and incompatibility of products
• Lack of marketing, planning and negotiating platforms to make an efficient demand-supply match
• Not ready for the new market conditions
Out-of-the-Box Solution: A Box, the Mini-Container

Sensor/Traceability module Inside
- Temperature
- RH
- CO₂
- Ethylene
- Vibration
- Transmission/recording/monitoring in real time of location and environmental conditions
- Unique ID for traceability purposes

Motorized Control Valves
- Cold Air Supply
- Humidity/Dehumidify Supply
- N₂ Supply
- Return Air
- Water/Debris Collection Area

Conceptual Design – Central Driving Unit (CDU)

- Traceability
- Energy Recovery
- Pre-cooling
- Electrification

Central Driving Unit (CDU) Provides services to mini-containers

- External Electricity Input
- Electrical Power Unit
- Battery Bank (or IC engine for special cases)
- Vapor Compression System
- Filtration and Energy Recovery Unit
Conceptual Design: Supply/Return Piping
Cold-Chain and Mini-Containers

• We can identify three different types of activities in the cold chain of FFV: precooling, storage and transportation.

• Mini-containers have the potential to integrate these activities seamlessly without the need of additional handling.

• The mini-containers can potentially connect the grower directly to the final customer without being unlocked, preserving the life-shelf of the product, reducing food waste to a minimum, providing full traceability and reducing energy footprint.
Solar Electrification Potential for Pre-Cooling and Storage

MCs + CDU (CDU = Central Driving Unit) can be stored at the farm, and solar PV can be used to provide electric power to maintain the required environmental conditions.

Note: The hybrid design of the MC allows for Solar PV to be supplemented with grid electricity and fuel-driven generators as needed.
First Mile Logistics Problems

• Harvest sizes too small to fill a full truck
• Very often regulations mandate that harvests from different growers cannot be consolidated in the same freight vehicle
• Lack of logistics agents with focus on harvest aggregation

What About the Regulations?
The Mini-Container as a Minimal Marketing Unit

- The mini-container can help standardize the logistics and trading units in the spot and forward markets
- For instance, a mini-container (interior dimensions of 44X44X39.5” or ) is equivalent to:

<table>
<thead>
<tr>
<th>Crop</th>
<th>Package Type</th>
<th>Weight (lbs)</th>
<th>Length</th>
<th>Width</th>
<th>Height</th>
<th>Package/MC</th>
<th>lbs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tomatoes</td>
<td>box</td>
<td>30</td>
<td>18.5</td>
<td>11.81</td>
<td>9.44</td>
<td>24</td>
<td>720</td>
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<tr>
<td>Lettuce, Romaine</td>
<td>cartons</td>
<td>30</td>
<td>22</td>
<td>14</td>
<td>11</td>
<td>18</td>
<td>540</td>
</tr>
<tr>
<td>Beans</td>
<td>bushel cartons/crates</td>
<td>21</td>
<td>15.43</td>
<td>11.81</td>
<td>10.7</td>
<td>24</td>
<td>504</td>
</tr>
<tr>
<td>Bell Pepper</td>
<td>box</td>
<td>25</td>
<td>14</td>
<td>14</td>
<td>12</td>
<td>27</td>
<td>675</td>
</tr>
<tr>
<td>Cauliflower</td>
<td>cartons film wrapped</td>
<td>25</td>
<td>19.9</td>
<td>11.81</td>
<td>10.7</td>
<td>24</td>
<td>600</td>
</tr>
<tr>
<td>Celery</td>
<td>cartons</td>
<td>31</td>
<td>19</td>
<td>19</td>
<td>9</td>
<td>16</td>
<td>500</td>
</tr>
<tr>
<td>Chayote</td>
<td>40 lb cartons</td>
<td>40</td>
<td>18.11</td>
<td>12.4</td>
<td>12</td>
<td>18</td>
<td>720</td>
</tr>
<tr>
<td>Cucumber</td>
<td>box</td>
<td>40</td>
<td>14</td>
<td>14</td>
<td>12</td>
<td>27</td>
<td>1080</td>
</tr>
<tr>
<td>Brussel sprouts</td>
<td>cartons</td>
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<td>10</td>
<td>10</td>
<td>4.8</td>
<td>128</td>
<td>384</td>
</tr>
<tr>
<td>Spinach</td>
<td>box</td>
<td>20</td>
<td>20</td>
<td>13</td>
<td>7.8</td>
<td>30</td>
<td>600</td>
</tr>
</tbody>
</table>
Current Version of Prototype
Some of the Benefits of the Mini-Containers

• Allow the aggregation of storage/transportation-incompatible small harvests into a single truck, reducing costs and the food waste generated by waiting for transportation

• Allow the virtual creation of cold storage facilities in places with limited access to these facilities, a major source of food waste

• Allow the immediate introduction to the cold chain of harvests by having a CDU at the farmer’s premises to do the precooling of crops

• **Allow the reduction of carbon footprint of food by reducing waste, operating with batteries and by enabling better vehicle routing, a major source of energy waste and carbon emissions**

• Enable direct small farm-to-market transaction, skipping intermediaries and inefficient extra handling of the crops

• Allow precise temperature and environmental control as well as full traceability and real-time tracking, characteristics appealing to industries such as pharmaceuticals

• Ideal for the upcoming automated and autonomous logistics systems
Sponsors Mini-Container Project

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- J. Rene Villalobos
- Pat Phelan

Students:
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- Mahmound Syam
- Sergio Garcia
Thank you.

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Autonomous Vehicles on Logistics

- Optimizes supply chains and logistics operations of the future, as players employ automation to increase efficiency and flexibility.

- In combination with smart technologies could reduce labour costs while boosting equipment and facility productivity.

- A fully automated and lean supply chain can help reduce load sizes and stocks by leveraging smart distribution technologies and smaller AVs.
Conceptual Design – CDU Details

- Filter
- Damper
- Refrigeration Unit
- Humidifier
- Blowers
- Modified Air Tank
- Damper