Reducing Losses and Extending Availability of Fruits and Vegetables

Beth Mitcham
University of California, Dept. of Plant Sciences
Horticulture Innovation Lab
Postharvest Technology Center
Our projects address:

- Production and marketing issues
- Creating better seed systems
- Reducing postharvest losses
- Improving extension and transferring innovative technologies
Fruits and Vegetables

- Nutritious
- Healthy
- Perishable
- Seasonally available
Increase Quantity, Quality and Seasonal Availability

• Increase proportion that makes it to the consumer (reduce losses)
• Reduce degradation of nutrients and edibility after harvest (maintain quality)
• Extend season of production/harvest
  – Irrigation, protected cultivation, staggered plantings/harvest
Characteristics of Fruits and Vegetables

- Good source of nutrients
- High water content
- Easily damaged
- Alive – a biological system
- Deterioration begins at harvest
Reducing Losses is Key to Sustainability and Food Security

• Highly nutritious products, like fruits and vegetables, are often more perishable
• Investments lost when produce degrades
  – land, energy, seed, fertilizer, water, and labor
• To increase food security, must reduce produce losses after harvest along with enhanced productivity
Postharvest Losses of Fruits and Vegetables

• Quantitative

• Qualitative
  – Loss of acceptability by buyer
  – Loss of weight
  – Loss of caloric and nutritive value
  – Loss of edibility
## Estimated Postharvest Losses (%) of Fresh Produce

<table>
<thead>
<tr>
<th>Locations</th>
<th>Developed Countries</th>
<th>Developing Countries</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Range</td>
<td>Mean</td>
</tr>
<tr>
<td>From production to retail sites</td>
<td>2-23</td>
<td>12</td>
</tr>
<tr>
<td>At retail, foodservice, and consumer sites</td>
<td>5-30</td>
<td>20</td>
</tr>
<tr>
<td>Cumulative total</td>
<td>3.5-26.5</td>
<td>32</td>
</tr>
</tbody>
</table>
Causes of Food Losses in U.S.

• Grade standards and economics
  – Some crop left in the field, not economical to harvest
• Deterioration during storage
  – Pathological and physiological deterioration
• Transportation losses
  – Packaging failures
  – Temperature mismanagement
• Retail losses
  – Decay
  – Water loss
  – Expiration dates
• Consumer loss and waste
  – Refrigeration deterioration
  – Food left on plates
  – Leftovers
Quantity losses at the consumer level are larger than retail level losses for all categories except added fats and oils.

1\ Includes loss in the home and in away-from-home locations. Includes cooking shrinkage and uneaten food.
Causes of Postharvest Loss in the Developing World

- **High Temperatures after Harvest**
  - Sun exposure, lack of cooling, cold transport/storage
- **Water Loss**
  - high temperatures, low RH, poor packaging
- **Physical Damage**
  - poor packaging, inadequate transportation
- **Decay**
  - high temperatures, poor sanitation, physical damage
- **Inadequate drying and dry storage**
  - molds, mycotoxins, deterioration
Causes of Postharvest Loss in the Developing World

• **High Temperatures after Harvest**
  – Sun exposure, lack of cooling, cold transport/storage

• **Water Loss**
  – high temperatures, low RH, poor packaging

• **Physical Damage**
  – poor packaging, inadequate transportation

• **Decay**
  – high temperatures, poor sanitation, physical damage

• **Inadequate drying and dry storage**
  – molds, mycotoxins, deterioration
Approaches to Reduce Losses

- Improved packaging
- Low cost cold storage
- Improved drying technologies
- Other processing methods
High Temperatures after Harvest

• Temperature related to water loss, decay and over-ripening
• Limits time for marketing after harvest
• Farmers must sell in short period
  – Cannot hold product
  – Price takers
• Unable to collect quantities required by some buyers
## Recommended vs. Measured Tomato Fruit Temperatures

<table>
<thead>
<tr>
<th>Country</th>
<th>Rec. Temp. °C</th>
<th>Farm</th>
<th>Wholesale Market</th>
<th>Retail</th>
</tr>
</thead>
<tbody>
<tr>
<td>India</td>
<td>15</td>
<td>25.2</td>
<td>30.5</td>
<td>29.1</td>
</tr>
<tr>
<td>Ghana</td>
<td>15</td>
<td>31.2</td>
<td>30.2</td>
<td>32.5</td>
</tr>
<tr>
<td>Benin</td>
<td>15</td>
<td>28.5</td>
<td>29.1</td>
<td>23.4</td>
</tr>
<tr>
<td>Rwanda</td>
<td>15</td>
<td>30.1</td>
<td>22.1</td>
<td>23.4</td>
</tr>
</tbody>
</table>

Kitinoja and Al Hassan, 2010  
N=30; 3 reps from 10 random samples per site
Effect of Temperature on Broccoli Quality

The graph shows the effect of various storage temperatures on the days required to initiate yellowing in broccoli. The x-axis represents the storage temperature in degrees Celsius, with corresponding Fahrenheit values. The y-axis indicates the number of days it takes for the broccoli to initiate yellowing.

- At 0°C (32°F), yellowing starts after 32 days.
- At 2.5°C (36°F), yellowing starts after 36 days.
- At 5°C (41°F), yellowing starts after 41 days.
- At 7.5°C (45°F), yellowing starts after 45 days.
- At 10°C (50°F), yellowing starts after 50 days.
- At 12.5°C (55°F), yellowing starts after 55 days.
- At 15°C (59°F), yellowing starts after 59 days.
- At 20°C (68°F), yellowing starts after 0 days.

The image on the right shows broccoli heads labeled after 7 days in storage at different temperatures, illustrating the visual changes in quality over time.
Effects of Sun Exposure after Harvest

- Produce in the sun are 3 - 10°C higher than ambient air temperature
- Tomatoes and eggplant in the sun for 1 hour after harvest >15°C hotter than produce in the shade
- Produce left in ambient air with low RH lose moisture up to 100x faster than produce that is cooled
Shading to Protect Produce from the Sun
CoolBot Cold Rooms
Low-cost Cold Room
CoolBot

Store It Cold
http://storeitcold.com

8 MT Capacity
$300 controller
$600 AC unit

90% less than equivalent capacity commercial refrigeration system
Low-tech Systems using Evaporative Cooling

- Charcoal cooler with wetted charcoal walls
- Pot in Pot System from Nigeria
- Work best in the dry tropics
- Use at farm or household level to hold a few days

Mohammed Bah Abba
Zero Energy Cool Chamber

(ZECC) is constructed from stacked bricks. A cavity between double walls is filled with sand and the bricks and sand are kept saturated with water.

Costs
1 MT - $1,200
100 kg - $125

Source: Roy [10]; Illustration from [6].
Physical Damage

• Skin provides protection from disease and water loss
• Damages increases metabolic rate and rate of deterioration
• Damage makes product less attractive to consumers
Postharvest Handling in Developing World
Examples of Shipping Containers Used in Developing Countries
Good Packaging Essential

- Protection from damage
- Moisture barrier to reduce water loss
- Modified atmosphere packaging (↓O₂, ↑CO₂)
Reusable Plastic Crates

- Support product
- Washable
- Resistant to moisture
INADEQUATE DRYING AND DRY STORAGE

The Dry Chain
Maintaining the Dry Chain

• Thorough drying of any dried product after harvest
  – Fruits, vegetables, nuts, grains, legumes
  – Challenging in warm humid environments

• Once products are dried to 60 to 70% moisture content, must be kept dry

• Must also prevent increase in moisture content in humid climates
  – Mold and insect activity
  – Aflatoxin contamination (anti-nutrient)
Stabilizing Production with Solar Drying

• Drying horticultural crops
  – Adds value
  – Use for excess product
  – Provides off-season nutrition

• Solar drying
  – Cabinet dryers are common
  – Product laid on flat surfaces

• Chilies, spices, mangos, nuts, herbs
The chimney Dryer Concept

• Use a chimney to draw the air through the tunnel
• Use a clear plastic tunnel to collect solar energy – free heat.
• Place the product at the top of the tunnel, where the warmer air is
• Fill unused parts of the tunnel to increase air speed past the product.
Air enters front of drier. Air flow is concentrated in a small cross section to cause high airspeed past product.

Warm air rises in chimney to produce airflow.

60 cm high ‘table’ covered with black plastic or cloth. Clear plastic film is placed over the trays and the sides of the table.
Apricot drying in Uzbekistan
Fruits and vegetables in Tanzania
Ready to be dried
Chimney Dryer Setup
Drying for 4 hours under cloudy skies

<table>
<thead>
<tr>
<th></th>
<th>Initial wt (gr)</th>
<th>Final wt (gr)</th>
<th>% loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capsicum</td>
<td>1000</td>
<td>667</td>
<td>33</td>
</tr>
<tr>
<td>Amaranthus</td>
<td>129</td>
<td>49</td>
<td>62</td>
</tr>
<tr>
<td>Broccoli</td>
<td>505</td>
<td>315</td>
<td>38</td>
</tr>
<tr>
<td>Tomato</td>
<td>1000</td>
<td>610</td>
<td>39</td>
</tr>
<tr>
<td>Pawpaw</td>
<td>491</td>
<td>209</td>
<td>57</td>
</tr>
<tr>
<td>Carrot</td>
<td>750</td>
<td>439</td>
<td>41</td>
</tr>
<tr>
<td>Moringa whole</td>
<td>100</td>
<td>39</td>
<td>61</td>
</tr>
<tr>
<td>Moringa crushed</td>
<td>84</td>
<td>22</td>
<td>74</td>
</tr>
<tr>
<td>Beans</td>
<td>614</td>
<td>505</td>
<td>18</td>
</tr>
</tbody>
</table>
How does drying affect nutrient content?

- Solar cabinet dryer
- Drying bead drying at ambient temperatures (20°C)

Solar Cabinet Dryer
Peak Temp. 53°C

Drying Beads
Peak Temp. 23°C

Drying Beads are a product of Rhino Research, Thailand
Nutrient Content in Mango and Tomato Following Solar and Drying Bead Drying

Source: Jamey Smith, Horticulture Innovation Lab
How can you tell if your product is dry enough?

- The DryCard™ is a simple, inexpensive visual tool to raise awareness about the level of dryness of any dried food.
- Actively searching for entrepreneurs and donors!
Despite everything we know, why have postharvest practices remained so poor?
Reasons for Low Adoption

- Lack of incentives/market
- Lack of resources/capital
- Lack of information among farmers, handlers and marketers
- Policies that inhibit best practices
- Others?
Questions?