Drying and Dehydration of Fruits and Vegetables

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Drying (Dehydration)

- One of the oldest methods of preserving food
-Removes moisture stops the growth of bacteria, yeasts & molds that normally spoil food
-Slows down but doesn’t completely inactivate enzymes
Drying Techniques

• Sun or solar drying
• Freeze drying
• Drum drying
• Spray drying
• Foam mat and vacuum belt
• Convection air & Superheated steam (tray, tunnel)
• Osmotic drying
• Microwave
Drying Techniques (continued)

• Combination of different techniques
• Vacuum- osmotic
• Osmotic – microwave
• Ultrasound pre-treatment followed by drying
• Fluidized bed
• Pulse combustion
• Jet zone or impingement
Drying Foods Outdoors

• **Sun Drying**
  – Fruits safe to dry due to high acid and sugar content
  – Vegetables should not be dried outside
    • They need constant temperature & airflow
  – Temperature of 30°C or higher for several days with humidity below 60%
  – Cover to protect against insects/pests
Drying Outside, continued

• Solar Drying
  – Need to construct a dryer with panel(s)
  – Need to stir and turn food several times a day
  – Need several days of sun in a row

• Vine Drying
  – Beans & Lentils
Room Temperature Drying

Method used mainly for herbs & hot peppers

» Strung on string or tied in bundles and suspended from overhead racks in air until dry

OR

» Enclosed in paper bags with openings for air circulation

» Herbs can also be dried in the microwave oven
Temperatures for Drying

• The ideal temperature for drying or dehydrating foods is 60-70 °C
  – If higher temperatures are used, food cooks instead of dries

• Avoid “case hardening”
  – dried on outside but moisture trapped inside allowing mold growth

• Temperature close to glass transition gives better products
Figure 1. During processing, drying occurs in three different periods, or phases, which can be clearly defined.
Factors affecting drying

- Temperature
- Humidity
- Air velocity
- Direction of air flow
- Type of dryer
- Type and size of food

*(very difficult to remove last 2% of moisture)*
The Process

• Prepare the fruit: wash, core and peel if desired
• Fruits can be halved or sliced and some left whole
• Thin, uniform, peeled slices dry fastest
• If fruit is whole, “check” or crack the skin to speed drying
Pre-treatment

Some fruits need to have their enzymes inactivated before drying, especially those that oxidize when exposed to air (e.g. bananas, apples, pears)

- Ascorbic Acid
- Fruit juice dip
- Honey dip
- Syrup blanching
- Commercial acids
Tunnel Dryer

Tray Dryer
Hot Air Drying

Carrots

Blueberries
Vacuum Belt Drying Of Blueberries
Solar Tray Dryer

- Air outlet opening (with protective net cover)
- Insulated drying chamber
- Polyethylene cover
- Bottom of solar collector (black painted)
- Solar panel (photovoltaic cell)
- Fan (solar panel driven)
- Air inlet (with protective net cover)
# Technical Data for Fruit Dehydration in Tunnels

<table>
<thead>
<tr>
<th>Fruits</th>
<th>Drying Conditions</th>
<th>Finished Product</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Load kg/m²</td>
<td>Temperature °C</td>
</tr>
<tr>
<td>Plums</td>
<td>15</td>
<td>I. 40-50</td>
</tr>
<tr>
<td></td>
<td></td>
<td>II. 75-80</td>
</tr>
<tr>
<td>Apples (Rings)</td>
<td>10</td>
<td>75-55</td>
</tr>
<tr>
<td>Apricots (Halves)</td>
<td>10</td>
<td>70-60</td>
</tr>
<tr>
<td>Cherries (w. stones)</td>
<td>10</td>
<td>55-70</td>
</tr>
<tr>
<td>Pears (Halves and quarters)</td>
<td>15</td>
<td>70-65</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>70-60</td>
</tr>
</tbody>
</table>

FAO 1990
## Technical Data on some Osmotically Dehydrated Products

<table>
<thead>
<tr>
<th>Fruit or vegetable</th>
<th>Type of cut</th>
<th>Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Banana</td>
<td>5 mm slices</td>
<td>2 hours, 80% sugar</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2000 ppm SO2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>at 70 °C</td>
</tr>
<tr>
<td>Carrots</td>
<td>10 x 10 x 2 mm dices or 5 mm slices</td>
<td>4 hours, 60% sugar + 10% salt</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4000 ppm SO2</td>
</tr>
<tr>
<td>Mango, green</td>
<td>8 mm slices</td>
<td>2 hours, 25% salt</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8000 ppm SO2</td>
</tr>
<tr>
<td>Mango, ripe</td>
<td>8 mm slices</td>
<td>2 hours, 60% sugar</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8000 ppm SO2</td>
</tr>
<tr>
<td>Onions</td>
<td>2 mm slices</td>
<td>2 hours, 60% sugar + 10% salt</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4000 ppm SO2</td>
</tr>
<tr>
<td>Papaya</td>
<td>8 x 8 mm slices</td>
<td>4 hours, 80% sugar</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2000 ppm SO2 at 70 °C</td>
</tr>
<tr>
<td>Strawberries</td>
<td>Whole</td>
<td>4 hours, 80% sugar</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4000 ppm SO2</td>
</tr>
<tr>
<td>Sweet peppers, red</td>
<td>6 mm dices</td>
<td>2 hours, 60% sugar + 10% salt</td>
</tr>
</tbody>
</table>
Arranging Fruit for Drying

• Do not over fill
  – Leave room for air circulation
• Lay as flat as possible
• Dry similar fruits together
  – Avoid mixing strong odors
Determined Dryness of Fruit

- Drying fruit can take anywhere from 6 hours for thin or small pieces or 10-12 hours for larger juicy fruits such as peach or apricot halves.
- Dried fruit will feel leathery; won’t stick to itself.
- Cut fruit should have no visible moisture inside though it may be soft.
After Drying Fruit…

• Cool fruit 30-60 minutes before packaging
• Don’t pack too soon or moisture buildup could occur
• Don’t wait too long or the fruit could pick up moisture from the air
Conditioning Fruit…

• Conditioning is used to equalize moisture
  ❖ Pack cooled fruit in plastic bag or glass jar
  ❖ Seal and let stand for 7-10 days
  ❖ Shake jars daily to separate pieces and check for moisture (condensation on sides of bag/jar)
  ❖ If there is condensation, return fruit to dehydrator for more drying or place in freezer

• There is a chance mold will have already started growing in too-moist fruit; discard if you find mold
Fruit Bars

Main raw material quantities to prepare approximately 100 kg of fruit bars are as follows:

<table>
<thead>
<tr>
<th>Type of fruit</th>
<th>Fruit required, kg</th>
<th>Pulp obtained, kg</th>
<th>Sugar required, kg</th>
<th>Yield (% of fresh fruit) approx.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mango</td>
<td>720</td>
<td>360</td>
<td>33</td>
<td>14</td>
</tr>
<tr>
<td>Banana</td>
<td>600</td>
<td>360</td>
<td>30</td>
<td>17</td>
</tr>
<tr>
<td>Guava</td>
<td>406</td>
<td>325</td>
<td>60</td>
<td>25</td>
</tr>
<tr>
<td>Mango + banana</td>
<td>540 + 150</td>
<td>360</td>
<td>35</td>
<td>15</td>
</tr>
<tr>
<td>Papaya + banana</td>
<td>500 + 140</td>
<td>336</td>
<td>54</td>
<td>23</td>
</tr>
</tbody>
</table>

Source: Amoriggi (1992), FAO (1990)
Fruit Leathers

- Made from pureed fruit
  - Can use fresh/frozen fruit or canned fruit
- May add sugar, honey, or lemon juice for flavor and color retention
- May add coconut or nuts
- Dry on special drying tray that comes with dehydrator
- Dry until pliable; no wet spots; not crispy
Drying Vegetables

• Prepare the vegetables
  - Wash, trim, and peel
  - Cut uniform pieces or leave whole
  - Dry as soon as possible after harvesting
Pre-treating Vegetables

• **Water blanching**
  - Follow recommended times
  - Do not over-fill basket or pan
  - Start timing when water returns to boil after placing vegetables in basket

• **Steam blanching**
  - Place in basket above boiling water (no more than 2 inches higher)
  - Cover pan/pot and begin timing
Cooling Vegetables

• Dip briefly in cold water only long enough to stop cooking
• Cool until they are only slightly hot to touch—about 120°F
• Wipe and spread vegetables out on racks for drying
Determining Dryness of Vegetables

- Dry vegetables until brittle or “crisp”
- Some vegetables shatter if hit hard
- Low moisture (10%)
- Cool, place in bags or jars and seal
  - Should store up to 1 year if in a cool dark place in jars with air-tight
Nutritional Value of Dried Foods

Fresh produce provides calories, fiber, minerals and vitamins. Changes that can be expected in home-dried food are:

- Calories: No change
- Fiber: No change
- Minerals: Minimal loss
- Vitamins: Greater loss during dehydration process (more susceptible to heat, air and light)
Yields

- Because drying removes moisture, the food shrinks and decreases in size and weight
- When water is added to the dried product, it returns close to its original size

25 lbs. apples = 4 lbs. dried
25 lbs. onions = 3 lbs. dried
References

• “So Easy to Preserve”- University of Georgia
• Drying Food, University of Illinois Extension
• Food Preservation: Dehydration- New Mexico State University
• Home Drying of Food, Utah State University Extension


• FAO Document, 1990