

# Drying and Dehydration of Fruits and Vegetables

**Rakesh Singh**

Department of Food Science and Technology

The University of Georgia

Athens, GA, USA

# 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



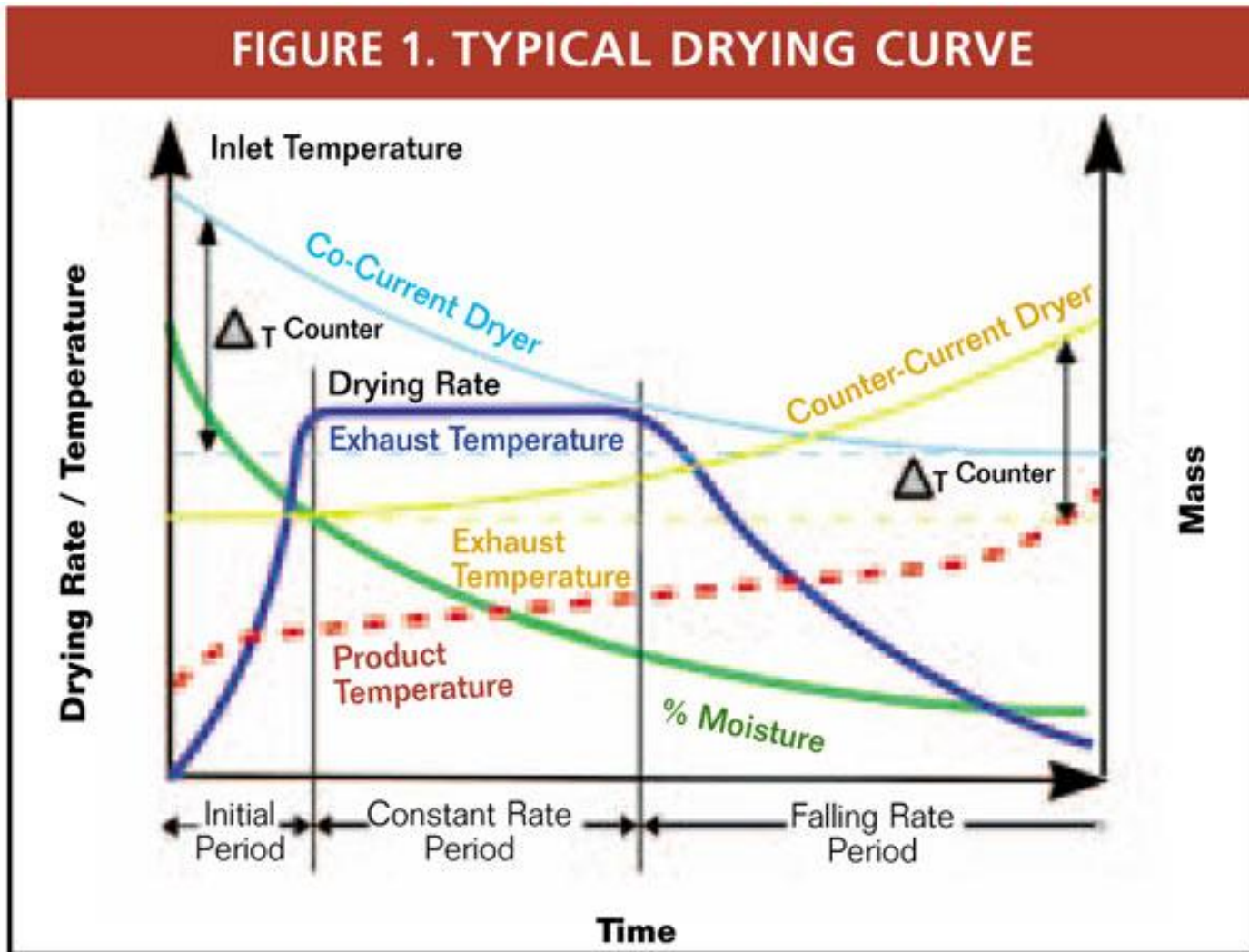
# Temperatures for Drying

- 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





# Drying Rates



**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



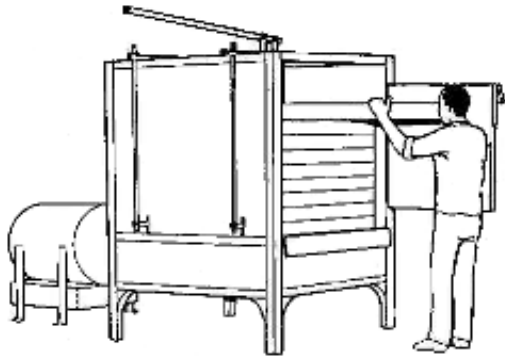
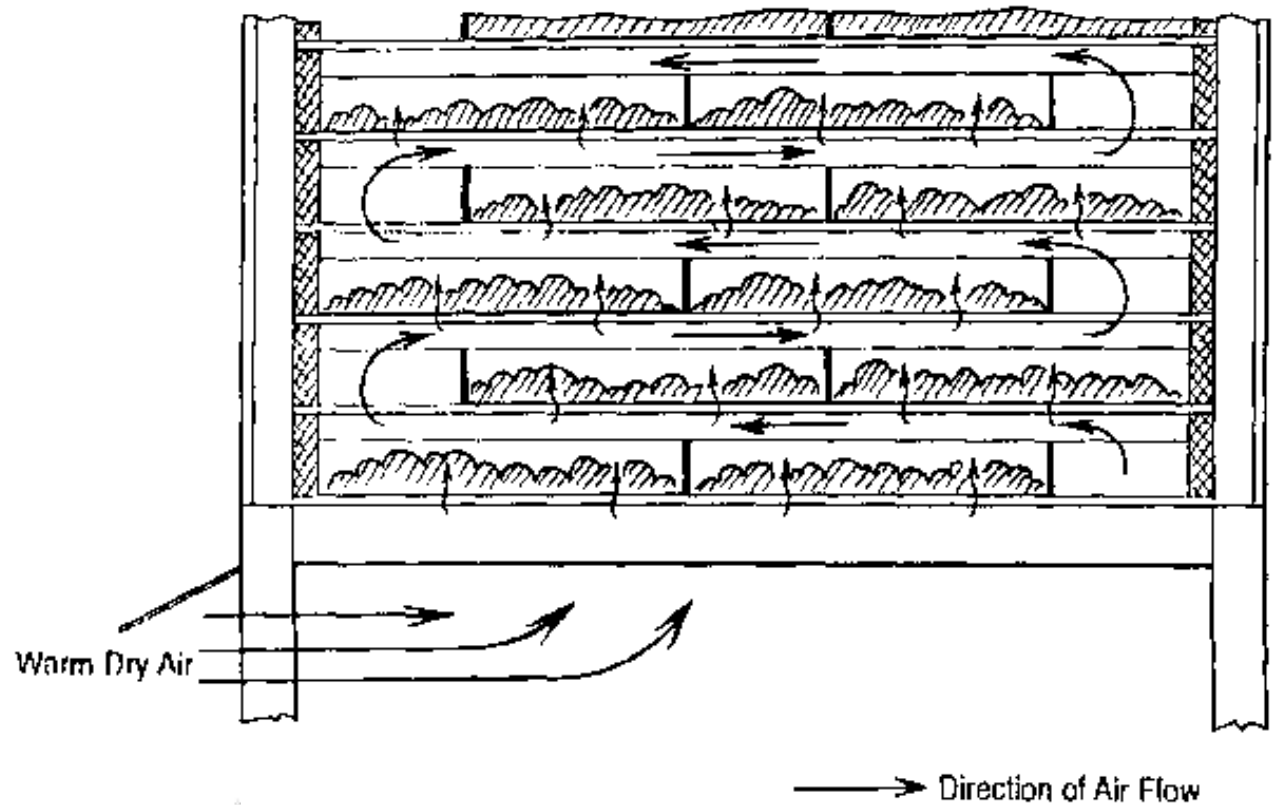
# Pre-treatment

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



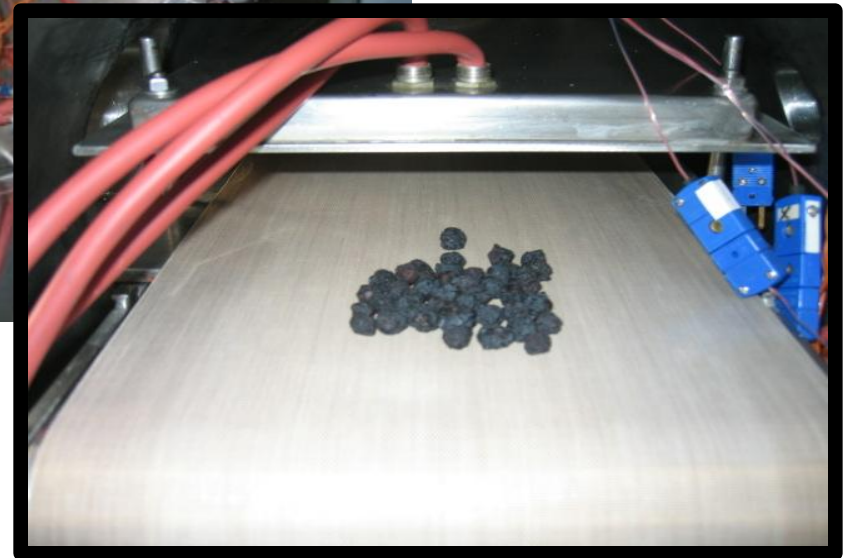
Tray Dryer

# Hot Air Drying

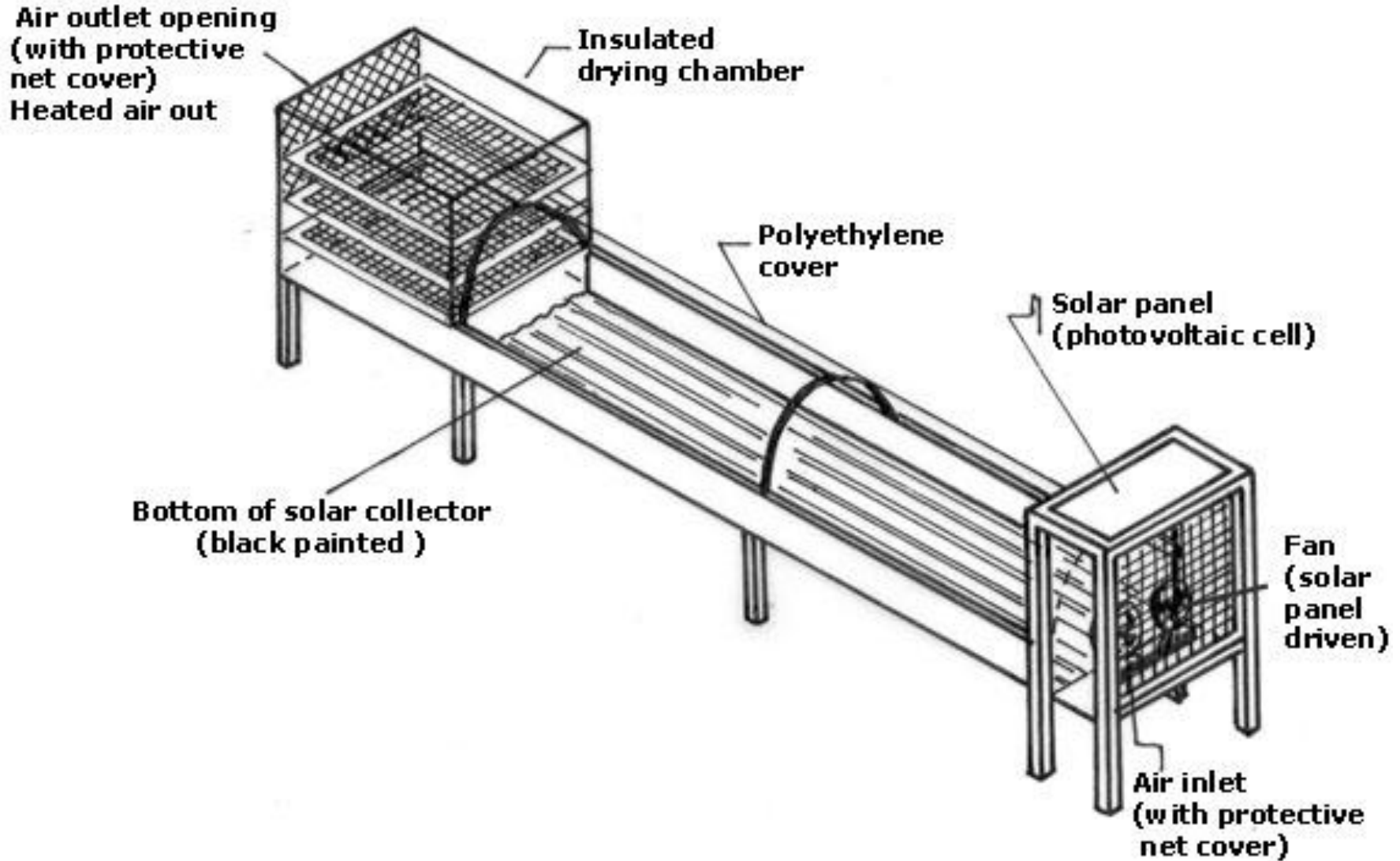


Blueberries

# Vacuum Belt Drying Of Blueberries



# Solar Tray Dryer





# Technical Data for Fruit Dehydration in Tunnels

Fruits	Drying Conditions			Finished Product	
	Load kg/m <sup>2</sup>	Temperature °C	Time	Moisture %	Yield %
Plums	15	I. 40-50	6 H	18-20	25-35
		II. 75-80	14 H		
Apples (Rings)	10	75-55	5-6 H	20	10-12
Apricots (Halves)	10	70-60	10- 15	15-20	10-15
Cherries (w. stones)	10	55-70	6-8	12-15	25
Pears (Halves and quarters)	15	70-65	15-22	18-20	10-15
	15	70-60	10-15	15-20	10-15

# Technical Data on some Osmotically Dehydrated Products

Fruit or vegetable	Type of cut	Treatment
Banana	5 mm slices	2 hours, 80% sugar
		2000 ppm SO <sub>2</sub>
		at 70 C
Carrots	10 x 10 x 2 mm dices or 5 mm slices	4 hours, 60% sugar + 10% salt
		4000 ppm SO <sub>2</sub>
Mango, green	8 mm slices	2 hours, 25% salt
		8000 ppm SO <sub>2</sub>
Mango, ripe	8 mm slices	2 hours, 60% sugar
		8000 ppm SO <sub>2</sub>
Onions	2 mm slices	2 hours, 60% sugar + 10% salt
		4000 ppm SO <sub>2</sub>
Papaya	8 x 8 mm slices	4 hours, 80% sugar
		2000 ppm SO <sub>2</sub> at 70 C
Strawberries	Whole	4 hours, 80% sugar
		4000 ppm SO <sub>2</sub>
Sweet peppers, red	6 mm dices	2 hours, 60 % sugar + 10 % salt

# 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



# Determining 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:

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

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

Download:

<http://extension.usu.edu/files/publications/publication/FN-330.pdf>

- FAO Document, 1990