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*Drying*: Introduction to principle of drying,  
Equilibrium moisture constant, bound and  
unbound moisture

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# Outline

## • Introduction

Drying should fulfill the following goals:

- (i) Minimal chemical and biochemical degradation reactions
- (ii) Selective removal of water over other salts and volatile flavor and aroma substances
- (iii) Maintenance of product structure (for a structured food)
- (iv) Control of density
- (v) Rapid and simple rehydration or redispersion
- (vi) Storage stability: less refrigeration and packaging requirements
- (vii) Desired color
- (viii) Lack of contamination or adulteration
- (ix) Minimal product loss
- (x) Rapid rate of water removal (high capacity per unit amount of drying equipment)
- (xi) Inexpensive energy source (if phase change is involved)
- (xii) Inexpensive regeneration of mass separating agents
- (xiii) Minimal solids handling problems
- (xiv) Facility of continuous operation
- (xv) Noncomplex apparatus (reliable and minimal labor requirement)
- (xvi) Minimal environmental impact



## Drying Fundamentals

Drying is defined as a process of moisture removal due to simultaneous heat and mass transfer. Heat transfer from the surrounding environment evaporates the surface moisture. The moisture can be either transported to the surface of the product and then evaporated or evaporated internally at a liquid vapor interface and then transported as vapor to the surface.

## Principles of Drying

- (i) evaporation from a free surface,
- (ii) flow as a liquid in capillaries, and
- (iii) diffusion as a liquid or vapour. The first mechanism follows the laws for heat and mass transfer for a moist product.



## Equilibrium Moisture content, Bound and unbound Moisture etc

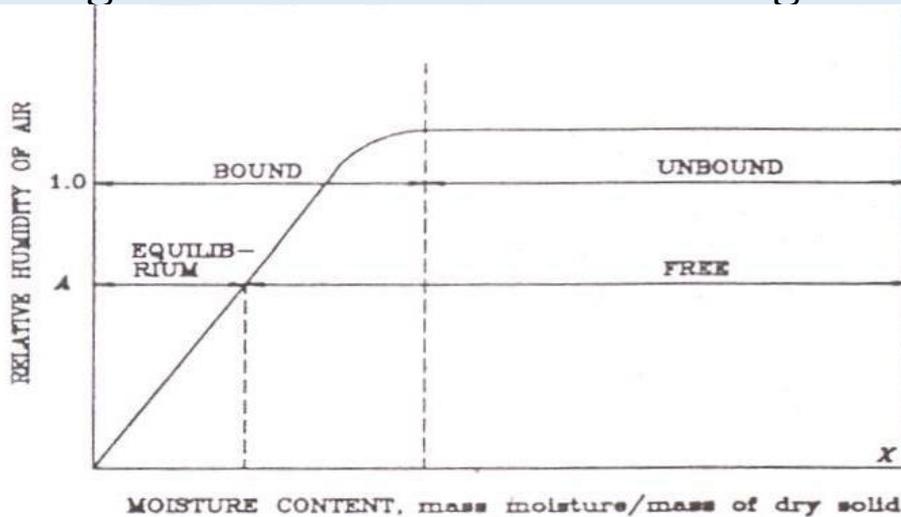
All solid materials have a certain equilibrium moisture content when in contact with air at a particular temperature and humidity. The material will tend to lose or gain moisture over a period of time to attain this equilibrium value.

This gradient provides the Driving force for water removal from the food. Water moves to the surface by following mechanisms.

1. Liquid movement by capillary forces.
2. Diffusion of liquids caused by difference in concentration of solutes in different regions of the food.
3. Diffusion of liquids, which are absorbed in layers at the surface of solid components of the food.
4. Water vapour diffusion in air spaces within the food caused by vapour pressure gradients.



The surface temperature of the food remains close to the wet bulb temperature of the drying air until the end of the constant rate period, due to cooling effects of evaporating water. During the falling rate period the amount of water evaporating from the surface gradually decreases but as the same amount of heat being supplied by the air the surface temperature rises until it reaches the dry bulb temperature of the drying air. Most heat damage to food occurs in the falling rate period.



Equilibrium moisture isotherm for a material showing various moisture content



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# Thank you