Drying of Foodstuffs

Foods are heterogeneous systems. The components are proteins, fats, carbohydrates, vitamins, minerals, etc.

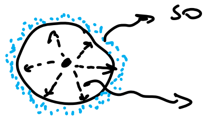
The water present is not pure but may be in the form of;

- a solution of solids
- a gel
- an emulsion OR
- bound in various ways with the solid constituents.

These behaviors of water may affect the drying of foods.

Movement of Solubles During Drying

* If there is a flow of <u>liquid water</u> to the surface during drying, the water carries with it various soluble materials. There is a build-up of such soluble materials at the surface as the water evaporates.



* Migration of soluble solids in the opposite direction, i.e., towards the center of the foods is also possible. As the surface dries out, concentration gradient is set-up between it and the wet center of food

which could result in the diffusion of soluble material to the center.

When concentration of solubles at D > conc. of solubles at W ⇒ solubles flow to the center due to the concentration difference of solids.

Shrinkage of Foods During Drying

Shrinkage takes place during drying by all the drying methods with the exception of freeze drying.

Three stages ⇒

1) During the early stages of drying (at high initial drying rates) the shrinkage in volume of fruits and vegetables pieces very nearly equals the volume of water lost by evaporation.

i.e., the more water evaporated, the more shrinkage is.

- the outer layer becomes rigid
- the final volume is fixed.

But at low initial drying rates the pieces will shrink with little change in shape.

2) As drying proceeds, the tissues split and rupture internally forming an open structure.

3) In the latter stages the volume shrinkage is

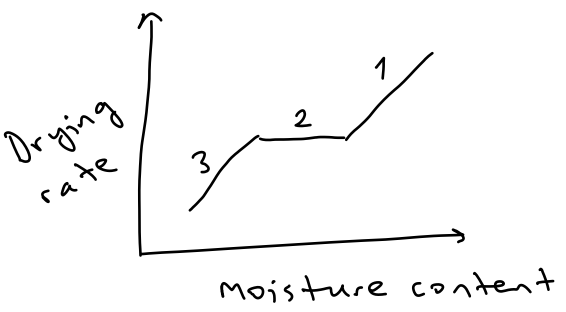
less and no substantial further decrease in volume occurs.

Case Hardening

During drying (as moisture content is lowered) of fruits, meat and fish, a hard impermeable skin (barrier to moisture migration) often forms at the surface. This phenomenon is known as <u>case hardening</u> and results in a reduction in drying rate.

Reasons for case hardening:

- migration of soluble solids to the surface
- high surface temperature towards the end of drying.



Region 1: First falling rate.

Region 2: A constant rate probably due to case hardening.

Region 3: Second falling rate. The hardened surface cracks or ruptures allowing water transfer to occur again.

Quality Changes in Foods During Drying

- All products undergo changes during drying and storage that reduce their quality compared to the fresh material and the aim of improved drying technologies is to minimize these changes while maximizing process efficiency.

- The main changes to dried foods are to the texture and loss of flavor or aroma, but changes in color and nutritional value are also significant in some foods.

1) Browning Reactions: Browning reactions change color, decrease nutritional value and solubility, create off flavors and induce chemical changes.

Browning reactions;

- enzymatic browning
- non enzymatic "

⊛ Non-enzymatic browning is more serious as drying process is concerned.

Non-enzymatic browning;

- Caramelization
- Maillard browning

⊛ To reduce browning during drying;

- avoid unnecessary heating
- sulfuring the product may retard the enzymatic and non-enzymatic browning.

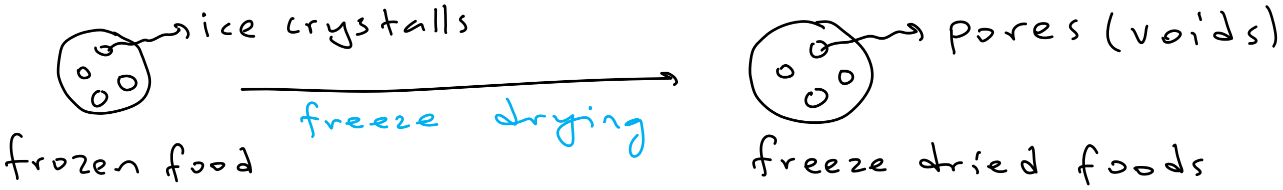
2) Lipid Oxidation: Lipid oxidation is responsible for

- rancidity
- development of off-flavors
- loss of fat-soluble vitamins and pigments in especially dehydrated foods.

⊛ To eliminate oxidation of foods, reduce amount of oxygen (O_2);

- package dried foods under vacuum
- " " " " inert gas; CO_2, N_2, ...

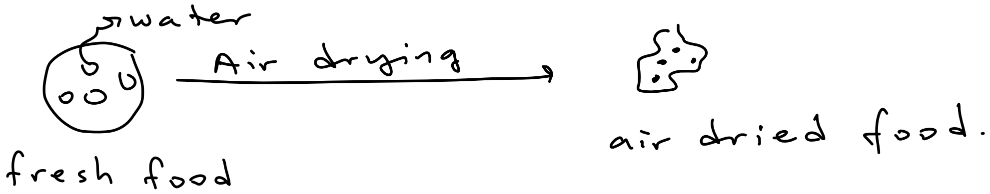
Effect of O_2 ∝ porosity ⇒ (freeze drying case)



In freeze drying ⇒

- no temperature effect
- no shrinkage
- more pores (voids) ≡ more surface area to oxidation.
- vacuum may be advised for these types of foods to protect from O_2.

⊛ Air dried foods tend to have less surface area due to shrinkage and are not affected by O_2.



In air drying ⇒

- there is temperature effect
- " " shrinkage
- there are less voids or surface area, hence, less oxidation is expected.

3) Color Change

- There are a number of causes of colour loss or change in dried foods; drying changes the surface characteristics of a food and hence alters its reflectivity and color. In fruits and vegetables, chemical changes to carotenoid and chlorophyll pigments are caused by heat and oxidation during drying and residual polyphenoloxidase enzyme activity causes browning during storage.

- This is prevented by blanching or treatment of fruits with ascorbic acid or sulphur dioxide. For moderately sulphured fruits and vegetables the rate of darkening during storage is inversely proportional to the residual sulphur dioxide content. However, sulphur dioxide bleaches anthocyanins, and residual sulphur dioxide is also linked to health concerns. Its use in dried products is now restricted in many countries.
- The rate of Maillard browning in stored milk and fruit products depends on the water activity of the food and the temperature of storage. The rate of darkening increases markedly at high drying temperatures, when the moisture content of the product exceeds 4–5%, and at storage temperatures above 38ºC.

Color change in fruits and vegetables is compose of a complex mixture of pigments;

- anthocyanins (water soluble),

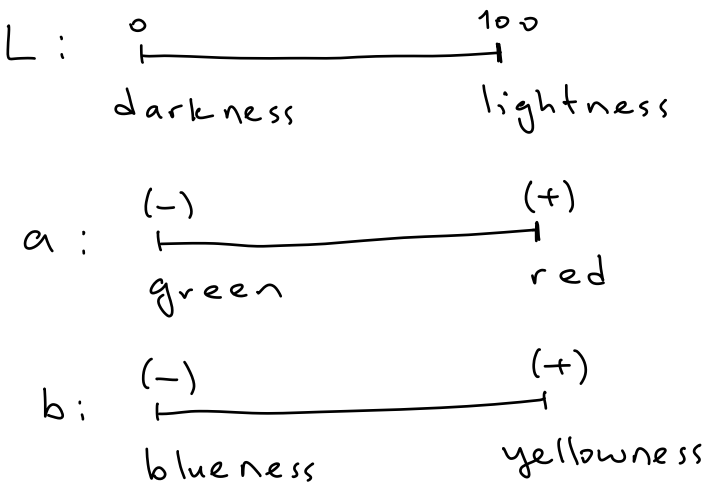
- carotenoids (lycopene, beta carotene),

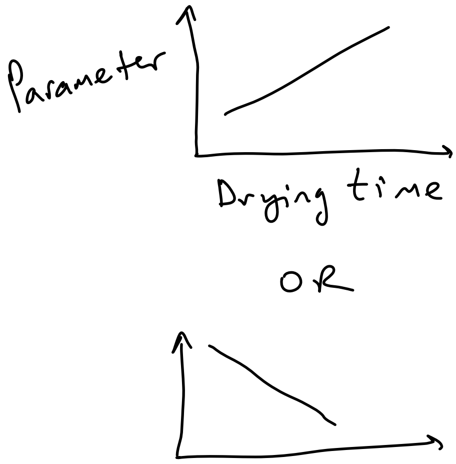
- chlorophylls (fat soluble pigments).

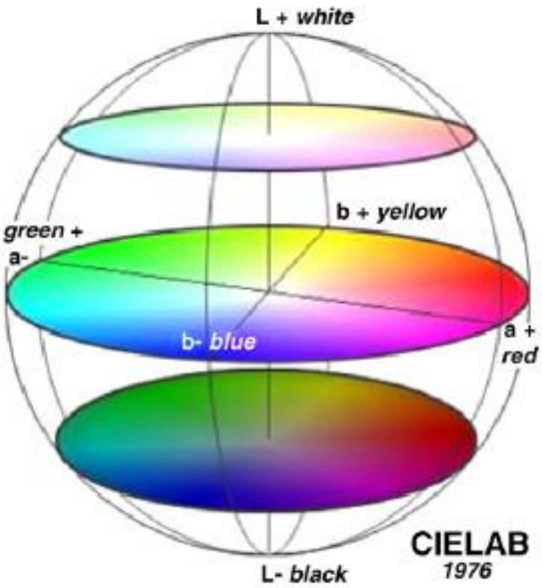
Heat treatment can change the color of products. They are susceptible to oxidation.

- Sulfuring minimizes the pigment (carotenoids) destruction.

Color Measurement: The color of foods can be measured by the Hunter Color Measuring device. It measures the color parameters L, a, b. So it is known as Hunter Lab







Total Color Difference (TCD): ΔE is calculated from the parameters L, a, b.

$$TCD = \sqrt{(L_0 - L)^2 + (a_0 - a)^2 + (b_0 - b)^2}$$

L_0, a_0 and b_0 are initial color values of food (reference)

L, a and b are the parameters measured at any time.

- when TCD < 5 => color is excellent } for a dried product.
  TCD ≅ 10 => " " acceptable }

* A TCD > 3 is unacceptable for many fruit juice concentrates.

* The a/b ratio can be used as a quality specification for tomato paste.
  - $a/b \geq 2$ => excellent color in paste,
  - $a/b < 1.8$ => the paste is not acceptable.

4) Rehydration ($\propto$ Shrinkage): The degree to which a dehydrated sample will rehydrate (gain water) is called rehydration.

It is influenced by structural and chemical changes caused by dehydration, processing conditions, etc,...
- the elasticity of cell walls and the swelling power of starch gell decrease by heat treatment and reduces the rehydration.
- rehydration is maximized when cellular and structural disruption such as shrinkage are minimized.

* Freeze drying => better rehydration properties of foods.

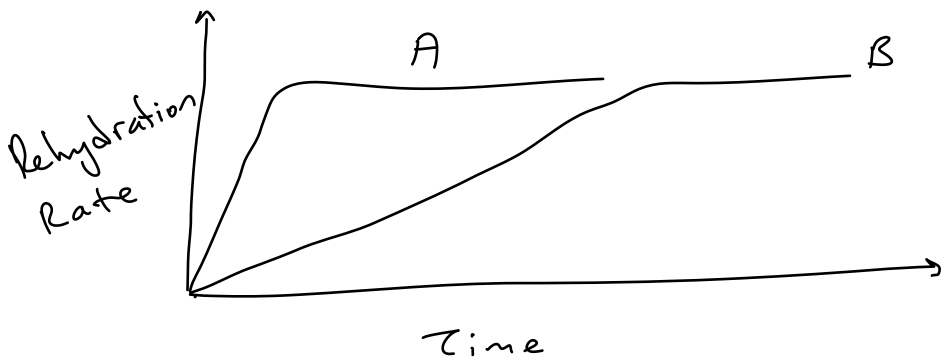
* To minimize shrinkage, low-temperature drying should be employed so that moisture

gradients throughout the product are minimized ⇒ rehydration increases in this case.

Water that is removed from a food during dehydration cannot be replaced in the same way when the food is rehydrated (that is, rehydration is not the reverse of drying); loss of cellular osmotic pressure, changes in cell membrane permeability, solute migration, crystallisation of polysaccharides and coagulation of cellular proteins all contribute to texture changes and volatile losses and are each irreversible.

Rehydration of a food

- should be rapid (due to risk of m/o development)
- " " nearly complete.



A is better than B.