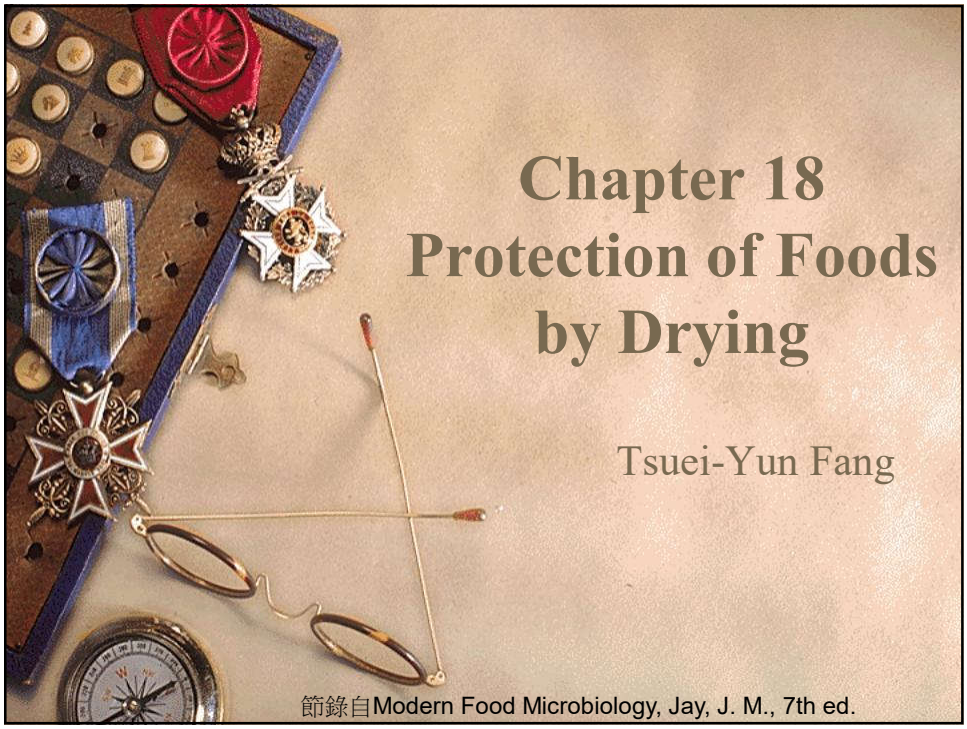

# Chapter 18 Protection of Foods by Drying

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## Introduction

- Based on the fact that **microorganisms and enzymes need water in order to be active.**
- **Lowering the moisture content** to a point where **the activities of food-spoilage and food-poisoning microorganisms are inhibited**.

# Introduction

- Dried, desiccated, or **low-moisture (LM)** foods ➔no more than 25% moisture and have an $a_w$ between 0.00 and 0.60.
- **Intermediate-moisture (IM)** foods➔ **15% and 50% moisture** and an **$a_w$ between 0.60 and 0.85**.

# PREPARATION AND DRYING OF LOW-MOISTURE FOODS

- Sun drying➔ requires a large amount of space for large quantities of product.
- Current drying methods include **spray, drum, evaporation,** and **freeze-drying**.
- Vegetable foods can be pretreated by **blanching or scalding** which is achieved by immersion from 1 to 8 min ➔ **destroy enzymes**

## PREPARATION AND DRYING OF LOW-MOISTURE FOODS

- Pretreatments of drying foods are similar to freezing with a few exceptions.
  - In the drying of fruits: **alkali dipping** is employed by immersing the fruits into hot alkali solutions (0.1% to 1.5%).
  - **Light-colored can be pretreated with $SO_2$** ➔maintains color, conserve vitamins, prevent storage changes, and reduce the microbial load.
  - After drying, fruits are usually **heat pasteurized** at 65˚- 85˚C (150-185˚F) for 30-70 min.

## PREPARATION AND DRYING OF LOW-MOISTURE FOODS

- **Freeze drying** is generally better than high-temperature vacuum drying.

**The disadvantages of the high-temperature vacuum drying** compared to the freeze drying are the following:

1. **Pronounced shrinkage of solids**
2. **Migration of dissolved constituents to the surface when drying solids**
3. **Extensive denaturation of proteins**

## PREPARATION AND DRYING OF LOW-MOISTURE FOODS

**The disadvantages of the high-temperature vacuum drying** compared to the freeze drying are the following:

4. **Case hardening**: the formation of a relatively hard, impervious (不可滲透的) layer at the solid surface, caused by one or more of the first three changes, that slows the rates of both dehydration and reconstitution
5. **Formation of hard, impervious solids** when drying liquid solution

## PREPARATION AND DRYING OF LOW-MOISTURE FOODS

**The disadvantages of the high-temperature vacuum drying** compared to the freeze drying are the following:

6. **Undesirable chemical reactions** in heat-sensitive materials
7. **Excessive loss of desirable volatile constituents**
8. **Difficulty of rehydration** as a result of one or more of the other changes.

## EFFECT OF DRYING ON MICROORGANISMS

- **Not lethal to microorganisms**
- Moisture for growth: **Bacteria > yeasts > molds**
- The **"alarm water"** content➔ **a guide to the storage stability of dried food.** ➔ **The water content that should not be exceeded if mold growth is to be avoided.** (Table 18-2)

## EFFECT OF DRYING ON MICROORGANISMS

Related $a_w$ levels to the probability of spoilage:

- **$0.80 < a_w < 0.85$, spoilage occurs readily by many fungi** in 1-2 weeks.
- **$a_w = 0.75$, spoilage is delayed**, with fewer types of organisms in those products that spoil.
- **$a_w = 0.70$, spoilage is greatly delayed** and may not occur during prolonged holding.
- **$a_w = 0.65$, very few organisms are known to grow**, and spoilage is most unlikely to occur for even up to 2 years.
- For a dried food to be held for several years, its final $a_w$ should be between **0.65 and 0.75**, with **0.70** suggested by most.

## EFFECT OF DRYING ON MICROORGANISMS

- **At $a_w$ levels of about 0.90➔ only yeasts and molds grow** ➔ near the minimum for most normal yeasts.
- Some molds are known to grow very slowly at $a_w$ around 0.60-0.62. ➔ the minimum $a_w$ values (Table 18-1).
- **The goal of dried foods should achieve:**
  - **a total count of not more than 100,000/g**
  - the **coliform count should be zero or nearly so**
  - **no food-poisoning organisms** should be allowed except low numbers of *Clostridium perfringens* (產氣莢膜桿菌)

## EFFECT OF DRYING ON MICROORGANISMS

- Relatively fewer organisms are destroyed during the freeze-drying process. More are destroyed during freezing than during dehydration.
- The **freeze-drying** method is one of the best known ways of preserving microorganisms. Once the process has been completed, the cells may remain viable indefinitely (無限期地).

## STORAGE STABILITY OF DRIED FOODS

- In the absence of fungal growth, dried foods are subject to undesirable chemical changes. These chemicals include fats, oxygen, and sugars.
- **Reducing sugar** undergo a **color change** known as **Maillard reaction** or **nonenzymic browning**.➔carbonyl groups of reducing sugars react with amino groups of proteins and amino acids

## STORAGE STABILITY OF DRIED FOODS

- Other chemical spoilages in dried foods include **a loss of vitamin C** in vegetables, general **discolorations, structural changes** leading to the inability of the dried product to rehydrate fully, and **toughness (韌性)** in the rehydrated, cooked product.
- One of the most important considerations in preventing fungal spoilage of dried foods is the **R.H. of the storage environment**.

## STORAGE STABILITY OF DRIED FOODS

- The methods to minimize chemical changes in dried foods:
  - **Keep the moisture content as low as possible.**
  - **Reduce the level of reducing sugars** as low as possible.
  - When **blanching**, use water in which **the level of leached soluble solids is kept low**.
  - **Use sulfur dioxide (≤200-300 ppm)**.

## INTERMEDIATE-MOISTURE FOODS

- **Intermediate-moisture foods (IMF)** ➔a moisture **15-50%** and **an $a_w$ between 0.60 and 0.85.** (Table 18.3)
- The water in IMF can be withdrawn by **desorption, adsorption, and/or the addition of permissible additives** such as salts and sugars, which act as humectant (保濕劑) or fungistat.
  - humectant: glycerol, glycols **(二醇類)**, sorbitol **(**山梨醣醇), sucrose.
  - Fungistat: sorbate **(≤0.2%)**, benzoate **(≤0.1%)**.

## Preparation of IMF

- Because ***Staphylococcus aureus*** is the only bacterium of public health importance that **can grow at $a_w$ values near 0.86**, an IMF can be prepared by formulating the product:
  - maintaining its **moisture content between 15% and 50%,**
  - **adjusting the $a_w$ to a value below 0.86** by use of humectants, and
  - adding an **antifungal agent** to **inhibit yeasts and molds** that can grow at $a_w$ values above 0.70.

## Preparation of IMF

- Water may be removed either by two methods:
  - **adsorption**. Food is **first dried** (often freeze dried) and then subjected to controlled **rehumidification** until the desired composition is achieved.
  - **desorption**. The food is **placed in a solution of higher osmotic pressure** so that at equilibrium, the desired $a_w$ is reached.
- **IMF produced by adsorption is more inhibitory to microorganisms** than that produced by desorption.

## Microbial Aspects of IMF

- The general $a_w$ range of IMF products makes **gram-negative bacteria** unlikely to proliferate. This is true also for most gram-positive bacteria with the exception of cocci, some sporeformers, and lactobacilli.

## Microbial Aspects of IMF

- In addition to the inhibitory effect of **lowered $a_w$**, antimicrobial activity results from an **interaction of pH, Eh, added preservatives** (including some of the humectants), **the competitive microflora**, generally **low storage temperatures**, and the **pasteurization** or **other heat processes** applied during processing.

## Storage Stability of IMF

- **Lipid oxidation** and **Maillard browning** are at their optima in the general IMF ranges of $a_w$ and percentage moisture.
- The storage of IMFs **under the proper conditions of humidity** is necessary in preventing moldiness and for overall shelf stability.