



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 SO₂**
→ 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 (不可渗透的) 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** ($\leq 200-300$ 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 (山梨糖醇), sucrose.
 - Fungistat: sorbate ($\leq 0.2\%$), benzoate ($\leq 0.1\%$).



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.