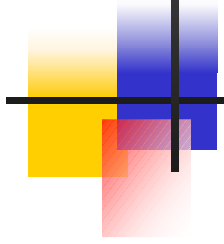


Lecture 4

UNIT OPERATIONS IN FOOD PROCESSING

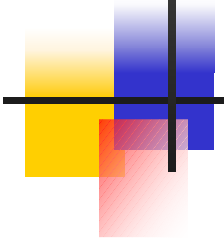
Ch. 5, pp.69-88

UNIT OPERATIONS IN FOOD PROCESSING



- The number of different food products and the operations and steps involved in their production are very numerous.
- Processes are in a continual state of evolution.
- The processes used by the food industry can be divided into common operations called **unit operations**.
- Food production involves a series of unit operations performed in a logical sequence. The success is in proper selection and combination of unit operations into the more complex integrated processing systems, and optimising energy.

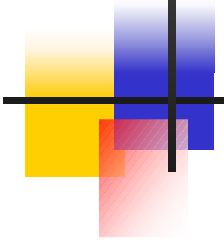
UNIT OPERATIONS IN FOOD PROCESSING



Examples of unit operations common to many food products include:

- Cleaning
- Coating
- Concentrating
- Controlling
- Disintegrating
- Drying
- Evaporating
- Fermentation
- Forming
- Heating/Cooling (Heat exchange)
- Materials handling
- Packaging
- Pumping
- Separating

UNIT OPERATIONS IN FOOD PROCESSING



➤ Most unit operations are utilized in the making of a variety of food products.

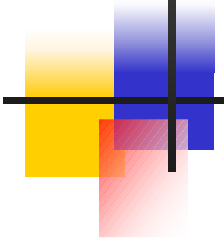
E.x. Heat exchanging or heating is used in the manufacture of liquid and dry food products, pasteurization of milk, sterilization of foods in cans, roasting peanuts, baking bread, etc.

Unit operations may include numerous different activities.

Example: A unit operation: **Mixing**

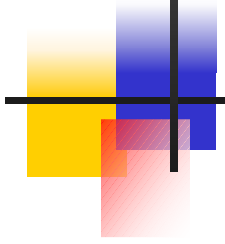
Mixing includes: agitating, beating, blending, diffusing, dispersing, emulsifying, homogenizing, kneading, stirring, whipping

UNIT OPERATIONS IN FOOD PROCESSING



Mix:

- ✓ To beat in air - as in making an egg white foam
- ✓ To blend dry ingredients - as in preparing a ton of dry cake mix
- ✓ To emulsify (to homogenize to prevent fat separation) - as in the case of mayonnaise or milk
- ✓ To develop a bread dough which requires stretching and folding (referred to as kneading)



COMMON UNIT OPERATIONS

1 - Materials Handling

➤ **Aim:** The movement of produce from farm to processing plant and of raw materials through the plant.

Includes various operations:

- Hand and mechanical harvesting on the farm
- Refrigerated trucking of perishable produce
- Box car transportation of live cattle
- Pneumatic conveying of flour from rail car to bakery storage bins.

UNIT OPERATIONS IN FOOD PROCESSING

1 - Materials Handling

Emphasis must be given to:

- ✓ Maintaining sanitary conditions
- ✓ Minimizing product losses (including weight loss of livestock)
- ✓ Maintaining raw material quality (vitamin content and physical appearance)
- ✓ Minimizing bacterial growth
- ✓ Timing all transfers and deliveries so as to minimize hold-up time

UNIT OPERATIONS IN FOOD PROCESSING

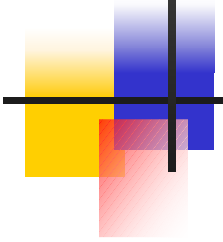
1 - Materials Handling

➤ **The movement of produce from farm to processing plant and of raw materials through the plant may take many forms:**

Example: Oranges are moved by truck trailers to the washing and grading area. The length of time is important since fruits and vegetables are **alive and respire** causing a rise in temperature of a batch. Thus, spoilage may occur.

Types of equipments for moving materials:

- Pneumatic lift systems
- Pneumatic conveyors
- Screw conveyors
- Bucket conveyors
- Belt conveyors
- Vibratory conveyors



2- Cleaning

➤ **Aim:** Foods by the nature of the way they are grown or produced on farms in open environments often require cleaning before use.

Cleaning ranges from:

Simple removal of dirt from egg shells with an abrasive brush

to ↓

Complex removal of bacteria from a liquid food by passing it through a microporous membrane

UNIT OPERATIONS IN FOOD PROCESSING

2- Cleaning

Cleaning can be accomplished with:

Brushes

High-velocity air

Steam

Water

Vacuum

Magnetic attraction of metal contaminants

Mechanical separation

(depending on the product and the nature of dirt)

UNIT OPERATIONS IN FOOD PROCESSING

2- Cleaning

- Just as different food materials require special cleaning, the surfaces of food processing equipment need thorough and frequent attention.
- The cleaning of equipment, as well as facility's walls and floors, must take into consideration the chemical and physical properties of both the surface to be cleaned and the type of soil (see Fig. 5.2)

Mildly alkaline detergents

Mildly acid detergents

Moderately alkaline and neutral detergents

UNIT OPERATIONS IN FOOD PROCESSING

3- Separating

➤ **Separating can involve:**

Separating a solid from a solid - peeling of potatoes, shelling of nuts

Separating a solid from a liquid - filtration

Separating a liquid from a solid - pressing juice from a fruit

Separating a liquid from a liquid - centrifuging oil from water

Removing a gas from a solid or a liquid - vacuum removal of air from canned food in vacuum canning.

UNIT OPERATIONS IN FOOD PROCESSING

3- Separating

Forms of separation in the food industry :

Hand sorting and grading (vegetables and fruits)

Mechanical and electronic sorting devices (difference in color)

Automatic separation (according to size by passing over different size screens, holes or slits.)

UNIT OPERATIONS IN FOOD PROCESSING

3- Separating

- The skins of fruits and vegetables may be separated using a lye peeler.
- Peaches, apricots are passed through a heated lye solution.
- The lye or caustic softens the skin so it can be slipped from the fruit by gentle action of mechanical fingers or by jets of water.
- Differences in the density of the fruit and skin can then be used to float away the removed skin.

UNIT OPERATIONS IN FOOD PROCESSING

3- Separating

- **Crystallization** is used to separate salt from sea water, or sugar from sugar cane juice. Evaporation of some of the water causes supersaturation, and crystals form. Crystals are then separated from the suspending liquid by centrifugation.
- Newer methods of separation include several techniques involving manufactured **membranes** with porosities or permeabilities capable of separations and fractionations at the colloidal and macromolecular size level.
- **Ultrafiltration** uses membranes of such porosity that water and low molecular weight salts, acids and bases pass through the membrane but larger proteins and sugar molecules are retained. This is carried out at ambient temperatures avoids the heat damage to sensitive food constituents.

UNIT OPERATIONS IN FOOD PROCESSING

4-Disintegrating

➤ **Aim:** To subdivide large pieces of food into smaller units or particles.

Cutting
Grinding
Pulping
Homogenizing

- ✓ The dicing of vegetables is done on automatic machines
- ✓ The cutting of meat represents a time-consuming, hand-labor operation (Automatic knives with a “brain” are being researched and developed)
- ✓ The cutting of bakery products can be done with fine jets of high-pressure, high velocity water.
- ✓ Laser beams also can replace knives in some cutting applications.

UNIT OPERATIONS IN FOOD PROCESSING

4-Disintegrating

- Homogenizing produces disintegration of fat globules in milk or cream from large globules and clusters into minute globules.
- The smaller fat globules then remain evenly distributed throughout the milk or cream with less tendency to separate from the water phase of the milk.
- Ways to homogenize:
Forcing the milk or cream under high pressure through a hole with very small openings
Use of ultrasonic energy to disintegrate fat globules or break up particles.

UNIT OPERATIONS IN FOOD PROCESSING

5-Pumping

- **Aim:** Moving of liquids and solids from one location or processing step to another.
- There are many kinds of pumps and the choice depends on the character of the food to be moved.
Gear pumps - effective for moving liquids and pastes, chew up chunk-like foods reducing them to purees.
Screw pumps - best for moving food with large pieces without disintegration (corn kernels, grapes, small shrimp)
- An essential feature for all food pumps is ease of disassembly for thorough cleaning.

UNIT OPERATIONS IN FOOD PROCESSING

6-Mixing

- Kinds of mixers depend on the materials to be mixed
- Mixing:
 - Solids with solids** - Dry cake mix
 - Liquids with liquids** - milk with coffee
 - Liquids with solids** - sugar with water
 - Gases with liquids** - coke
- Conical blender: for simple mixing of dry ingredients
- Ribbon blender: Cut the shortening into the flour, sugar and other ingredients (in cake mixes)
- A propeller type agitator- for mixing solids into liquids to dissolve them
- Increase in temperature is a problem during mixing.

7-Heat Exchanging

HEATING

- Addition of heat energy to foods
- Foods are heated for different reasons:
- ✓ To destroy microorganisms and preserve the food- pasteurization of milk and canning of vegetables
 - ✓ To drive off moisture and develop flavors - roasting of coffee and toasting of cereals
 - ✓ During cooking to make more tender and more palatable-
 - ✓ To inactivate natural toxic substances - for soybean meal

7-Heat Exchanging

HEATING

- Foods are heated by:
 - Conduction
 - Convection
 - RadiationOr by Combination of these
- Foods are sensitive to heat. Prolonged heating causes:
 - Burned flavors
 - Dark colors
 - Loss of nutritional value
- Microorganisms are more sensitive to **rapid heating** than are chemical reactions.

7-Heat Exchanging

HEATING

- It is desirable to heat and cool foods rapidly to maintain optimal quality.
- Rapid heating is facilitated if the food is given maximum contact with the heating source.
- It is accomplished by dividing the food into thin layers in contact with heated plates as in the **plate-type heat exchanger** used to pasteurize milk.
- For sterilizing foods in cans or other containers **large pressure cookers or retorts** are used. Steam under pressure is used to obtain high temperature.

7-Heat Exchanging: Heating or cooling

HEATING

- Supply of heat energy
- Foods may be heated or cooked using:
Toasters, direct injection of steam, direct contact with flame, electronic energy as in microwave cookers, and so on...
- Processes such as:
Baking, Frying, Food concentration, food dehydration, various kinds of package closure all employ the unit operation of heating.

UNIT OPERATIONS IN FOOD PROCESSING

7-Heat Exchanging

COOLING

- Removal of heat energy
- May be done to the degree where food is chilled to refrigerator temperature 0-4°C
- Beyond this range to where the food is frozen -18°C
- We refrigerate and freeze foods to prolong their keeping quality.
- A great deal of milk and cream are cooled by passing them in thin layers through heat exchangers.

7-Heat Exchanging

COOLING

- Liquid egg, apple slices and other fruits in cans are commonly frozen solid in an air-blast freezer or sharp freezer room maintained at about -26°C . Cans are spaced to allow the cold air, which is circulated by fans and blowers to get between them and speed the freezing operation.(freezing of peas, beans and other vegs. As individual pieces)
- Use of liquid nitrogen with its extremely low temperature -196°C . Sprayed directly onto foods to be frozen (mushroom).

UNIT OPERATIONS IN FOOD PROCESSING

8-Evaporation

- **To concentrate foods by the removal of water**
- Also used to recover desirable food volatiles and to remove undesirable volatiles.
- Sun evaporates water from sea water and leaves behind salt
- Fruit juice concentrates and tomato pastes are produced by evaporation
- All liquids boil at lower temperatures under reduced pressure and this is the key to modern evaporation (simple vacuum evaporator)
- Multiple-stage evaporators can easily remove water at 50°C and some are designed to boil off water at temperatures as low as 21°C.

UNIT OPERATIONS IN FOOD PROCESSING

9 - Drying

- **Aim:** To remove water with minimum damage to the food
 - Whereas evaporators will concentrate foods twofold or threefold, driers will take foods very close to total dryness (2-3%)
- Drying:
- To preserve food from spoilage
 - To reduce its weight and bulk.
 - e.x. Dried milk powder, instant coffee

UNIT OPERATIONS IN FOOD PROCESSING

9 -Drying

➤ It is generally much easier to dry liquid foods because these are easier to subdivide, either as a spray or a film, the moisture can be removed more quickly.

➤ **Spray drier** - Milk, coffee, eggs

Liquid is atomized by a spray nozzle, heated air is introduced, The heated air in contact with the fine droplets of food dries the droplets.

➤ **Drum drier** - Mashed potato, tomato puree, several milk products.

Drying as a thin film on a drum or roller. The drum is heated with steam and the applied layer of food in contact with the drum dries. Mechanically scraped from the drum with long knives.

UNIT OPERATIONS IN FOOD PROCESSING

9 -Drying

- **Tunnel drier** - Small food pieces such as peas, diced onions and mushrooms
By moving them through a long tunnel oven
 - **Vacuum freeze drying** - Brewed coffee, quality juice products
- Sublimation: Dehydration under vacuum where water in frozen state is converted to water vapor . Protects all food quality attributes (color, flavor, texture, nutrients)**

UNIT OPERATIONS IN FOOD PROCESSING

10-Forming

- Foods must be formed into specific shapes
- Hamburger patties are formed by compacting ground beef into a disk shape
- Characteristic shapes of several popular breakfast cereals are the result of pressure extrusion through designed dies, under controlled conditions of temperature, pressure, dough consistency, cutoff and other variables.
- Shaping of butter and margarine bars
- Pressing of cheese curd into various shapes
- Manipulations given to bread dough to produce variety breads.

UNIT OPERATIONS IN FOOD PROCESSING

11 - Packaging

Purposes of packaging:

- ✓ Protect the food from microbial contamination, physical dirt, insect invasion, light, moisture pick up, flavor pick up, moisture loss, flavor loss, physical abuse
- ✓ Containment for shipping
- ✓ Unitizing into appropriate sizes
- ✓ Improve the usefulness of the product

Foods are packaged in: metal cans, glass and plastic bottles, paper and paperboard, a wide variety of plastic and metallic films, and combinations of these, by automatic machines.

UNIT OPERATIONS IN FOOD PROCESSING

11 - Packaging

- Milk is packaged in paper cartons. Containers are automatically formed from stacked paper flats, volumetrically filled, and sealed.
- Other machines form pouches from rolls of plastic film, fill them and seal them, as in the packages of snack foods.
- Also draw a vacuum on the package to remove oxygen, back flush the package with inert nitrogen gas, seal the package and finally stack the packages into cardboard cartons
- (Examples: Dessert powders and dehydrated soups).

UNIT OPERATIONS IN FOOD PROCESSING

12-Controlling

- Ways of measuring and controlling processing operations to obtain the desired food product quality.
- Tools are: valves, thermometers, scales, thermostats, and a wide variety of other components and instruments to measure and adjust factors such as:
- temperature, pressure, fluid flow, acidity, specific gravity, weight, viscosity, humidity, time, liquid level, etc.

UNIT OPERATIONS IN FOOD PROCESSING

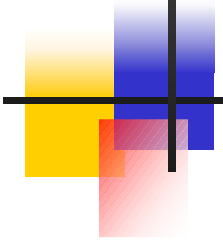
13-New Processes

New processing technologies are constantly being developed :

Supercritical fluid extraction: Uses gases such as carbon dioxide at high pressures to extract or separate food components. E.x. Extraction of caffeine from coffee to obtain decaffeinated product.

Ohmic heating: The temperature of particulates in a conducting medium is raised quickly. E.x. Soups or stews

High hydrostatic pressure: Liquid foods such as fruit juices and beverages or particulate foods suspended in liquid are subjected to pressures as high as several thousand atmospheres Inactivate microorganisms and in some cases enzymic activity



END OF LECTURE 4