INTRODUCTION to FOOD PROCESS TECHNOLOGY
A Module Developed by
Southern Africa Development Consortium
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FOOD PROCESSING TECHNOLOGIES

Objectives of the module

By the end of the module, participants should be able to:
(a) Explain the reasons for processing food.
(b) List the main processing methods that can be used to preserve food.
(c) Explain the purpose of packaging
(d) List the different types of packaging available
(e) Describe the properties of each type of packaging available.
9 FOOD PROCESSING TECHNOLOGIES

9.1 REASONS FOR PROCESSING OF FOOD

Food is processed to make and/or keep it safe for human consumption for as long a period as possible, without extensively impairing its nutritional content and maintaining its quality and sensory properties. Foods are processed in order to:

- ensure their microbiological safety
- inhibit chemical, microbiological and biochemical spoilage
- maintain the quality, including shelf-life and sensory qualities
- develop new products

Factors that affect the microbiological, chemical and biochemical safety of foods have to be controlled. These factors include:

Growth and activities of microorganisms
Activities of natural food enzymes
Insects, parasites and rodents
Temperature (heat and cold), moisture and dryness
Air, more particularly oxygen
Light
Time
The above factors often do not work alone in nature and may be beneficial to the food up to certain levels. Many of the factors, when exerting a negative influence on food safety, are discussed in other modules in more details.

9.2 PRINCIPLES OF FOOD PRESERVATION

The basic principles for food preservation are the control of microorganisms, the control of chemical and biochemical reactions and naturally occurring negative components in foods.

9.2.1 Control of microorganisms, enzymes and other deteriorative reactions

A number of food processing technologies are used to control microorganisms and other reactions:

<table>
<thead>
<tr>
<th>Temperature management</th>
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<tbody>
<tr>
<td>Drying</td>
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<tr>
<td>Addition of acid, sugar, salt and smoke</td>
</tr>
<tr>
<td>Exclusion of oxygen</td>
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<tr>
<td>Use of chemicals</td>
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<tr>
<td>Radiation</td>
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9.3. FOOD PROCESSING TECHNOLOGIES

The reasons for processing of foods and the various principles of food preservation are combined in food processing technologies, which aim at the ultimate production of safe and wholesome foods. The most important technologies are discussed in more detail below.

9.3.1 Pre-processing operations

Food raw materials must be of good quality, ripe, free from extraneous
matter and undamaged. A good product cannot be manufactured from damaged or spoilt raw materials. Pre-processing operations consist of:

• **Sorting** that is the separation of material based on one of its characteristics (example colour sorting)

• **Grading** that is the assessment of number of attributes to obtain indication of good quality foods

• **Cleaning** or the removal of contaminated materials to leave surfaces suitable for further processing

• **Separating** using centrifugal forces and other methods such as filtration and expression

• **Size reduction** of food particles

• **Mixing** consisting of bringing together different components of foods or ingredients

**Peeling** that is the removal of peel or outer skins.

### 9.3.2 Heat processing

Heat is usually applied to preserve foods, as it kills microorganisms, destroys enzymes, cooks the food and changes the sensory properties. Heat is applied in different ways.

<table>
<thead>
<tr>
<th>Examples</th>
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<tbody>
<tr>
<td>• Blanching</td>
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<tr>
<td>• Pasteurisation</td>
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<tr>
<td>• Cooking</td>
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<tr>
<td>• Baking</td>
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<tr>
<td>• Sterilisation</td>
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</table>
Blanching
Blanching is a short time, high temperature treatment carried out to

- destroy enzymes in vegetables and some fruits before further processing,
- reduce the number of microorganisms
- soften the tissue

Factors influencing blanching time are

- type of fruit or vegetable
- size of the pieces of food
- blanching temperature
- method of heating

(2) Pasteurisation
Pasteurisation is the application of heat below 100 °C. This method kills most but not all of the pathogenic and spoilage organisms in foods. Pasteurisation conditions used are

• HTST: High Temperature Short Time
  72 °C for at least 15 seconds
• LHT-Low Temperature Long Time or holding
  65.6 °C for 30 minutes
Method of pasteurisation
The products are heated by steam, hot water, dry heat, or electric current, then cooled promptly to about 10 °C. Pasteurisation can be applied to milk, sauces, juices, cream, and wine.

Heating at about 100°C is sufficient to kill everything except bacterial spores.

100 °C is obtained by
- boiling a liquid food
- by immersion of container of food in boiling water
- by simmering-gentle boiling about 100 °C

(3) Baking and roasting
Baking and roasting is cooking of food using dry heat. Heating temperatures are high but internal food temperature may be slightly below 100 °C.

Roasting - applies to meats, nuts and vegetables
Baking – applies to flour-based foods or fruits

<table>
<thead>
<tr>
<th>Primary purpose</th>
<th>To change the structure/sensory properties of the food</th>
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<tbody>
<tr>
<td>Secondary purpose</td>
<td>Preservation by destruction of microorganisms and reduction of the water activity at the surface of the food.</td>
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</table>

Additives and other ingredients are used to add flavour and develop characteristics, which are special to such products.

(4) Frying
Frying utilises oil or fat to transfer heat to a raw or cooked food product.

During frying,
- the food is cooked,
- chemical changes impart flavour and texture characteristics
and the product loses a certain amount of water

Depending on the level of water loss, the food may be shelf stable or need refrigeration for shelf life. Here also, the external temperature is high whereas the temperature inside the food is not more than 100 °C.

Heating above 100 °C is obtained by means of steam under pressure in sterilisers or retorts. The temperature in the retort increases with rising steam pressure.

<table>
<thead>
<tr>
<th>Pressure (lb)</th>
<th>Temperature (°C)</th>
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</thead>
<tbody>
<tr>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>5</td>
<td>109</td>
</tr>
<tr>
<td>10</td>
<td>115.5</td>
</tr>
<tr>
<td>15</td>
<td>121.1</td>
</tr>
</tbody>
</table>

**(5) Ultra Heat Treatment (UHT)**

This is a type of sterilisation, which involves heating a liquid to a very high temperature for a very short time. Milk is heated to 132.2 °C by use of steam injection for a few seconds. This milk can be kept unopened for up to six months.

**(6) Canning**

Canning is a heat treatment of foods in hermetically sealed containers (tin coated steel cans, glass or aluminium containers, plastic
pouches). The aim is not complete sterilisation but rather to kill all microorganisms that could spoil food under normal conditions of storage.

Time and Temperature relationship. With high retort temperatures, shorter times are used. The process varies with the acidity of foods, the sauces used, the sizes and shapes of the cans, and the initial food temperatures.

Loosely packed foods in liquid require less heat than solidly packed ones. Acid foods require less heat than those nearer neutrality. Foods such as artichokes cannot withstand high temperatures and are acidified and processed at lower temperatures.

Sterilisation can be done in two ways

- The food is sterilised and placed in a container in aseptic conditions
- The food is placed in a container first, then sterilised
In both canning and bottling, the product is placed in a hermetically sealed container to prevent re-entry of and thus recontamination by microorganisms.

(7) **Cold processing**

Cold processing is the removal of heat from a product. In foods, cooling and freezing slow down enzymatic, chemical and microbial activities and can be used for preservation. This method is essential for some food items such as ice cream. Methods of cold processing include chilling, cook chilling and freezing.

**Chilling**

Chilling or cold storage temperatures are above freezing temperatures but usually less than 5 °C

Important considerations in chilling storage are:

**Temperature**

The lower the temperature, the higher is the cost. Although most foods will keep best at temperatures just above freezing point, they are not necessarily stored at this temperature unless required.

**Relative Humidity (RH)**

Optimal level varies with the foods stored and with environmental factors. A too low relative humidity may lead to a loss of moisture and hence loss in weight, wilting and softening of fruits and vegetables. High relative humidity may cause growth of spoilage microorganisms.

<table>
<thead>
<tr>
<th>Near saturation RH</th>
<th>bacteria growth</th>
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</thead>
<tbody>
<tr>
<td>90-92 % RH</td>
<td>development of yeast</td>
</tr>
<tr>
<td>85-90 % RH</td>
<td>development of moulds</td>
</tr>
</tbody>
</table>
Ventilation

Ventilation or control of air velocities is important to maintain a uniform relative humidity in the storage room and to remove odours. The rate of air circulation affects the rate of drying foods. Poor ventilation may give rise to local areas of high humidity leading to microbial decomposition.

Cook-Chill products are usually dishes that are cooked, rapidly chilled and stored at low temperatures. These foods should be reheated prior to consumption.

Freezing

Freezing is the process of lowering temperature of food to below its freezing resulting in reduced reaction time and lowered water activity. Freezing has little effect on flavour, nutritional value and colour but may damage the texture due to large ice crystal formation during slow freezing.

Methods used are:

1. Direct immersion of the food or packaged food in a refrigerant (freezing of fish in brine)
2. Indirect contact with refrigerant at –17.8 to –45.6 °C
3. Air blast freezing where frigid air of –17.8 to –34.4 °C is blown across materials being frozen
4. Plate freezing where the food is placed between two plates which make contact with the food’s surface

Since freezing does not completely stop enzymatic action, fruits and vegetables are blanched (dipping in boiling water for a short time), prior to freezing.

(8) Dehydration (evaporation and drying)
Drying of food is the reduction of its water content to such a level that micro organisms cannot grow. Chemical reactions, such as browning may still occur causing deterioration of quality. Sun drying requires little equipment for the drying process. Other methods used include oven drying, hot air beds, spray drying, and drum drying.

Evaporation (concentration) is often used to reduce the amount of water before dryin, but it can also be used to manufacture products with specific characteristics.

(9) **Addition of salt, acids, sugar and smoke**

**Salting**

At high concentrations, salt preserves the food through reduction in water activity and control of microbial growth. Salt also adds flavour.

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**Uses of salt**

- Basic flavouring agent
- Flavouring agent and preservative in meat
- Flavouring ingredient and curing agent in cheese
- Flavouring agent in butter
- For control of fermentation processes
- In brine storage of cucumbers and other vegetables
- In brine storage of citrus peel before further storage
- For temporary storage of cut fruits
- Fish preservation
Addition of acids
Acids are usually added to enhance flavour, to reduce the pH (preservative effect) and to create specific products, such as fermented foods.

**Acids used in foods**

- Citric acid (also lemon juice)
- Tartaric acid
- Lactic acid
- Malic acid
- Acetic acid (also vinegar)
- Phosphoric acid

Addition of sugar
Sugar is a common ingredient in many foods.

Sugar is added for its

Sensory properties (taste, texture, flavour enhancer)

Preservative action (lowers water activity at high concentration)

Colour reactions

Sugar at concentrations of 40 % or more, aids in the preservation of products such as jellies, jams, condensed milks, candies and grapefruits. A sugar concentration of about 60% in finished or processed products generally ensures preservation. Sugar addition followed by evaporation will lower the water activity to about 0.848
aw. However at this level, mould and osmophile yeast can still grow on the product.

For jam preparation, fresh or pre-cooked fruits are boiled in a solution of cane or beet sugar until sufficient water has evaporated giving a mixture that will set to a gel on cooling. Gel formation is dependent on the presence of pectin, a carbohydrate of the fruit. At a pH of 3.2 to 3.4 and in the presence of a high concentration of sugar, pectin can form a viscous semi-solid. Other sugar preserves from fruits are marmalade, jelly and fruit paste.

Addition of smoke
Smoking is a traditional food preservation method. Presently the sensory properties of smoke are also sought. Smoke can be added to foods by
- burning wood and letting the smoke soak into the product or
- adding the flavour as a liquid to the surface of the product

<table>
<thead>
<tr>
<th>Effects of smoke</th>
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<tbody>
<tr>
<td>- Drying</td>
</tr>
<tr>
<td>- Developing and fixing of colour of lean portions</td>
</tr>
<tr>
<td>- Tenderising action from proteolytic activity of enzymes, supported by the higher temperatures</td>
</tr>
<tr>
<td>- Producing desirable finish or gloss on skin</td>
</tr>
<tr>
<td>- Imparting desirable flavour</td>
</tr>
<tr>
<td>- Imparting fat antioxidants</td>
</tr>
<tr>
<td>- Impregnating outer portion of meat with components with a preserving action</td>
</tr>
<tr>
<td>- Reducing microbial level of meat</td>
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</tbody>
</table>
Use of food additives

Additives may be added intentionally for five main reasons:

1  **To control food texture.** Emulsifiers, stabilizers, and thickeners give food an even texture and help keep ingredients and flavours blended in the product. Lecithin, mono and diglycerides, guar gum and carrageenan are examples of such additives. Emulsifiers are also used to keep peanuts and oil from separating.

2  **To improve flavour and colour.** Natural and artificial colours and flavours enhance the appearance and taste of certain foods. Examples include: Aspartame, FD&C Red No 40, Monosodium glutamate (MSG).

3  **To improve nutritional value.** When nutrients are added to foods to replace those that are lost during processing, these foods are said to be enriched. Vitamins and minerals, as well as fibre, are often added to enrich foods. Many of the B vitamins are lost as whole wheat flour is being refined into white flour, so these are added back to enrich the flour. Vitamins A and D are added to fortify milk.

4  **To maintain freshness and safety.**
Preservatives prevent spoilage of foods by controlling or preventing growth and survival of microbial agents. Preservatives include: citric acid, sulfites, calcium propionate and sodium nitrite.
Antioxidants, such as vitamin E, BHA and BHT are added to fats and oils to prevent rancidity. They also are used in baked goods, cereals, processed foods, and salad dressing to prevent spoiling and discoloration.

5  **To help foods rise and to control the acid-base balance of food.**
Leavening agents cause baked goods, such as bread, to rise. Other additives, such as yeast and sodium bicarbonate, help control the acidity and alkalinity of foods and hence the flavour, taste, and colour.

**Irradiation**

Food can be irradiated to render it safe and to maintain its quality.

The food is exposed to ionising radiation, either from *gamma* rays or an *electron beam*. The rays pass through the food just like microwaves in a microwave oven, but the food doesn’t heat up. *Gamma rays* are a form of radiation that shares some characteristics with microwaves, but in a more concentrated form. *Electron beams* are formed from electricity and do not need radioactive material to work.

At low doses, irradiation extends shelf life of products. At higher doses, this process kills insects, moulds, bacteria and other potentially harmful microorganisms.
9.5 INTRODUCTION TO PACKAGING

Packaging is necessary to impart visual identification to food products, to maintain the beneficial effects of food processing, that is to prevent recontamination of the food and to preserve its sensory properties.

<table>
<thead>
<tr>
<th>Uses of packaging</th>
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<tbody>
<tr>
<td>• to contain</td>
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<tr>
<td>• to protect</td>
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<tr>
<td>• to communicate</td>
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<tr>
<td>• to market the produce</td>
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</tbody>
</table>

Packaging materials Different types of packaging materials are available for packing food products. The characteristics of commonly used materials are listed below.

• **Paper**
  – Strength; rigidity; opacity; printability.

• **Aluminium foil**
  – Negligible permeability to water vapour, gases and odours; grease proof, opacity and brilliant appearance; dimensional stability; dead folding characteristics.

• **Cellulose film (coated)**
  – Strength; attractive appearance; low permeability to water vapour (depending on the type of coating used), gases, odours and greases; printability.

• **Polythene**
  – Durability; heat-sealability; low permeability to water vapour; good chemical resistance; good low-temperature performance.

• **Rubber hydrochloride**
–Heat-sealability; low permeability to water vapour, gases, odours and greases; chemical resistance.

**Cellulose acetate**
–Strength; rigidity; glossy appearance; printability; dimensional stability.

**Vinylidene chloride**
–Low permeability to water vapour, gases, copolymer odours and greases; chemical resistance; heat-sealability.

**Polyvinyl chloride**
–Resistance to chemicals, oils and greases; heat-sealability.

**Polyethylene terephthalate**
–Strength; durability; dimensional stability; low permeability to gases, odours and greases.

**Tinplate**
Tinplate, a rigid and impervious material, consists of a thin sheet of low carbon steel coated on both sides with a very thin layer of tin. Tin is not completely resistant to corrosion but its rate of reaction with many food materials is considerably slower than that of steel.

**9.6 CHOICE OF PROCESSING METHODS FOR FRUITS AND VEGETABLES**
Practically any fruit, vegetable and animal product can be processed. The rationale for processing the product and the method to be used will depend on the following factors:

1. demand for a particular fruit, vegetable or animal product in the processed form;
2 quality of the raw material and its ability to withstand processing;

3 supply of the raw material;

4 cost of processing.
REFERENCES


