MODULE 11

SAFE FOOD PROCESSING

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Objectives of the module

By the end of the module, participants should be able to:

(a) List the reasons for preserving food

(b) Explain how growth of microorganism occurs and how this can be controlled.

(c) Describe the processes recommended for ensuring food safety

(d) Explain the sanitary procedures essential when preparing food for preservation

(e) Explain the effects of processing on the nutritional properties of food

11 SAFE FOOD PROCESSING

1 INTRODUCTION

The two common causes of food borne illness in the SADC region are

- Consumption of foods that have become unsafe by toxin-producing bacteria present in the food
- Consumption of foods that are carriers for harmful bacteria.

Microorganisms are present in the soil, in dust, air, sewage, plants, animals and men. Food can thus be easily contaminated.

A teaspoon of soil, for example, contains about 2 000 million bacteria, while the human body carries some 150 types.

It is possible for harmful microorganisms to be present within food as well as on its surface. A food that contains harmful microorganisms does not have to look spoiled to be dangerous. Bacteria live in warm, moist climates and prefer foods high in protein and moisture. These foods include milk products, meats, fish, poultry, cream puffs, cream pies, and potato salads. Without proper care, they can spoil or become dangerous foods. However, the vast majority of bacteria are not harmful.

General symptoms of a food borne illness are

- Vomiting
- Diarrhea
- Abdominal cramps
- Chills and fever

2 REASONS FOR PRESERVING FOOD

QUESTIONS FOR DISCUSSION

Why do we preserve food?

Why do fruits and vegetables keep after drying?

Are preserved foods as nourishing as fresh ones?

Why does food spoil?

Possible answers

- Extending the shelf life of foods, thus increasing supply
- Making seasonal foods available throughout the year, thus stabilising prices of foods
- Improving the nutrition of the population
- A reserve supply of food prepared at home provides the psychological satisfaction of being self-sufficient
- Concern over the safety of our food supply has motivated some consumers to preserve and prepare their own foods rather than rely so heavily on industrially prepared and convenience food items
- Adding variety to diet
- The spiralling costs of food in today's markets provide additional impetus to the desire to preserve food when supplies are high and costs are correspondingly low.

The choice of method of food preservation to be used is purely an individual matter. All foods can be preserved by drying, canning, pickling or freezing. However, the characteristics of the finished product will vary with the method of preservation selected.

Any food preservation method should ensure that the preserved food ***is safe to eat and that it is of optimum palatability***

This module provides

- valuable insights into the microbiological aspects of food safety for each of the methods of preservation
- a greater understanding of the changes which occur when foods are dried, canned or frozen
- appropriate scientific basis of the preservation techniques, which will assist in preserving foods safely and achieving the goal of preserving foods of excellent quality at home.

3. MICROORGANISMS IN FOODS

- Micro organisms are minute living organisms, present in all normal surroundings, and which are capable of growth and multiplication under suitable conditions.

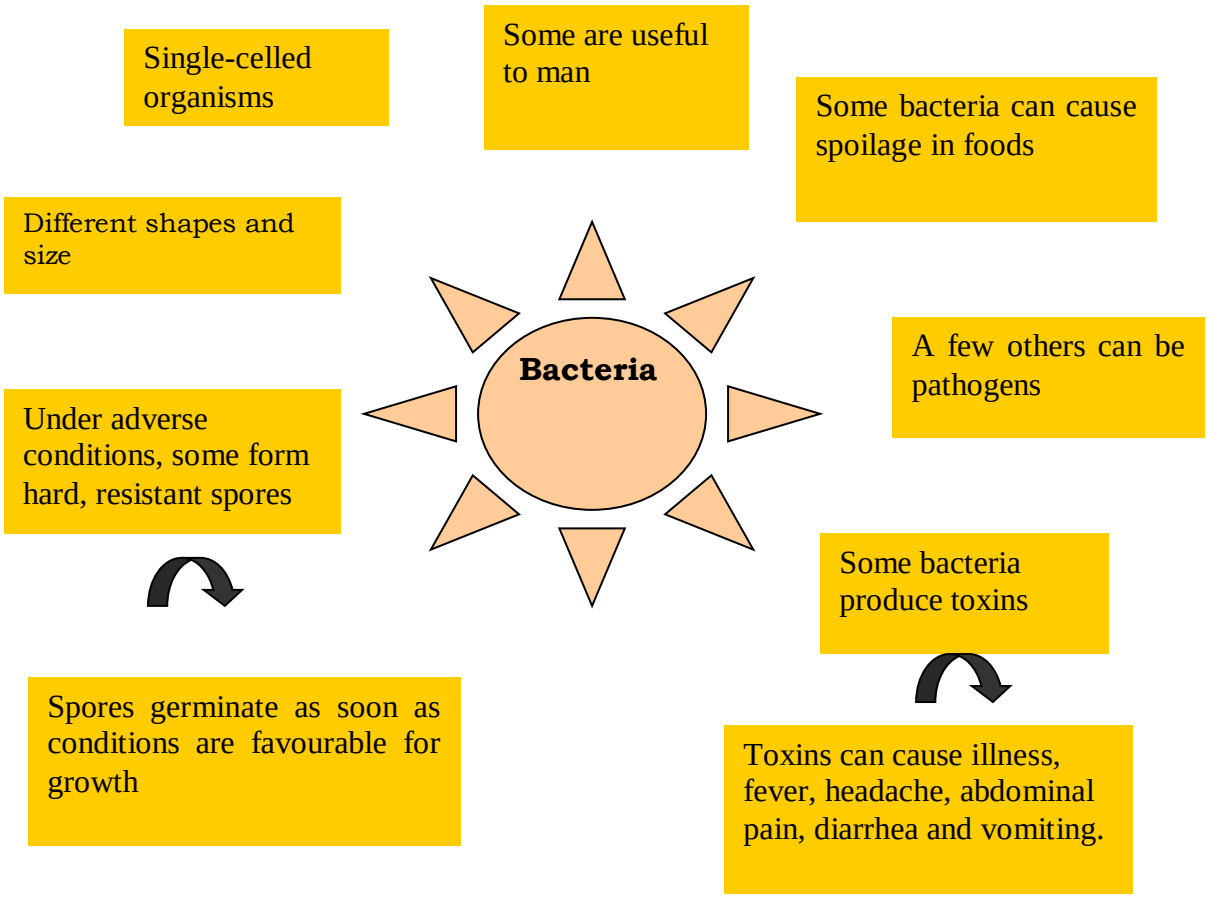
- Such conditions are generally fulfilled by stored foods of all kinds; therefore it is necessary to take precautions to prevent the growth of the microorganisms.

- Some of these organisms can produce desirable changes like formation of curd but they are more often agents of spoilage and food borne diseases.

- Some microorganisms can exist both in vegetative and spore forms. Spores are more resistant to destruction by heat or other agents than the vegetative forms.

Micro organisms, which are important in food spoilage, are divided into three groups:

Bacteria

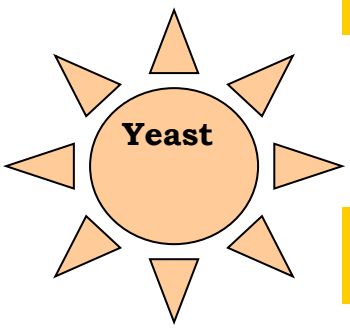

Single-celled organisms
Some are useful to man
Some bacteria can cause spoilage in foods
Different shapes and size
Bacteria
A few others can be pathogens
Under adverse conditions, some form hard, resistant spores
Some bacteria produce toxins
Spores germinate as soon as conditions are favourable for growth
Toxins can cause illness, fever, headache, abdominal pain, diarrhea and vomiting.

Yeast

Found mainly on foods rich in sugar and water

Grows well in acid conditions

Growth is most rapid between 25 °C and 30 °C



Cause spoilage by conversion of sugars present in foods to alcohol and carbon dioxide

Reproduces by a process called 'budding'

Part of the yeast cell would form a bud . The bud grows and eventually breaks away to form a new cell

Foods liable to be spoiled are fruit juices, syrups, jams, jellies, honey

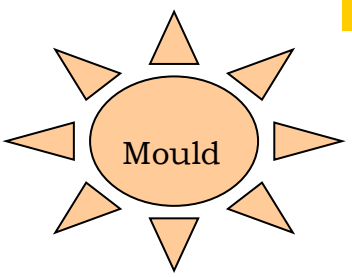
Moulds

Aflatoxins in groundnuts

Very few moulds produce disease in man

Moulds can grow on almost all kinds of foods and are most likely to develop in warm and damp conditions

Moulds are mainly involved in spoilage of food



It is usually recognised by its fuzzy and cottony appearance

Mould starts as a fine thread known as hypha, which as it grows, forms a mass called mycelium.

Spores are formed and they germinate to develop a fluffy growth, which may be white, grey, blue, red, depending on the pigment in the spore

Conditions required for microbial growth are summarised in figure 1 and are discussed in Module 4

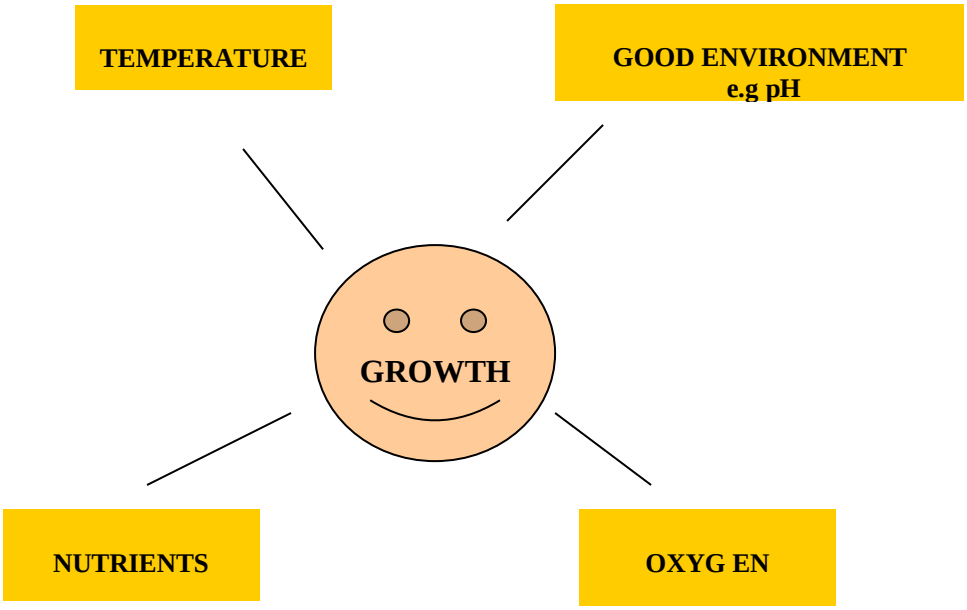


Figure 1: Conditions required for microbial growth.

Not all micro organisms are harmful. In commercial food processing, some micro organisms are cultivated for their desired effects on foods. Examples can be found in the production of cheeses and breads, as well as many other products. Controlled use of the micro organisms is the key to success in such foods.

Control of microbial growth

-Low pH
-Low or high temperature
-Low moisture content
-Exclusion of oxygen

♣pH

- Most micro-organisms grow well in neutral conditions, therefore food that is kept for a longer period, could be stored in acidic conditions, like using vinegar and salt as preservatives.
- Precautions have to be taken to make sure that yeast do not affect the food because yeast multiply well in acidic conditions.

♣Moisture content

- All microorganisms need water to maintain life. So if food is kept dry, its shelf life is increased.
- Foods that are dry or have little moisture should be kept in dry places so that they do not absorb water. Moist foods could be dried to remove the moisture to prevent spoilage through microbial multiplication.

♣Temperature

- All micro-organisms have an optimum growth temperature.
- The majority of bacteria can grow between 5 to 63^{o} C, but are destroyed at 100 ^{o}C. Yeast do not withstand temperatures higher than 60 °C and moulds are also destroyed at 60-98°C.
- All micro-organisms are inactivated by deep-freezing; some might die, but the cold temperature stops the multiplication of the bacteria.

♣Oxygen

- Most microorganims need oxygen for growth. However there are others, which grow in the absence of oxygen (anaerobic conditions).

MICROBIOLOGICAL CONTAMINANTS

Microbiological contamination in preserved foods is of interest because of :

its effects on the ***storage time*** and the ***quality*** of the food following storage	possible **health hazards** associated with eating contaminated food

* The microorganisms that may be found in preserved foods are of the same types as those found in fresh foods, notably moulds, yeast, bacteria and toxins produced by these organisms.

* Microorganisms can enter the food supply via a number of routes (Figure 2)

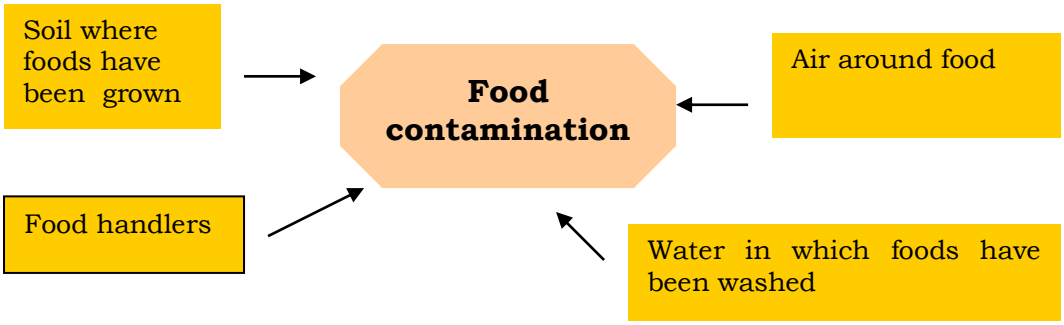


Figure 2: Sources of food contamination

In short, ***the total environment prior to processing for preservation*** affords opportunities for contamination of foods.

* Since there are so many opportunities for foods to become infected with microorganisms, contamination should be controlled.

* Methods of food preservation have been developed to minimize growth of microorganisms during the storage period, thus promoting longer shelf life and reduced hazard from eating the food.

4. FOOD PROCESSES AND FOOD SAFETY

The goals of food preservation in relation to microbiological concerns are:

- to minimize the original contamination of the food,
- to process the food in a manner designed to reduce the microbial population to an absolute minimum, and
- to store the processed food in conditions that will limit the growth of microorganisms during storage.

4.1 BASIC RULES OF SAFE FOOD PROCESSING

♣Choice of raw materials

- Raw materials in food processing are the raw foods that have to be changed into their edible or preserved forms. These include raw meat and poultry, fruits and vegetables.
- When choosing raw foods, one has to make sure that the food is as fresh and clean as possible, because then it will be at its best.
- There are different ways in which freshness in food can be tested.

Meat

- No unpleasant odour
- Colour is deep red for beef, pinkish-red for mutton, pale pink for pork
- Fat is firm, not oily
- No juice running from the meat

Fruits and vegetables

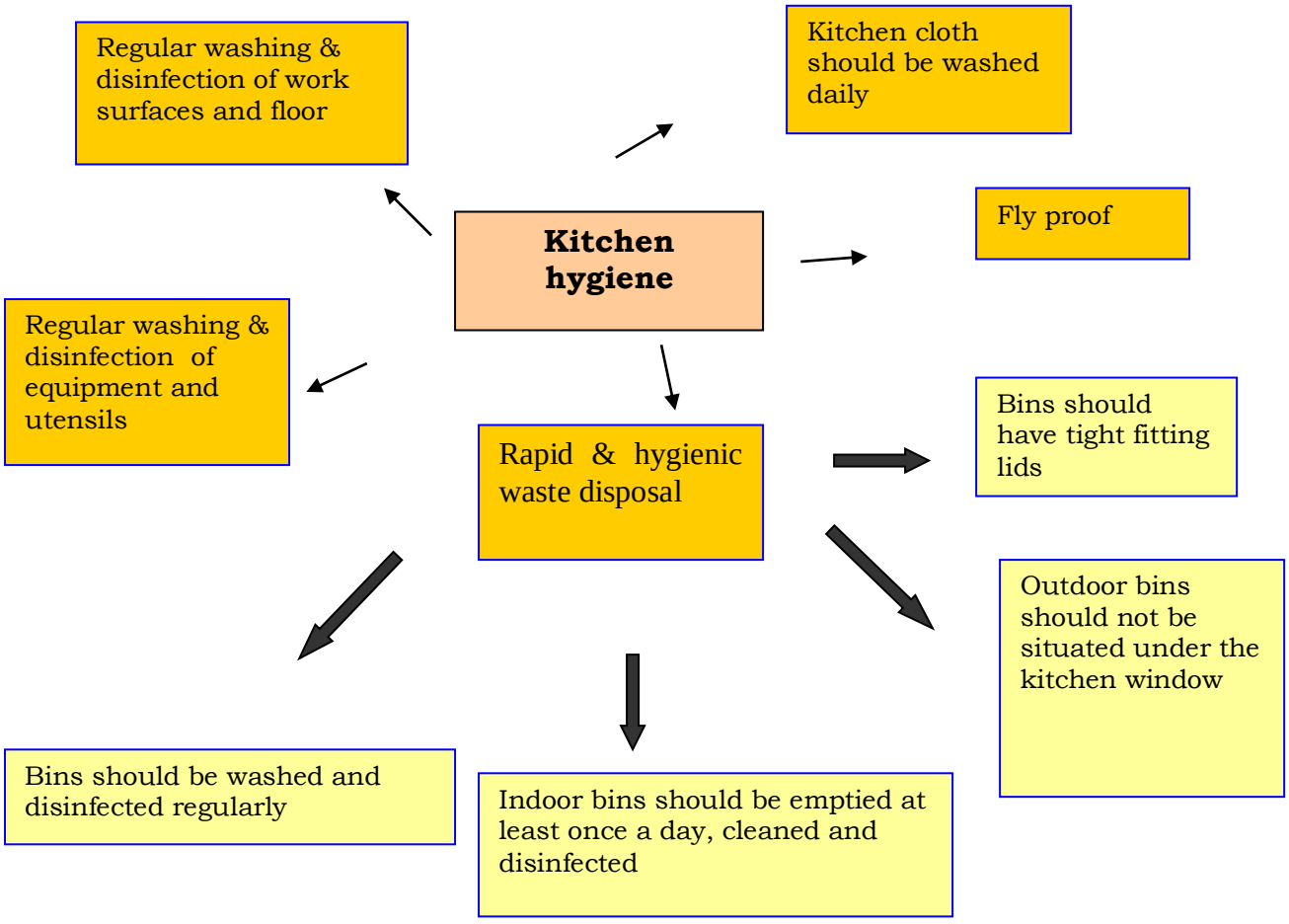
- Fresh and undamaged
- Firm to the touch

♣

Raw materials should be kept in an environment, which does not allow rapid multiplication of microorganisms immediately after purchase or harvest to avoid deterioration. Refrigeration is the best way to keep most foods before processing.

♣**Personal hygiene of food handlers** This has been discussed in Module 5

♣**Kitchen hygiene**



♣Proper handling of food

Foods should be covered to prevent contamination

Foods should not be reheated several times

Cooked food should not be stored for too long

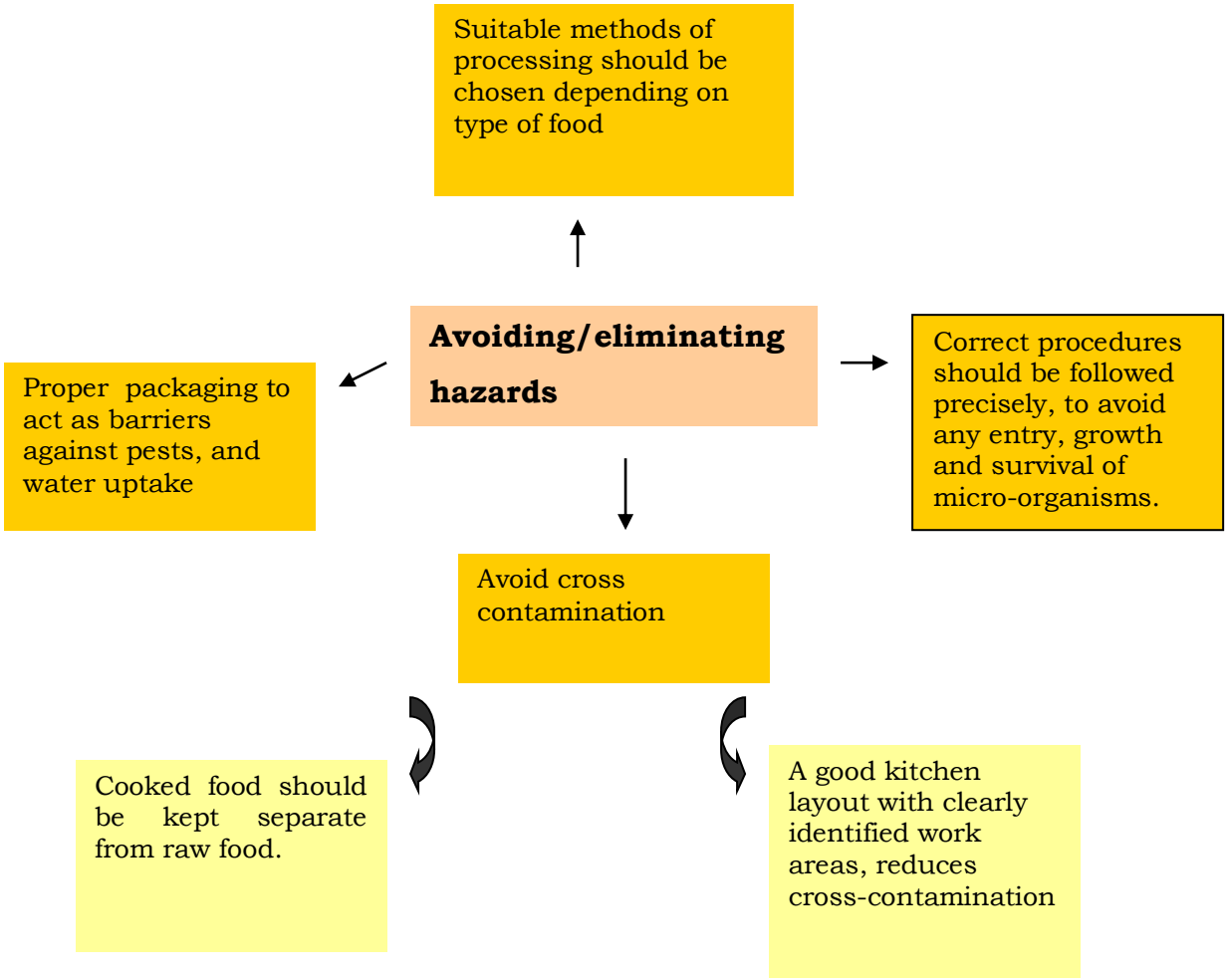
Proper handling of foods

Foods should be thoroughly cooked

Direct handling of food should be avoided if possible

If food is to be eaten cold, it should be cooled rapidly

♣Avoiding/eliminating hazards



4.2 SPECIFIC PROCESSES FOR SAFETY

Food preservation is usually carried out to ensure a safe food supply. As soon as animals have been slaughtered or plant foods have been harvested, deterioration begins; therefore it is necessary to keep the food safe by applying processes that prevent microbial growth.

In preservation, it is essential not only to destroy spoilage agents and pathogens but to prevent the entry of further micro-organisms during storage.

Commercial methods are not always practical in the domestic environment and some are potentially dangerous if not done properly, e.g. home canning is not usually recommended because of practical difficulties in reaching the desired temperatures for the production of safe food.

PRINCIPLES OF FOOD PRESERVATION

Different methods are available for preserving food

- Some preservation methods just ***inhibit*** microbial growth
- Some methods ***kill*** microorganisms
- Some methods ***inhibit chemical*** reactions in foods
- Some methods do all of the above

1 Prevention or delay of microbial activity

Method	**Example**
•Keeping out micro organisms	Asepsis, Packaging
•Removal of micro organisms	Filtration
Preventing growth & activity of micro organisms	Low Temperature, Drying, Anaerobic Conditions, Chemicals
•Killing micro organisms	Heat, Radiation

2 Prevention or delay of self-decomposition of food

Method	**Example**
•Destruction or inactivation of food enzymes	Blanching
•Prevention or delay of purely chemical reactions	Use of antioxidants, drying

Methods of preservation

- **Preservation by high temperature**

The aim of any heat treatment is to destroy pathogenic and spoilage microorganisms. Heat denatures proteins in microbes and enzymes

•Depending on heat treatment →
- Some or most or all vegetative cells may be destroyed
- Some or all spores may be destroyed

Examples

Pasteurisation	**Blanching**
Cooking	**Baking**
Sterilisation (canning)	

Pasteurisation is used when

•When more rigorous heat treatment might affect quality of produce such as milk

•When the aim is to kill pathogens

•When spoilage organisms are not too heat resistant for example yeast in juices

•When any surviving spoilage organisms will be taken care of by additional preservative methods, for example chilled milk

•When competing microorganisms are to be killed, thus allowing desired fermentation, for example in cheese

Preservative methods used to supplement pasteurisation are

- Refrigeration — milk
- Keeping out of microorganisms — **Packaging in sealed containers**
- Maintenance of anaerobic conditions — **In evacuated, sealed containers**
- Addition of high concentration of sugar — Condensed milk
- Presence or addition of chemical preservatives — Organic acids in pickles

Canning

Canning is a time-honoured method of preserving foods using high temperatures to destroy bacteria, yeast, and moulds and spores, which would cause unprocessed foods to spoil. The processing conditions required for effective and safe storage of heat-processed foods vary with the type of microorganisms being considered.

Some cells of microorganisms are rather heat sensitive; many are of medium resistance to heat treatment, while some cells and spores are extremely resistant to heat. Higher processing temperatures result in preparation of higher quality canned foods in several instances. When the cell count of microorganisms is high, the time required to ensure the death of all is longer than when the population is smaller. However, in all cases, there is a time-temperature relationship, which can be observed.

For canned foods to be safe, it is essential that processing times and temperatures are monitored carefully and that a good seal be achieved. This is true for both home and commercially-processed canned foods. Unless microorganisms in food prior to processing are destroyed by heating and

unless subsequent contamination is prevented by a tight seal, spoilage will occur in the canned product during storage on the shelf.

Fruits, vegetables, meats, poultry, and fish can be canned satisfactorily at home provided attention is given to using correct processing techniques and equipment. The decision on the type of processing required for food safety is based on the acidity (pH) of the food. The medium in which the microorganisms are being heated has a distinct influence on the rate of destruction. Most spores and cells are at their maximum potential for heat resistance at or near a pH of 7 (approximately neutral in reaction). As the medium becomes more acidic, the resistance to heat decreases more rapidly than it does if the medium is adjusted into the alkaline range, but either side of neutral is more destructive than a pH of 7. This effect is of prime significance in the processing of foods by heat.

Foods for heat processing often are clustered into groups according to their acidity.

(1) Low-acid foods (pH 5.3 or higher). Examples are peas, maize, lima, beans, meats, fish, poultry and milk.
(2) Medium-acid foods (pH 5.3 to 4.5). Examples are spinach, asparagus, beets and pumpkin.
(3) Acid foods (pH 4.5 to 3.7). Examples are pears, pineapples and tomatoes, although the newer varieties of tomatoes often are higher in pH than this range.
(4) High-acid foods (pH 3.7 or lower). Examples are Sauerkraut , citrus and berries

The type of heat processing required for safety in canned foods is influenced by the acidity of the food being processed. Foods with a pH lower than 4.5 can be processed safely in a water bath under atmospheric conditions. Examples: fruits, pickles, juices

Foods classified, as low-acid foods must be processed with the aid of special pressurized equipment so that the temperatures reached in processing will be high enough to destroy the microorganisms, which are present. In other words, meats, poultry, and vegetables need to be processed in pressure canners in the home if they are to be safe.

The pH of some foods will change during heat processing of the food. This is particularly true of the low-acid foods. When the pH is 5.5 or higher, heat processing will result in a drop in the pH of the food; more acidic foods will change pH very little during processing.

Careful timing of heat processing is required regardless of the method of canning. Special precautions for cooling slowly the pressure canner and its contents must be observed to avoid extreme and sudden pressure changes in the jar and its surroundings. Microwave ovens and conventional ovens should not be used for canning because of safety hazards.

Canned foods should be assessed visually before opening to note any signs of spoilage or leakage. In addition, low-acid foods should be boiled 15 minutes before they are even tasted because of the possible presence of the toxin from *Clostridium botulinum.*

Preservation by use of low temperature

Growth and metabolic reactions of microbes depend on enzymes and the rate of enzymatic reactions is directly affected by temperature.

Low temperature

•Retards chemical reactions, action of food enzymes

•Slows down or stops the growth and activity of microorganisms in food

•Influences type of spoilage flora

In general, in **freezing**, liquid is converted to a solid and is unavailable for microorganisms and the low temperature slows down growth rates. Most foods are well suited to freezing, but there are some exceptions e.g. eggs, milk products. Vegetables, fruit and meat can keep up to 12 months when frozen

Chilling is a short-term process of preservation where foods are stored at temperatures below 8 ^{o}C but above their freezing point. The optimal temperature is 5 ^{o}C

Preservation by drying

Microorganisms only grow and multiply in the presence of moisture.

Depriving microorganisms of water, reduces perishability as bacteria, moulds and yeast are unable to grow under these conditions

Bacteria do not grow in environments with less than 16 percent available moisture	Yeast require higher moisture levels, at least 20 percent	Moulds can survive at moisture levels as low as 13 percent. They are the most resistant to destruction during storage of dried foods

Dehydration is nature's way of preserving reserve foods from one growing season to the next. Sun drying is used mainly in the hot climatic areas for the preservation of fruit and vegetables. The drying of fruit and vegetables at home can be done quite simply. No expensive apparatus is used and only correct temperature and movement of air are required.

Example : dried grapes, dried milk powder, pulses

Preservation by use of chemicals

♦***Salt***

Salt can preserve food in two ways:

- providing an antiseptic action
- diminishing the amount of moisture

Most bacteria stop growing in salt concentration of about 15 % but yeast can grow even at 18 % salt in soy sauce.

The amount of salt determines

-the type of fermentation

-type of organisms that will grow

Example: Salted fish

♦***Sugar***

•Spoilage bacteria will not develop in sugar solutions of 40-50%, but certain yeast and moulds are able to develop in much higher concentrations.

At high sugar concentrations, water is not available to microbes thus inhibiting the growth and reproduction of most species of bacteria, yeast, and moulds

Examples: Jam, jelly, candies

♦***Organic acids***

Acids can be added directly to foods to control microbial growth. They preserve food similar to fermentation.

Examples are citric acid, vinegar (acetic acid) in pickled fruits

Preservation by the use of additives

A food additive is a substance or mixture of substances, other than the basic foodstuff, which is added to the food during processing, treatment, packaging, transportation or storage of the food.

Preservatives	Antioxidant
Sodium Benzoate Sorbate Proprionates Sulfur dioxide Nitrates and nitrites	BHT BHA

Preservation by irradiation

Food irradiation is a processing technique with similar results to freezing or pasteurisation. Food is exposed to ionising radiation. This method reduces food spoilage, destroys microorganisms, slows down undesirable changes and destroys insects and pests.

Exposure to gamma rays does not make food radioactive. Considerable scientific research over the past five decades indicates that food irradiation is a safe and effective form of processing.

Food irradiation has been approved in forty countries including the United States, China, France and Holland.

Examples: Fruits, vegetables, grain foods, spices and meats (such as chicken)

The process alters the nutrient content of some foods by destroying vulnerable vitamins, but this loss is similar to other accepted food processing techniques, such as canning or blanching. Some foods, such as dairy foods and eggs, cannot be irradiated because it causes changes in flavour or texture.

Radura Symbol : Irradiated foods must have this symbol and be labeled "Treated by Irradiation" or "Treated with radiation »

Preservation by Packaging

Packaging plays an important role in food preservation.

- It protects against physical damage, bruises which can be a major cause for poor quality of product.
- It prevents contamination of foods by insects, micro organisms and rodents.
- It limits gaseous exchange and movement of water from and to the product
- It maintains a sanitary environment during marketing

5. EFFECTS OF PROCESSING ON NUTRIENTS

The detrimental effects of processing on the nutritional quality of food are:

Loss of major components

- Bulk (weight) (by milling, peeling, leaching),
- Dietary fibre (by milling, peeling)
- Protein quality (excessive heat treatment only)
- Sugars (leaching)

Loss of Minor Components

- Water-soluble vitamins (by milling, peeling, leaching, oxidation, heat instability)
- Fat-soluble vitamins (by heat instability, oxidation)
- Minerals (by milling, peeling)

The most important losses on processing are of

Bulk (weight) (through milling, peeling)

Dietary fibre

Water-soluble vitamins.

Heat treatment

Beneficial effects of heat are summarized in figure 3

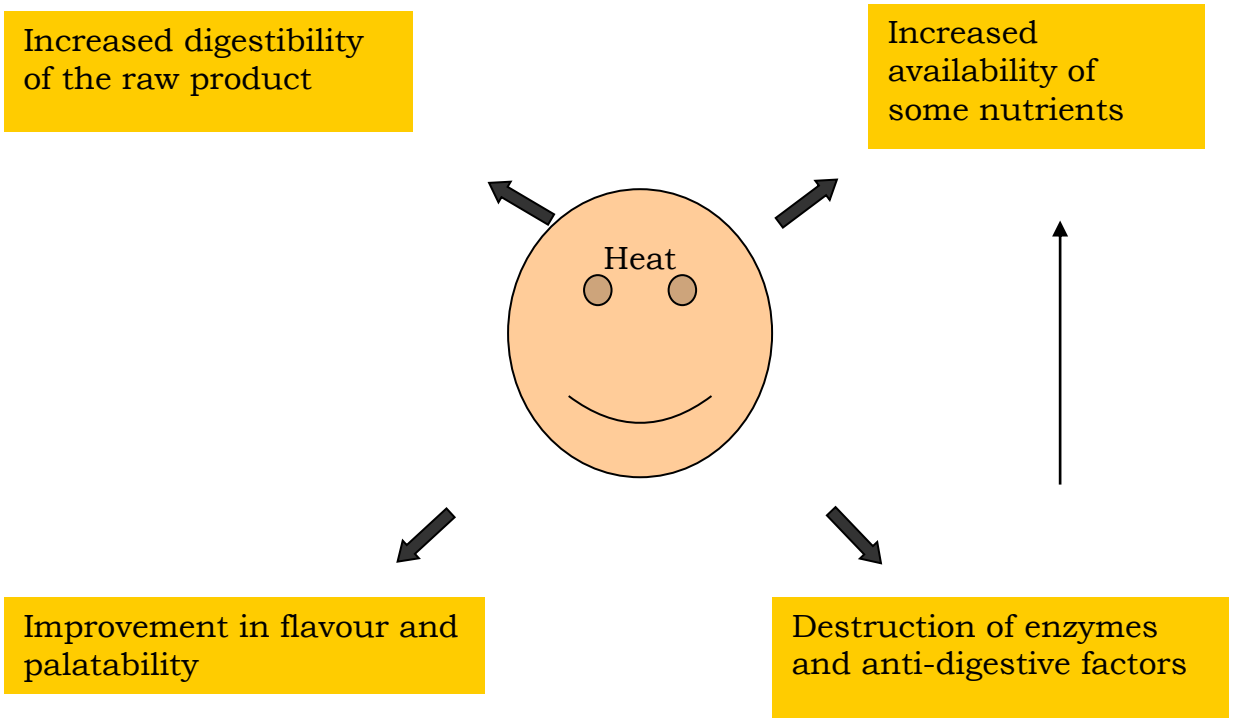


Figure 3: Beneficial effects of heat

But heat treatments can result in the loss of nutrients, this being greatest at high temperatures with long cooking times. If cooking is done with an excessive amount of liquid, losses will be high if the liquid is discarded. Very high temperatures can completely denature proteins and lower their digestibility. The main commercial processes involving heat and which cause loss of nutrients are blanching, sterilisation, drying or dehydration

Factors affecting the magnitude of loss of nutrients

- surface-to-mass ratio (large surface → larger losses)
- product to water ratio
- time and temperature of treatment
- food maturity and size of food

Blanching or scalding in water or steam is a first step in the preservation of most vegetables for subsequent canning, freezing or dehydration. Usually the process is carefully controlled but small amounts of some minerals and water- soluble vitamins dissolve in the water and are lost.

Heat processing in metal cans (Sterilisation) or bottling in glass jars will reduce the amounts of heat-sensitive vitamins, especially. Thiamine, Folic acid and Vitamin C.

Losses will depend

(a) on the length of time needed to destroy any harmful micro-organisms. Losses are higher in large cans with thick consistency of foods

(b) acidity of food and presence of light and air

Dehydration

Dehydration (in air) under carefully controlled conditions has little effect on most nutrients but half of the Vitamin C is lost. Complete loss of thiamine may occur if sulphur dioxide is added as a preservative.

Freezing

The differences between the nutrient content of cooked fresh food and cooked frozen foods as served on the plate are small. The freezing process itself has little effect on the nutritional value, and since the delay after harvesting is minimal, the nutrients in the high quality fresh foods that are used are generally well retained. Some losses of Thiamine and Vitamin C do occur when vegetables are blanched in water before freezing, but these losses are lower than would otherwise result from the continuing action of enzymes in the plant tissue during storage.

ACTIVITY

Each participant will take an example of processed food he/she produces or consumes and explains in five minutes how the food is processed and preserved. Brainstorm how inadequate processing may affect quality and safety of the products.

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