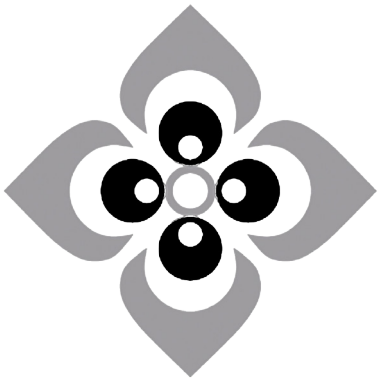

Consortium for Educational Communication

Module on

Basic concepts in food processing and preservation

By

Dr Anu Appaiah K A

Principal Scientist

Microbiology and Fermentation Technology

CSIR-Central Food Technological Research Institute (CFTRI),

Mysuru 570020, Karnataka, India

Text

Introduction:

People process foods every day when preparing meals to feed their families. However, the term "food processing" is broader than preparing and cooking foods. It involves applying scientific and technological principles to preserve foods by slowing down or stopping the natural processes of decay. Food processing changes basic raw materials into tasty attractive products that provide variety in the diets of consumers.

Food preparation and processing can be defined as any change that is made to a food to alter its eating quality or shelf life.

The aims of food processing can be considered under four subtitles:

1. Extending the shelf life during which food remains good both in terms of microbial and biochemical characters
2. Providing or supplementing nutrients required for health
3. Providing variety and convenience in diet
4. Value addition to food.

The scope of food processing includes processes after the harvest of raw materials until they are processed, packaged and sent to the point of sale could be considered part of food processing. Typical processing operations may include raw material handling, ingredient formulation, heating and cooling, cooking, freezing, shaping, and packaging. These could broadly be categorized into

- Primary processing
- Secondary processing.

Primary processing: Primary processing is the processing of food that is carried out soon after harvesting or slaughter. Primary processing ensures that foods can easily be transported and are ready to be sold, eaten or processed into other products e.g. Mango is graded cleaned and packed, which can be eaten fresh.

Secondary processing: Secondary processing turns the primary processed food or ingredient into other food products. It ensures that foods can be used for a number of purposes, do not spoil quickly, are healthy and wholesome to eat, and are available throughout the year for example seasonal fruits. E.g. Production of mango pulp or slice for canning.

Basic Principles of Food Preservation

The basic principles of food preservation involves

- Inhibiting the growth and activity of microorganism
- Inhibiting the activity of endogenous enzymes
- Inhibiting the chemical reactions which may deteriorate the quality of food
- Inhibiting the invasion and spoilage by insects and rodents

Several methods are available for preservation of food based on the above principles, the methods include:

- Preventing the accessibility of food to microorganism by asepsis and packaging
- Physical removal of microorganisms from food by filtration or centrifugation
- Hindering the growth and activity of microorganism by use of preservatives, use of low temperatures atmospheric control in packaging and storing of foods and decreasing water activity in foods by drying or evaporation
- Killing the microorganism by use of high temperature and ionizing radiation
- Inactivation of endogenous enzymes by moderate heating
- Inhibition of chemical reaction through the use of chemical additives
- Fermentation of foods to yield more stable or less perishable food product

Food preservation as it is practiced in the industry always involves combination of methods for achieving maximum effectiveness.

As much as 50 to 60 percent of fresh food can be lost without processing between harvest and consumption. This may be because of wrong storage and transportation, which allows micro-organisms or pest to spoil the stored food. Improved storage can greatly reduce these losses. Processing methods can be grouped into six categories **(Table 1).** Production of most processed foods uses more than one of the categories. For example, jam making involves heating, removing water, increasing the levels of acidity and sugar, and packaging.

In addition to preserving foods, secondary processing alters their eating quality. Eg. Wheat - where primary processing is cleaning, drying and milling to produce flour. However, flour is inedible. Secondary processing is used to produce a wide range of rotis and bakery products, snack foods, beer etc. Foods should have an attractive appearance or colour for the consumers to buy. Hence, processing industry should ensure that the products meet the requirements of the consumers.

Scales of operation

When operating as a business, food processing can take place at any scale from a single person to a multinational company (**Table 2).**

Home-scale processing

Foods that are intended for household consumption are usually processed by individual families or small groups of people working together. Many of the world's multinational food companies started from a single person or family working from home. In developing countries, home-scale processors are to generate extra income. When this becomes successful, they expand production and develop first into a micro- or small-scale business and later into larger scale operations. Characteristically, home-scale processors cannot afford specialized food processing equipment and rely on domestic utensils, such as cooking pans and stoves for their production.

They may work part time as the need for money arises and use part of the house, or an outer building for processing. However, in many situations the lack of dedicated production facilities means that there is a risk of contamination and product quality may be variable. This may lead to low valued processed foods.

Micro-scale processing

When families generate a good income from their home scale operations, some may choose to invest in speciality equipment (such as a bakery oven, or a press for dewatering or a pulp making machine). This allows home scale businesses to expand and become micro or small scale enterprise.

Home processors may sell their products to neighbours or in village market places the micro-scale processing requires additional skills and confidence to compete with other processors and marketing. Similarly, although the quality of their products may be suitable for rural consumers, it may not be sufficient to compete with products from larger companies. To successfully expand to micro scale production, village processors need technical skills to make consistently high quality products and financial. They may require, assistance or short training programmes to establish improved production methods, quality assurance and selling techniques.

Small-scale processing

The expansion to a small scale processing operation requires additional investment to produce larger amounts of product in a dedicated production room. It requires specialised equipment. At this level of production, they need to develop attractive packaging, quality assurance techniques, and the financial and managerial skills that is needed to run a successful small business.

Many governments promote the development of small-scale food processing enterprises because they:

- have the potential to create significant levels of employment;
- increase food security for growing urban populations as well as rural families;
- Produce products that can substitute for imported foods or have export potential,
- Help reduce balance of payments problems and improve the overall prosperity of the country.

Medium and large scale processing.

These industries are professionally run with a certain level of automation. The products are of uniform quality with strict quality control and quality assurance. These products are sold over a large geographical areas with attractive packing and are advertised well. These companies procure their raw materials from assured suppliers with strict quality controls. The products are normally well researched and tested over a large base of consumers before it is brought to the market.

Steps of processing

Raw material handling: Raw material handling is the very first step in the food processing. Raw material handling includes transportation from farm to primary processing units, where it is sorted, cleaned or

sanitized before it is dispatched to markets or to processing plants.

Cleaning and sanitation: Cleaning and sanitation of raw food material could be considered the first step in controlling any contamination of foreign materials or microorganisms during food processing. Cleaning removes foreign materials (i.e. soil, dirt,animal contaminants). These operations retards the growth of harmful microbes, which may cause disease and/or produce toxins. Sanitization is the use of any chemical or other effective method to reduce the initial bacterial load on the surface of raw materials or food processing equipment.

Engineering properties of food, biological, and packaging material: Knowledge of various engineering (physical, thermal, and thermodynamic) properties of food, biological, and packaging material is critical for successful product development, quality control, and optimization of food processing operations.

Microbiological considerations: Most raw food materials naturally contains microorganism, which bring both desirable and undesirable effects toprocessed food. For example, many fermented food like ripened cheeses, pickles, sauerkraut, and fermented sausages have considerably extended shelf life, developed aroma, and flavour characteristics over those of the raw materials arising from microorganisms such as *Lactobacillus, Lactococcus,* and *Staphylococcus* bacteria. On the other hand, raw food material also contains pathogens and spoilage organisms. E g. *Escherichia coli*, *Listeria monocytogenes*, *Clostridium botulinum* spores. Different pathogenic and spoilage microorganisms have varied degrees of resistance to thermal treatment.

Role of acidity and water activity in food safety and quality: Intrinsic food properties like water activity, acidity, redox potential helps to decide foodprocessing operations needed to ensure food safety and quality. Higher acidity levels (pH <4.6) helps in minimizing the microbial load, which requires milder treatments to preserve, for example orange juice or tomato products. By lowering the water activity by the addition of salt of sugar microbial growth can be controlled. Eg jams and pickles.

Reaction kinetics: During processing, the constituents of food undergo a variety of chemical, biological, physical, and sensory changes. Food scientists and engineers need to understand the rate of these changes caused by applying a given processing agent and the resulting modifications. These control process operations helps to produce a product with the desired quality. Enzyme hydrolysis, browning, and colour degradation needs to be controlled during processing. An in site into microbial and chemical kinetic equations to predict and control various changes happening in the processed food needs to be studied.

Common methods of food preservation

Following are some common techniques and methods that are used to convert raw food into processed food:

Drying

Microorganisms need moisture to grow so when the concentration of water in the food is brought down below a certain level, they are unable to grow. Moisture can be removed by the application of heat as in sun-drying

which is most popular and oldest method of preservation. In present days, mechanical drying has replace sun-drying. This is a more rapid process as artificial heat under controlled conditions of temperature, humidity and air flow, is provided. Fruits and vegetables, like green peas, cauliflower, mango, mahua, etc are blanched and dried to such an extent that the microorganisms are destroyed.

Chemical Preservation

Microbial spoilage of food products is also controlled by using chemical preservatives which do not include salt, sugar, acetic acid, oils, alcohols etc. The inhibitory action of preservation is due to their interfering with the mechanism of cell division, permeability of cell membrane and activity of enzymes.

The two important chemical preservatives permitted in many countries are:

(i) Sulphur dioxide (including sulphites), and
(ii) Benzoic acid (include benzoates)

These two are also permitted in India according to FSSAI

Smoking

Many foods such as meat, fish and others are processed, preserved and flavoured by the use of smoke mostly in big smoke houses. The food processing technique is quite simple, and the combination of smoke with the aroma of hydrocarbons generated from the smoke processing enhances the taste of smoked food.

Salting

Salt at a concentration of 15 to 25 per cent is sufficient to preserve most products. It inhibits enzymatic browning and discoloration and also acts as an antioxidant. Salt in the form of brine is used for canning and pickling of vegetables. It exerts its preservative action by

(i) Causing high osmotic pressure resulting in the plasmolysis of microbial cells,
(ii) Dehydrating food as well as microorganisms by drawing out and tying up the moisture by ion hydration,
(iii) Ionizing to yield the chloride ion which is harmful to microorganisms,
(iv) Reducing the solubility of oxygen in water, sensitizing the cells against carbon dioxide, and interfering with the action to proteolytic enzymes.

Preservation by Sugar

Syrup containing 66 per cent or more of sugar do not ferment. Sugar absorbs most of the available water with the result that there is very little water for the growth of microorganisms hence their multiplication is inhibited, and even those already present die out gradually. Thus, sugar acts as a preservative by osmosis. Fruit syrup, jam, jelly, marmalade, preserve, candy, crystallized fruit and glazed fruit are few example of preservation by sugar.

Freezing

Microbial growth and enzyme reactions are retarded in foods stored at low temperatures. Low temperatures can be produced by

(i) Cellar storage (about 15^0C),

(ii) Refrigeration or chilling (0 to 5^0C), and by
(iii) Freezing (-18 to -40^0C).

Preservation by Carbonation

Fruit juice beverages are generally bottled with carbon dioxide content varying from 1 to 8 g per liter. Though, this concentration is much lower than that required for complete inhibition of microbial activity (14.6g/liter), it is sufficient for supplementing the effect of acidity on pathogenic bacteria. Another advantage of carbonation is the removal of air thus creating an anaerobic condition, which reduces the oxidation of ascorbic acid and prevents browning.

Pickling

In this method of food processing, the food is cooked in chemicals and materials which destroy micro-organisms. Usually, these include brine, vinegar, ethanol, vegetable oil and many other types of oils. Pickling is very commonly seen in vegetables such as cabbage and peppers.

Preservation by Acids

Acid conditions inhibit the growth of many microorganisms hence organic acids are added or allowed to preserve foods. Acetic acid (vinegar), citric acid (lime juice) and lactic acid are commonly used for preservation. About 2 per cent acetic acid prevents spoilage of many products. Eg. Onions bottled in vinegar with a little salt. Vinegar is also added to pickles, chutneys, sauces and ketchups. Citric acid is added to many fruit squashes, jams and jellies to increase the acidity and prevent mould growth.

Preservation by oil and spices

A layer of oil on the surface of any food produces anaerobic conditions which prevent the growth of moulds and yeasts. Thus, pickles in which enough oil is added to from a layer at the top can be preserved for long periods. Spices like turmeric, pepper, and asphoetida have little bacteriostatic effect and their ability to prevent growth of other microorganisms is questionable. Their primary function is to impart characteristic flavor to the food.

Preservation by antibiotics

Certain metabolic products of microorganisms have germicidal effect and are termed as antibiotics. Very few antibiotics are used to preserve fruits, vegetables and their products. They effectively reduce the thermal process requirements, necessary to control the spoilage of several food products.

Nisin is an antibiotic produced by *Streptococcus lactis*, an organism commonly found in milk, curd, cheese and other fermented milk products. It is commonly used in canning of mushrooms, tomatoes and milk products. Nisin suppresses the growth of spoilage organisms, mainly the gas-producing, spore-forming bacteria and toxin-producing *Clostridium botulinum.*

Subtilin, an antibiotic obtained from certain strain of *Bacillus subtilis*. It is most effective against gram-positive bacteria and spore-forming organisms. Canned peas and tomatoes containing 10 and 20 (parts per million) ppm of subtilin respectively were found to be free of microorganisms.

Pimaricin, an antifungal antibiotic, can be used for treating fruits and fruit juices.

Preservation by Irradiation

When gamma rays or electron beams pass through foods there are collisions between the ionizing radiation and food particles at atomic and molecular levels. This results in the production of ion pairs and free radicals. The reactions of these products among themselves and with other molecular result in physical and chemical phenomena which inactivate microorganisms in the food. Thus, irradiation of food can be considered to be a method of "cold sterilization", i.e., food is free of microorganisms without high temperature treatment. Eg. Control of infestation in stored cereals, prevention of sprouting of potatoes, onions, etc.

Vacuum packs

Here, the food is packed in airtight bags and bottles in a vacuum area. An air-tight environment does not provide oxygen needed by germs, especially, bacteria to survive. This method is very commonly used for preserving processed nuts.

Few important facts on food processing in India are presented hereby

India is ranked number one in the world in terms of production of areca nut, banana, castor oil seed, chick peas, chillies and peppers dry, ginger, lemons and limes, mangoes, mangosteens, guavas, millet, okra, papayas, pigeon peas, meat- buffalo, milk-whole fresh buffalo and goat, ghee, butter oil of cow milk, ghee of buffalo milk, sesame seed. India has 127 agro-climactic zones. A total of 66.10 million hectares of net irrigated area, with 42 mega food parks set up with an allocated investment of US Dollars 2.38 billion.

India ranks second in the world in the production of Aniseed, fennel, coriander, beans-dry, cabbages and other brassicas, cauliflower & broccoli, Egg plants (brinjal), garlic, groundnuts with shell, lentil, onions dry, peas green, potatoes, pumpkins, squash and gourds, rice/paddy, safflower seed, sugar cane, tea, tomatoes, wheat, meat-goat, milk whole fresh cow.

Further, India is at third position in the production of cashew nuts, with shell, coconuts, lettuce and chicory, nutmeg, mace and cardamoms, black pepper, rapeseed. 134 cold chain projects are setup to develop supply chain infrastructure in 2016. The number of registered food processing units has increased from 37,175 in 2012-13 to 37,445 in 2013-14.

Food processing industry is one of the major employment intensive segment contributing to 11.69% of employment generated in all registered factory sector in 2013-14.

Conclusion

The importance of preservation of food lies in the fact that, it has capability to provide food to our population through scientific conservations. It eliminates the avoidable losses and making available food more balanced , nutritious and safe. A number of preservation technologies are in vogue. High value products from low grade material can be produced by innovative and appropriate processing and packaging technologies. It is also possible to utilize by-products and residue waste using integrated approach. Thus, modernization of postharvest operations and agro-processing industries through innovative and appropriate technology has a vital role to play in national economy in general and rural economy in particular.

Table 1. Categories in food processing

Category of process	Examples of processes
Heating to destroy enzymes and micro-organisms.	Boiling, blanching, roasting, grilling, pasteurization, baking, smoking
Removing water from the food	Drying, concentrating by boiling, filtering, pressing
Removing heat from the food	Cooling, chilling, freezing
Increasing acidity of foods	Fermentation, adding citric acid or vinegar
Using chemicals to prevent enzyme and microbial activity	Salting, syruping, smoking, adding chemical preservatives such as sodium metabisulphite or sodium benzoate
Excluding air, light, moisture, micro-organisms and pests	Packaging

Table 2: Types of commercial scale in food processing

Type of food proceeding industry	Requirements
Home- (or household-) scale	No employees, little or no capital investment
Micro- (or cottage-) scale	Less than 5 employees, capital investment less than Rs 50,000
Small-scale	5-15 employees, capital investment Rs 50,000-5,00,000
Medium-scale	16-50 employees, capital investment Rs.5,00,000 – 5,00,00,000
Large-scale	More than 50 employees, capital investment over Rs 5,00,00,000

Table 3 Effect of quality on food processing operations

Quality	Operations
Density	separation, size reduction or mixing processes
Thermal properties	process uniformity for pasteurization and sterilization
Rheological characteristics (liquid foods)	Viscosity of the product during heating, cooling, and concentration
Phase and glass transition	freezing, dehydration, evaporation, and distillation