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SCHOOL OF BIO AND CHEMICAL ENGINEERING

DEPARTMENT OF BIOTECHNOLOGY

B.TECH – BIOTECHNOLOGY

UNIT – I - FOOD PROCESSING AND PRESERVATION - SBT1607

HISTORY OF FOOD PROCESSING AND FOOD PRESERVATION

FOOD PROCESSING

Food processing dates back to the prehistoric age when crude processing including various types of cooking, such as over fire, smoking, steaming, fermenting, sun drying and preserving with salt were in practice.

Foods preserved this way were a common part of warriors' and sailors' diets. These crude processing techniques remained essentially the same until the advent of the Industrial Revolution.

Nicolas Appert developed a vacuum bottling process to supply food to troops in the French army, which eventually led to canning in tins by Peter Durand in 1810.

Modern food processing technologies, in the 19th century were also largely developed to serve military needs.

In the early 20th century, the space race, change in food habits and the quality conciousness of the consumers in the developed world furthered the development of food processing with advancements such as spray drying, juice concentrates, freeze drying and the introduction of artificial sweetners, colourants, and preservatives.

In the late 20th century products including dried instant soups, reconstituted fruit juices, and self cooking meals such as ready-to-eat food rations etc., were developed.

Benefits of Processing

- Converts raw food and other farm produce into edible, usable and palatable form.
- Helps to store perishable and semi-perishable agricultural commodities, avoid glut in the market, check post harvest losses and make the produce available during off-season.
- Generates employment.
- Development of ready-to-consume products, hence saves time for cooking.
- Helps in preservation.
- Helps in improving palatability and organoleptic quality of the produce by value addition.
- Helps in easing marketing and distribution tasks.
- Increases seasonal availability of many foods.
- Enables transportation of delicate perishable foods across long distances.

- Makes foods safe for consumption by checking of pathogenic microorganisms.
- Modern food processing also improves the quality of living by way of healthy foods developed for allergics, diabetics, and other people who cannot consume some common food elements.
- Food processing can also bring nutritional and food security.

FOOD PRESERVATION:

During the 20th century the continued application of scientific research to food production has significantly changed the way the world eats.

Food preservation is as old as human civilization. Preservation of foods inhibits spoilage cause by bacterial growth, oxidation, insects or desiccation.

The Chinese reportedly preserved vegetables by fermentation in prehistoric times and Plinius preserved white cabbage in earthenware pots in Italy in the first century.

The earliest recorded instances of food preservation date back to ancient Egypt and the drying of grains and subsequent storage in seal silos.

Fermentation, oil packing, pickling, salting, and smoking are all ancient preservation technologies.

Refrigeration in caves or under cool water were also well known ancient techniques of food preservation.

But the potential of this particular food preservation technique was not fully realized until the 1900's when Clarence Birdseye introduced frozen foods to the American public.

People in many parts of the world developed techniques for drying and smoking foods as far as 6000 BC. Microorganism need water to carry out their metabolic processes.

Ancient Mesoamericans used salt as a preservative for trade in fish and other food stuff over long distances, as well as for storing food for long periods of time.

Since Phoenician times (from around 1250 BC) the standard practice for preserving fish was to gut it, dry it and pack it in layers with salt.

The first dehydrator for drying fruits and vegetables was introduced in France in 1795.

In 1803, a French chef named Nicholas Appert invented a new technique for preserving food. He prepared and preserved soup, beef with gravy, beans and pea. The French navy store it for three months, Then they tried it. The food was delicious and safe to eat.

When Appert published this method in 1810 he had no knowledge of bacteria. It took another 50 years and Louis Pasteur to elucidate the relationship between microorganism and the spoilage of food.

In 1854 Louis Pasteur began his investigation in wine. And pasteurization process of milk was begun in Germany and United States in 1880 and 1890 respectively.

Freezing did not fully develop until the 1950s. Freezing keeps food safe by slowing the movement of molecules, causing microbes to enter a dormant stage.

It extended periods of time because it prevents the growth of microorganisms that cause both food spoilage and foodborne illness; so frozen food is theoretically safe forever.

The term of irradiation appeared only around 1950s, but the technology can be traced back to the late 19th century.

Although food preservation has now reached a high standard at least in the developed countries, the quantities of food still spoiled are astonishing.

WHAT IS FOOD BORN DISEASE?

Foodborne illness is caused by consuming contaminated **foods** or beverages. Many different **disease**-causing microbes or pathogens can contaminate **foods**. Most **foodborne diseases** are infections caused by a variety of bacteria, viruses, and parasites. Other diseases are poisonings caused by harmful toxins or chemicals that have contaminated food.

Of note many foodborne pathogens also can be acquired through recreational or drinking water, from contact with animals or their environment, or through person-to-person spread.

Symptoms of Foodborne Illness

- Common symptoms of foodborne illness are diarrhea and/or vomiting, typically lasting 1 to 7 days. Other symptoms might include abdominal cramps, nausea, fever, joint/back aches, and fatigue. What some people call the "stomach flu" may actually be a foodborne illness caused by a pathogen (i.e., virus, bacteria, or parasite) in contaminated food or drink. The incubation period (the time between exposure to the pathogen and onset of symptoms) can range from several hours to 1 week.

Causes of Foodborne Illness

Campylobacteriosis (*Campylobacter*)	Listeriosis (*Listeria monocytogenes*)	Salmonellosis (*Salmonella*)	Vibrio Infection (*Vibrio parahaemolyticus*)
Toxoplasmosis (*Toxoplasma gondii*)	Yersiniosis (*Yersinia* species)	Scombroid Fish Poisoning	Shigellosis (*Shigella*)
Norovirus Infection	Giardiasis (*Giardia*)	*Escherichia* coli O157:H7 Infection	Cyclosporiasis (*Cyclospora* spp.)

Types of Foodborne Illnesses

There are dozens of different bacteria, viruses, parasites and other pathogens which can contaminate raw or improperly prepared food thereby leading to human infection and the transmission of various foodborne diseases.

The CDC estimates that about 90% of all foodborne illness in this country is caused by the following seven pathogens**: Norovirus, Salmonella, Clostridium perfrigens, Campylobacter, Listeria, E. coli 0157:H7 and Toxoplasma.**

The following are the most significant foodborne illnesses based upon frequency of occurrence and/or severity of potential adverse health consequences:

- **Salmonellosis** - a potentially life threatening infectious disease caused by various species of Salmonella bacteria. This infection can cause a debilitating condition referred to as Reactive Arthritis ("Reiter's Syndrome").
- **Hemorrhagic Colitis** - infectious disease primarily caused by the bacterium *Escherichia coli* O157:H7. E. coli infection can lead to a serious complication known as Hemolytic Uremic Syndrome (HUS).
- **Listeriosis** - infectious disease caused by the bacterium *Listeria monocytogenes*. This infection is particularly dangerous for pregnant women because it can cause stillbirth, premature labor and/or infection of the baby.
- **Campylobacteriosis** - infectious disease caused by the bacterium *Campylobacter jejuni*. This infection can lead to a serious disorder affecting the peripheral nervous system known as Guillain – Barre Syndrome.
- **Shigellosis** (bacillary dysentery) - infectious disease caused by various species of Shigella bacteria. This infection can also cause HUS or Reactive Arthritis.
- **Perfringens Poisoning** - enteric disease caused by the bacterium *Colostridium perfrigens*.
- **Foodborne Botulism** - life threatening disease caused by consumption of foods containing neurotoxins produced by the bacterium *Colostridium botulinum*.
- **Norovirus Gastroenteritis** - highly contagious disease caused by the Norwalk virus family. This viral infection can sometimes result in a chronic functional gastrointestinal disorder known as Post Infectious Irritable Bowel Syndrome.

- **Acute Viral Hepatitis A** - infectious disease of the liver caused by the Hepatitis A virus (HAV).
- **Toxoplasmosis** - infectious disease caused by a microscopic parasite called *Toxoplasma gondii*. In pregnant women, this infection can be transmitted and harmful to the fetus.

The Potential Complications of Foodborne Illnesses

- Infants and young children
- Pregnant women (and their unborn fetus)
- Elderly adults over the age of 65
- Persons with a weakened or compromised immune system
- Cancer patients especially those undergoing chemotherapy or radiation treatments
- Persons who are HIV positive or suffering AIDS
- Persons with a certain chronic conditions such as diabetes, liver disease or kidney failure
- Persons who have sickle cell anemia or other disorders affecting red blood cells
- Transplant recipients especially while taking medications to reduce the risk of rejection
- Persons taking antibiotics, antihistamines or steroid medications.

The most common foodborne infections

1)Campylobacter -- Campylobacter is the most common bacterial cause of diarrheal illness in the world. The bacteria live in the **intestines** of healthy birds, and most raw poultry meat has Campylobacter on it. Eating undercooked chicken, or other food that has been contaminated with juices dripping from raw chicken is the most frequent source of this infection. Aside from **diarrhea**, common symptoms include causes **fever**, **diarrhea**, and abdominal cramps.

2)Salmonella -- Salmonella is widespread in the intestines of birds, reptiles and mammals. People can acquire the bacteria via a variety of different foods of animal origin. The illness it causes is called salmonellosis and typically includes **fever**, diarrhea and abdominal cramps. In persons with poor underlying health or weakened immune systems, Salmonella can invade the bloodstream and cause life-threatening infections.

3)E. coli O157:H7 -- E. coli O157:H7 has a reservoir in cattle and other similar animals. Illness typically follows consumption of food or water that has been contaminated with microscopic amounts of cow feces. The illness it causes is often a severe and **bloody diarrhea** and painful abdominal cramps, without much fever. But in 3 to 5% of cases, a life-threatening complication called the **hemolytic uremic syndrome** (**HUS**) can occur several weeks after the initial symptoms, resulting in **anemia**, profuse bleeding, and **kidney failure**.

4)Calcivirus (Norwalk-like virus) -- Calicivirus (Norwalk-like virus) is an extremely common cause of foodborne illness (though it is rarely diagnosed, because the laboratory test is not widely available). It causes an acute gastrointestinal illness, usually with more **vomiting** than diarrhea, that resolves within two days.

Common diseases that are usually transmitted by other routes are occasionally foodborne. These include infections caused by **Shigella**, **hepatitis A**, and the parasites **Giardia lamblia** and Cryptosporidia.

Steps to Prevent Foodborne Illness:

Cleanliness is a major factor in preventing foodborne illness.

- Clean: Wash hands and surfaces often.
- Separate: Don't cross-contaminate.
- Cook: Cook to proper temperatures.
- Chill: Refrigerate promptly.
- Use safe water and raw materials.

FOOD-BORNE INFECTIONS & INTOXICATIONS

FOOD-BORNE INFECTION

- **DEFINITION:**

A foodborne infection is an inflammation of the stomach and bowels. The infection can happen when you eat or drink something that is contaminated by a bacteria, virus or parasite.

Often the inflammation leads to diarrhoea, nausea, vomiting, abdominal pain, abdominal cramps and sometimes fever.

- **FOODS ASSOCIATED**:
  - Raw foods of animal origin, that is, raw meat and poultry, raw eggs, unpasteurized milk, and raw shellfish are the most likely to be contaminated
  - Fruits and vegetables can also be contaminated with animal waste when manure is used to fertilize produce in the field, or unclean water is used for washing the produce.
  - Raw sprouts are particularly concerning because the conditions under which they are sprouted are ideal for growing microbes.
  - Unpasteurized fruit juices or cider can also be contaminated if there are pathogens on the fruit that is used to make it.
  - Any food item that is touched by a person who is ill with vomiting or diarrhoea, or who has recently had such an illness, can become contaminated. When these food items are not subsequently cooked (e.g., salads, cut fruit) they can pass the illness to other people.

- **SYMPTOMS:**
  - Common symptoms of foodborne illness are diarrhoea and/or vomiting, typically lasting 1 to 7 days. Other symptoms might include abdominal cramps, nausea, fever, joint/back aches, and fatigue

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  - What some people call the "stomach flu" may actually be a foodborne illness caused by a pathogen (i.e., virus, bacteria, or parasite) in contaminated food or drink

    .

- The incubation period (the time between exposure to the pathogen and onset of symptoms) can range from several hours to 1 week.

- **CAUSATIVE AGENTS & COMPLICATIONS:**

MICROORGANISMS:

- **Escherichia coli 0157:H7**

Found: Intestinal tracts of some mammals, raw milk, unchlorinated water; one of several strains of E. coli that can cause human illness.

Transmission: Contaminated water, raw milk, raw or rare ground beef, unpasteurized apple juice or cider, uncooked fruits and vegetables, person-to-person.

Symptoms: Diarrhoea or bloody diarrhoea, abdominal cramps, nausea, and malaise; can begin two to five days after food is eaten, lasting about eight days. Some, especially the very young, have developed Hemolytic Uremic Syndrome (HUS) that causes acute kidney failure. A similar illness, thrombotic thrombocytopenic purpura (TTP), may occur in older adults.

- **Hepatitis A virus**

Found: Hepatitis A is widely distributed throughout the world, occurring in both epidemic and sporadic cases.

Transmission: Hepatitis A virus is excreted in feces of infected people and can produce clinical disease when a susceptible individual consumes contaminated water or foods. Cold cuts and sandwiches, fruits, fruit juices, milk and milk products, vegetables, salads, shellfish, and iced drinks all can be considered vehicles for the transmission of Hepatitis A.

Symptoms: Hepatitis A is usually a mild illness characterized by sudden onset of fever, malaise, nausea, anorexia, and abdominal discomfort, followed by several days of jaundice

- **Listeria monocytogenes**

Found: Intestinal tracts of humans and animals, milk, soil, leaf vegetables, and processed foods; can grow slowly at refrigerator temperatures.

Transmission: Soft cheese, raw milk, improperly processed ice cream, raw leafy vegetables, meat, and poultry. Illness caused by bacteria that do not produce toxin.

Symptoms: Fever, chills, headache, backache, sometimes abdominal pain and diarrhea; 12 hours to three weeks; may later develop more serious illness in at-risk patients (meningitis or spontaneous abortion in pregnant women); sometimes just fatigue.

OTHER POSSIBILITIES:

- Chemicals: cleaning products and pesticides
- Metals: tin and copper
- Natural Poisons: Red kidney beans (phytohaemagglutinin), brinjal (Salicylates), groundnuts, berries
- Physical Contamination: Plastics and screws

➢ **PREVENTIVE MEASURES:**

- Proper hygiene will prevent contamination and further spreading.
- For instance, wash your hands before preparing dinner, and after each visit to the toilet.
- Also pay particular attention to separating your prepared and unprepared food.
- Put food in the refrigerator within two hours, chop your meat and vegetables on separate cutting boards and wash tea towels at 60 degrees.

FOOD-BORNE INTOXICATION

➢ **DEFINITION:**

Consumption of toxic chemicals liberated or produced by bacterial growth in food. These respective toxins result in variety of illness of the consumers. These toxins are not visible to naked eye but will change the chemical properties of the food.

➢ **FOODS ASSOCIATED:**

- Growth of staphylococcus and their toxin produced on required food sources. Example: milk and milk products (yoghurt, chocolate milk, fermented milk, cream filled pastries), poultry, fish, shellfish, non-meat salads, egg and egg products and cereal products have been involved.
- Canned food-string beans, corn, beets, peas, figs etc.
- Preserved meat and fish.
- Baked potatoes and garlic/oil mixtures.
- Vehicle foods: the food involved are those that are prepared one day and served the next day. Normally food poisoning occurs when the level reaches **107-108 cells/g of food**. Growth is enhanced by anaerobic conditions achieved after removal of oxygen by cooking.

➢ **SYMPTOMS:**

Vomiting, constipation, difficulty with vision, swallowing, speaking, paralysis and death.

➢ **CAUSATIVES & COMPLICATIONS:**

MICROORGANISMS:

- **Clostridium botulinum**

Found: Widely distributed in nature; soil and water on plants and intestinal tracts of animals and fish. Grows only in little or no oxygen.

Transmission: Bacteria produce a toxin that causes illness. Improperly canned foods, garlic in oil, vacuum-packed and tightly wrapped food.

Symptoms: Toxins affect the nervous system. Symptoms usually appear in 18 to 36 hours, but can sometimes appear as few as four hours or as many as eight days after eating. Double vision, droopy eyelids, trouble speaking and swallowing, and difficulty breathing may occur. Can be fatal in three to 10 days if not treated.

- **Bacillus Cereus**

Found: Widely distributed in nature; can be isolated from meats, milk, vegetables, and fish.

Transmission: Bacteria produce a toxin that causes illness. Vomiting-type outbreaks have usually been associated with rice products and other starchy foods such as potatoes, pasta, and cheese products. Sauces, puddings, soups, casseroles, pastries, and salads have also been implicated in outbreaks.

Symptoms: Food poisoning is characterized by nausea and vomiting 0.5 to six hours after the ingestion of a contaminated food product. In more severe cases, abdominal cramps and diarrhoea might occur with symptoms lasting up to 24 hours.

- **Staphylococcus aureus**

Found: On the skin, infected cuts, pimples, noses, and throats.

Transmission: From people to food through improper food handling. Multiply rapidly at room temperature to produce a toxin that causes illness.

Symptoms: Severe nausea, abdominal cramps, vomiting, and diarrhoea can occur one to six hours after eating; recovery within two to three days—longer if severe dehydration occurs.

OTHER POSSIBLITIES:

- Chemicals that can cause an intoxication include cleaning products, sanitizers, pesticides and metals (lead, copper, brass, zinc, antimony and cadmium).

- Seafood toxins include ciguatera toxin, scombroid toxin, shellfish toxins and systemic fish toxins.

- Plants and mushrooms can also cause an intoxication**.**

- **PREVENTIVE MEASURES**

- Proper cooking of food and eating freshly prepared food.

- Storage of leftovers or unused in freezers
- Pasteurization
- Sterilization
- Smoking
- Use of common salt and organic acids
- Plant substances
- Fast cooling of cooling of cooked foods. Storing food in small quantities will enhance cooling.

FOOD PROCESSING:

Food processing operations includes many methods that are used to add value to the raw food materials (including marine products, poultry and meat) which can be consumed by human beings or animals. Raw food materials are transformed into edible products processing and value addition.

IMPORTANCE OF FOOD PROCESSING:

1. All the raw food materials are processed to improve their palatability, nutritional value and shelf-life.
2. **Makes food edible:**
   Grain crops, for example wheat and corn, are not edible in their natural state. Processing techniques, such as milling and grinding, turn them into flour, after which they can be made into breads, cereals, pasta and other edible grain-based products.
3. **Safety, shelf life, and preservation:**
   Processing improves or even ensures food safety by removing harmful microorganisms. The main methods are pasteurisation, air-tight packaging, and the use of preservatives.
4. **Convenience:**
   Processing and packaging technologies help to answer modern day time-constraints by providing a range of convenient foods: ready meals, bagged salads, sliced

and canned fruits and vegetables that take little time to prepare and can be consumed “on the go”.

5. **Price:**

   Food processing can decrease the cost of foods. For example, frozen vegetables have a similar nutritional value as fresh ones, but at a lower price, as they have already been prepared, do not contain inedible parts, can be bought in bulk, and can last longer. This way, processing increases the shelf life of food, and decreases the amount of waste, reducing thereby the overall costs of food production.

6. The varies of food can be enjoyed in any different area and any seasons.

7. The supplement of food can be increased.

8. People can taste food from any location.

9. Can store the processed food more easily.

10. It is a major source of food in the diet.

11. Provides opportunities for import substitution.

SCOPE OF FOOD PROCESSING:

- India is the world's second largest producer of food next to China, and has the potential of being the biggest with the food and agricultural sector. The total food production in India is likely to double in the next ten years and there is an opportunity for large investments in food and food processing technologies, skills and equipment, especially in areas of Canning, Dairy and Food Processing, Packaging, Frozen Food/Refrigeration and Thermo-Processing. Fruits & Vegetables Processing, Fisheries, Milk & Milk Products, Meat & Poultry, Packaged/Convenience Foods, Alcoholic Beverages & Soft Drinks and Grain processing are important sub-sectors of the food processing industry. The consumer product groups like confectionery, chocolates and cocoa products, Soya-based products, mineral water, high protein foods, soft beverages, alcoholic and non-alcoholic fruit beverages, etc. along with the health food and health food supplements is another rapidly rising segment of this industry which is gaining vast popularity.

- India produces nearly 16% of the world's total food grain production. It is one of the largest producers of agricultural produce. With a population expected to reach to about 590 million people by 2030 in urban India, India has a huge potential domestic demand for processed foods other than the demand from the exports. There are many socio-economic factors that are driving the demand side of the Indian Food Processing Industry. The changing consumption patterns, both in tier 1 and tier 2 cities, rising income levels among the middle-class and changing lifestyles, are some of the factors providing the demand side push for the Food Processing Industry. Moreover, the central government has given a priority status to all agro-processing businesses.
- Food and crop processing - largest industry in most countries.
- Benefits a large number of poor people, such as farmers, packaging suppliers and vendors.

CAREER SCOPE:

- Food processing industries lead to the highest employment in all industry. So, giving employment indirectly to the almost lakhs of people. Food processing industry in India provides numbers of direct and indirect employment opportunities because it somehow connects the Agriculture to the Manufacturing. In the upcoming years, there will be good demand for healthy, modern food products. India is the second largest producer of food next to China.
- It is expected that in upcoming of few years the total food production in India is maybe double and there is an opportunity for the graduates of food processing technicians. The most common areas of employment are Canning, Dairy and Food Processing, Packaging, Frozen Food / Refrigeration and Thermo-Processing.

Traditional methods of preservation

Food preservation was traditionally done to make food available throughout the year by increasing their shelf life. Food spoilage is caused mainly due to microbial contamination and growth or due to the intrinsic enzymes themselves that cause its degradation. Preservation involves employing techniques in order to inhibit the growth of microbes and the activity of these intrinsic enzymes thereby making it last longer.

Some of the most common traditional preservation techniques include:

1. Salting
2. Sun drying
3. Pickling

1) Salting

Salting is a simple method of preservation that can be used for various types of food. Food spoilage is caused due to growth of various microbes like bacteria, mould, or yeast. Salting draws out the moisture from the food by a process called osmosis. When cells are exposed to about 20% salinity, they lose water. Water as we know is essential for life, and microbes need a certain amount of water activity and pH in order to be able to survive. Salting reduces the water activity of food and also alters its pH thereby inhibiting or killing microbes present in the food. Water is also essential for enzyme activity and altered pH and low water activity makes the intrinsic enzymes in the food inactive.Salting is either done by applying dry salt to the food for curing, or by storing the food in a brine solution.

- Brine Solution

Brine solution of about 20% salinity is used to preserve food. The salinity of the solution draws the water out of the food due to osmosis and makes the food inhospitable for microbes. It also draws out moisture from the microbial cells themselves thereby killing them.

- Dry salting/ Curing

Dry salting or curing is a technique commonly used to preserve meat that involves using granulated salt. The granulated salt is rubbed over the surface of the food that results in its dehydration by osmosis. Curing salt or Prague powder is more commonly used nowadays for meat curing, it contains added nitrates or nitrites that are more effective at microbial inhibition compared to common salt.Though salting is a very effective method of preservation, too much salt consumption can be unhealthy.

Sun drying

Sun drying is one of the easiest methods of drying. It involves dehydration of food under sunny conditions to increase its shelf life. This method removes water from the food source by means of evaporation thereby reducing the water activity of food.

A minimum temperature of about 35 C is required for this method. The moisture content can be brought down to 15%, fruits need to have a maximum of 10-20%, While other products need to have a maximum of 6-8 %.

This method uses very simple equipment and almost zero energy is required. The food can be rehydrated when required by soaking in water.

Though this method is simple there's sometimes contamination by bacterial or fungal spores as it isn't always carried out in a sterile environment.

Pickling

Pickling is a preservation method that involves anaerobic fermentation of food in brine or immersion in an acid solution like vinegar. The ingredients used for pickling usually alter the pH of the food, inhibiting the growth of undesirable microbes.

Pickles are generally of the following types:

· Fresh-pack Pickles:

These types of pickles used an acidic solution and little to no salt. The use of vinegar is most common as it quickly acidifies the food.

- Ø Mature fruits or vegetables are selected
- Ø They're washes and patted dry
- Ø Then they're cut into pieces are unwanted parts like cores and seeds are removed
- Ø The pieces are then blanched in water
- Ø Dried in shade for 2-3 hours
- Ø The pieces are then placed into a jar (sterile)
- Ø The jar is then filled in with vinegar solution and store at room temperature.

- **Brined Pickles:**

Use of salt solution to make fermented pickles. A salt solution of about 20% concentration is used. This method is used to induce fermentation and production of lactic acid for preservation. This method is also used for promoting the growth of desirable microbes i.e. probiotics in sauerkraut etc.

- Ø The fruits or vegetables are washed and patted dry
- Ø They are then cut and peeled if necessary
- Ø The pieces are filled into a sterilized jar/can
- Ø Then the brine solution is filled in until all the pieces are completely immersed.
- Ø The pickles are then stored at room temperature.

Relishes and Fruit pickles:

These mostly involve use of sugar and even vinegar to draw out the moisture from the vegetables or fruits and also alter their pH. The sugar similar to salt causes the cells to lose water through osmosis thereby reducing the water activity.

Factors that should be kept in mind to ensure a good shelf life of pickles:

1. Selection of good quality food (meat/vegetables/fruits)
2. Using sterile methods and sterilizing pickle jars/containers
3. Proper measurement of ingredients (salt/sugar/vinegar etc.)

Pickling in addition to preservation and enhancing flavour, is also a good way to include probiotics in your diet (fermented pickles) but due to their high sodium content they are not healthy if regularly consumed.

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UNIT – II - FOOD PROCESSING AND PRESERVATION - SBT1607

Types of microorganisms in food like meat, poultry, sea foods, dairy products, fruits and vegetables

Spoiled Food

1. Damage or injuries that make food undesirable for human consumption.
2. Can be the result of:
    a. insect damage
    b. physical injury
    c. enzymatic degradation
    d. microbial activity

Basic Types of Food Spoilage

1. Appearance: when a food "looks bad," what is this referring to?
    a. Microbial growth
        mycelia or colonies visible on surface

        development of cloudiness in liquids

    b. Changes in food color due to heme or chlorophyll breakdown
        colony pigments, growth of mycelia, etc.

2. Textural changes (feel)
    a. Slime formation
        due primarily to surface accumulation of microbial cells

        also be a manifestation of tissue degradation

    b. Tissue softening due to enzymatic degradation (e.g. soft rot in veggies)

3. Changes in taste and odor
    a. Development of:
        1. nitrogenous compounds (ammonia, amines, etc.)
        2. sulfides
        3. organic acids

The **numbers** and **types** of MO in a food are largely determined by:

1. Environment from which the food was obtained.
2. Microbiological quality of the food in its raw or unprocessed state (intrinsic factors).
3. Handling and processing sanitation.
4. Effectiveness of packaging, handling and storage conditions in restricting microbial growth (extrinsic factors).

Specific Food Groups

A. **Fresh Meats:**
Chemical composition:

-75% water

-18% protein

-3% fat, 1% ash, traces of CHO, vitamins, etc.

1. **Whole Meats:**

The microflora of fresh meat is composed primarily of:

1. Gram negative aerobic rods such as *Pseudomonas, Acinetobacter* and *Moraxella.*

2. *Bacillus* and clostridia (e.g. *C. perfringens*) are also common on all types of meat.

Although subsurface portions of meat are generally sterile, some parts such as lymph nodes may be heavily contaminated.

Mechanical disruption of the tissue during processing can distribute microorganisms from the meat surface throughout the product.

Fresh meats are among the most perishable foods.

Storage temperature is the single most important control factor for meat spoilage.

Handout - Sources of Contamination

Several genera of **molds** grow on the surface of meat and can cause spoilage, but cannot grow on meat stored below $5^{o}C$.

Usually, fresh cut meats in the refrigerator at high humidity undergo bacterial spoilage by:

Gram negative aerobes like *Pseudomonas, Acinetobacter* and *Moraxella* spp.

The intrinsic and extrinsic parameters of ground beef favor these bacteria so strongly that they are almost exclusive spoilage agents.

Meat spoilage is characterized by the appearance of off odors and slime, which are manifest when surface loads exceed **10^7 CFU/cm^2**.

The slime is due to the accumulation of bacterial cells.

Interestingly, meat spoilage (including poultry and fish) occurs without any significant breakdown of the primary protein structure.

Instead, spoilage bacteria utilize glucose, free amino acids or other simple nitrogenous compounds to attain population of about **10^8 CFU/cm^2**, at which point the organoleptic quality of the meat will clearly reveal it is spoiled.

2. **Ground Meats:**

   Same MO as whole meats, but always have higher microbial loads. **Why?**

   - greater surface area which gives microbes better access to the food and also traps air to favor the growth of gram-negative, aerobic bacteria like *Pseudomonas* spp.

- every handling or processing (storage utensils, cutting knives, grinders) step can contribute additional contamination to the final product.

- one heavily contaminated piece (e.g. a lymph node) can contaminate an entire lot when they are ground together.

Use of: (a) soy protein extenders (b) mechanically deboned meat (MDM)

-does not change the microflora significantly but does raise the pH of meat which leads to more rapid spoilage

-ground beef pH=5.1-6.2, add extenders raise it to 6.0-7.0)

3. Vacuum packaged meats

- 80% of beef leaves packing plant in vacuum package.
- not all O_2 is removed during packaging but residual is consumed by respiration of aerobic MO and the tissue itself
- results in increased CO_2 levels and thus get a longer shelf life.

Impermeable films used:

1. CO_2 levels are higher
2. Eh lower

The microflora shifts from predominantly G- aerobes to G+ anaerobes and microaerophilic lactic acid bacteria (LAB) like *Lactobacillus*, *Carnobacterium* and *Leuconostoc.*

- if nitrites have been added to the vacuum packaged meat (e.g. to inhibit *C. botulinum* in hams, bacon), LAB domination is even more pronounced

In general, vacuum packaged meats are considered very safe foods and free from most pathogenic species of bacteria.

-with the possible exception of *S. aureus* and *Y. enterocolitica*

Spoilage in vacuum packaged meats is manifest by:

1. Slime development
2. **Greening** caused by microbial production H_2O_2 or H_2S.

   H_2O_2 production in meat has been associated with several types of lactic acid bacteria (primarily *Lactobacillus*)

Handout - Meat Pigments

The oxidant (H_2O_2) reacts with nitrosohemochrome (cured meat color cmpd) to form a green porphyrin compound.

H_2S greening occurs in fresh meats that have been vacuum packaged and stored between 1-5^{o}C.

H_2S reacts with myoglobin to form sulphmyoglobin in meats with a pH above 6.0.

H_2S is produced by:

1. *Shewanella putrefaciens* and *Pseudomonas* spp. (when O_2- permeable films are used).
2. Some lactobacilli (when O_2- impermeable films are used).

Off odors which result from:

1. the release of short chain fatty acids
2. the production of volatile compounds like acetoin, diacetyl and H_2S (and many other compounds, depending on the dominant spoilage bacterium)

The type of spoilage bacteria that will dominate is influenced by several factors that include:

1. Is the meat product raw or cooked?

   Cooked products have a higher pH (>6.0) which may allow growth of G- facultative anaerobic pathogens like *Yersinia enterocolitica*.

   Raw products have a pH of about 5.6 which favors lactic acid bacteria, esp. *Lactobacillus, Carnobacterium,* and *Leuconostoc.*

2. Nitrite concentration in meat.

   High nitrite conc. favors lactic acid bacteria.

   Low nitrite levels may allow growth of *Brochothrix thermosphacta* (G+ rod, fac anaer, growth @ 0-30^{o}C from pH 5.0-9.0 catalase+).

   B. thermosphacta is an important spoilage bacterium in anaerobically stored meats kept at low temperature, but the bacterium is inhibited by nitrite.

4. Processed meats (hot dogs, sausage and luncheon meats)

These products are composed of a variety of blended ingredients, any of which can contribute microorganisms to the food.

Yeasts and bacteria are the most common causes of spoilage, which is usually manifest in **3 ways**:

A. **Slimy spoilage**

   Like other meat products, this occurs on the surface and is caused by the buildup of cells of yeasts, lactobacilli, enterococci or *Brochothrix thermosphacta.*

   Washing the slime off with hot water can restore the product quality.

B. **Sour spoilage.**

Results from growth of lactic acid bacteria (which originate from contaminated ingredients like milk solids) under the casing.

These organisms ferment lactose and other CHOs in the product and produce organic acids.

Taste is adversely affected but the product is not harmful if eaten.

C. **Greening** due to H_2O_2 or H_2S production.

Because greening indicates more extensive product breakdown, I would not recommend eating green wieners.

<u>Reasons Cured meats (bacon, hams) are resistant to spoilage:</u>

1. Use of nitrite/nitrate
2. Smoking or brining of hams
3. The high fat content (thus low a_w) of bacon

Instead, spoilage of these products is often caused by molds from several genera including *Aspergillus, Fusarium, Mucor, Penicillium, Rhizopus* and *Botrytis.*

5. Poultry:

a. general trends are the same as other fresh meats
b. similar microflora on fresh birds
c. whole birds have lower counts than cut-up parts
d. additional processing steps add to the microbial load

When poultry is in the advanced stages of spoilage, the skin will often fluoresce under UV because so many <u>fluorescent pseudomonads</u> are present.

<u>Off odors</u> generally appear before sliminess develops.

The same bacteria can produce visceral taint, a condition manifest by off odors in the abdominal cavity or poultry.

Point to remember:

During the initial stages of spoilage, the skin supports bacterial growth better than does the tissue (which remains essentially free of bacteria for some time). Thus, the skin can sometimes be removed to salvage the food.

6. Fish:

a. Fish have high nitrogen content but no carbohydrate.

b. The microbial quality of fish and especially shellfish is heavily influenced by the **quality of the water** from which they were harvested.

Unsanitized processing steps are principal culprits in fish products with high microbial loads.

In general, frozen fish products have lower counts than fresh products.

Bacteria on fresh fish are concentrated on the outer slime, gills and intestine.

Spoilage of salt- and freshwater fish occurs in similar ways; the most susceptible part of the fish to spoilage is the gill region, and the best way to detect spoilage in fresh fish is to sniff this area for off odors produced by *Pseudomonas and Acinetobacter-Moraxella* bacteria.

The odors include ammonia, triethylamine, H_2S and other compounds.

If fish are not eviscerated quickly, bacteria will move through the intestinal walls and invade the meat that lies next to the abdominal cavity.

Spoilage of **crustaceans** (shrimp, lobsters, crabs and crayfish) is similar, but these products have some CHO (0.5%) and more free amino acids so spoilage can occur more rapidly.

M**ollusks** (oysters, clams, mussels, squid and scallops) have more CHO (3-5%) and less nitrogen than either fish or shellfish.

Microflora of mollusks can vary a great deal depending on the quality of the water from which they were harvested.

Shellfish are filter feeders and can be expected to contain almost any microorganism or virus that occurs in the water where they were obtained.

If these products were taken from clean waters, then the usual *Pseudomonas* and *Acinetobacter-Moraxella* types of spoilage bacteria dominate.

B. Vegetables

Typical composition:

-88% water

-8.6 % CHO. Includes readily available mono- and disaccharides like glucose and maltose, as well as more complex oligosaccharides, which are available to fewer types of microorganisms.

-1.9% protein

-0.3 % fat

-0.84 % minerals

-also contain fat and water soluble vitamins and nucleic acids (<1%).

-pH of most veggies is around 6.0; within the growth range of many bacteria

Vegetables are a good substrate for yeasts, molds or bacteria

It is estimated that 20% of all harvested fruits and vegetables for humans are lost to spoilage by these microorganisms.

Because bacteria grow more rapidly, they usually out-compete fungi for readily available substrates in vegetables. As a result, bacteria are of greater consequence in the spoilage of vegetables with intrinsic properties that support bacterial growth (favorable pH, Eh).

Microflora of vegetables is primarily composed of:

1. G+ bacteria like lactic acid bacteria (e.g. leuconostocs, lactobacilli, streptococci.
2. Coryneforms and staphylococci (the latter coming from the hands of employees during processing.
3. Staphylococci are usually unable to proliferate but cross-contamination can introduce them into other foods where growth conditions are more favorable.

Soft rot

a. One of the most common types of bacterial spoilage.

b. caused by *Erwinia carotovora* and sometimes by *Pseudomonas* spp., which grow at 4^oC

Softening can also be caused by endogenous enzymes.

FlavrSavr story:

a. polygalacturonase (PB); hydrolyzes a (1-4) glycosidic bond in pectin which leads to softening.

b. Calgene made antisense RNA to tomato pg, constructs soften slower and so can be harvested after they are ripe (better flavor).

c. First commercially avail. genetically engineered vegetable.

Handout - Table 8.5 pp 155 – (note the number of pseudomonads)

Mold spoilage

a. In vegetables where bacterial growth is not favored (e.g. low pH), molds are the principal spoilage agents.

b. Most molds must invade plant tissue through a surface wound such as a bruise or crack.

c. Spores are frequently deposited at these sites by insects like *Drosophila melanogaster,* the common fruit fly.

d. Other molds like *Botrytis cinerea*, which causes grey mole rot on a variety of vegetables, are able to penetrate fruit or vegetable skin on their own.

The microflora of vegetables will reflect:

a. the sanitation of processing steps

b. the condition of the original raw product

Soil-borne MO such as clostridia are common on raw vegetables, and some species, like *C. botulinum,* are of such great concern that they are the focus of processing steps designed to destroy MO.

<u>Sources of Contamination</u>

1. Surface contamination – Soil, water, air, human pathogens from manure (night soil)
2. Harvesting - hand picking vs. machines

   high damage if crop is ripe...harvest before ripe

   Geotrichium candidum – mold on harvestors

3. Packaging: containers reused-sanitized
4. Processing plant
5. Markets – handling, cross-contamination

C. Fruits

<u>Average composition</u>

-85% water

-13% CHO

-0.9% protein (a bit low on nitrogen sources)

-0.5% fat

-0.5% ash

-trace amounts of vitamins, nucleotides, etc.

-less water and more CHO than veggies

-low pH (1.8-5.6)

Handout - Fig. 7.1 Type pH of vegetables and fruits

Like vegetables, fruits are nutrient rich substrates but the pH of fruits does not favor bacterial growth. As a result, **yeasts and molds are more important than bacteria** in the spoilage of fruits.

a. Several genera of yeasts can be found on fruit.

b. Because these organisms grow faster than molds, yeast often initiate fruit spoilage.

c. then molds finish the job by degrading complex polysaccharides in cell walls and rinds.

Specific Spoilage Organisms:

1. Blue rot – *Penicillium,* fruits
2. Downy mildews – *Phytophora,* large masses of mycellium (grapes)
3. Black rot – *Aspergillus,* onions
4. Sour rot – *Geotrichum candidum*

D. Other Foods

1. <u>Dairy Products</u> - Milk is a very rich medium

Raw milk flora may include:

a. All MO found on the cow hide (which incl. soil and fecal bacteria), udder, and milking utensils

b. Can include G-, G+, yeasts and molds.

When properly handled and stored, the flora of pasteurized milk is primarily G+ bacteria.

Psychrotropic pseudomonads are common in bulk stored raw milk

-produce heat stable enzymes that can reduce milk quality and shelf life

Pasteurization kills most G^- (incl. Pseudo.), yeasts and molds

-some G^- enzymes, thermotolerant G^+ bacteria and spores survive

-Psychrotropic *Bacillus* spp. are also common in raw milk

Pasteurized fluid milk – spoiled by a variety of bacteria, yeasts and molds.

a. In the past, milk was usually soured by LAB such as enterococci, lactococci, or lactobacilli, which dropped the pH to 4.5 where milk proteins coagulate (curdling).

b. Today, milk is more frequently spoiled by aerobic sporeformers such as *Bacillus*, whose proteolytic enzymes cause curdling.

c. Molds may grow on the surface of spoiled milk, but the product is usually discarded before this occurs.

Table 20.1 pp 281 – Defects of fluid milk

Butter; high lipid content and low a_w make it more susceptible to surface mold growth than to bacterial spoilage.

Some pseudomonads can be a problem; “surface taint” -putrid smell, caused by the production of organic acids (esp. isovaleric) from *P. putrefaciens*

Rancidity due to butterfat lypolysis caused by *P. fragi* are common.

Cottage cheese can be spoiled by yeasts, molds and bacteria.

The most common bacterial spoilage is "**slimy curd**" caused by *Alcaligenes* spp. (G^- aerobic rod bound in soil, water, and intestinal tract of vertebrates).

Like *Campylobacter*, these species do not oxidize CHOs but instead use amino acids and TCA intermediates.

Penicillum, Mucor and other fungi also grow well on cottage cheese and impart stale or yeasty flavors.

Ripened Cheeses – (1) low a_w, (2) low pH and (3) high salt inhibit most spoilage microorganisms except surface mold growth.

Spores of *C. butyricum, C. sporogenes* and others can germinate in cheeses (e.g. Swiss) with intrinsic properties that are less inhibitory (e.g. lower salt, higher pH).

-These organisms may metabolize citrate, lactose, pyruvate or lactic acid and produce butyrate or acetate plus CO_2 or H_2 gas which "blows" the cheese.

Defects Table 20.2 pp 282

Eggs

Eggs have several intrinsic parameters which help to protect the nutrient-rich yolk from microbial attack. These include the shell and associated membranes, as well as lysozyme, conalbumin, and a high pH (>9.0) in the white. Freshly laid eggs are generally sterile, but soon become contaminated with numerous genera of bacteria.

Eventually, these MO will penetrate the eggshell and spoilage will occur.

Pseudomonads are common spoilage agents, but molds like *Penicillium* and *Cladosporium* sometimes grow in the air sac and spoil the egg.

Cereal and Bakery Goods

These products are characterized by a low a_w which, when stored properly under low humidity, restricts all MO except molds. *Rhizopus stolonifer* is the common bread mold, and other species from this genus spoil cereals and other baked goods.

-Refrigerated frozen dough products have more water and can be spoiled by lactic acid bacteria.

Fermented Foods and Beverages

The low pH or ethanol content of these products does not allow growth of pathogens, but spoilage can occur.

Beer and wine (pH 4-5) can be spoiled by yeasts and bacteria. Bacteria involved are primarily lactic acid bacteria like lactobacilli and *Pediococcus* spp., and (under aerobic conditions) acetic acid bacteria like *Acetobacter* and *Gluconobacter* spp. Acetic acid bacteria convert ethanol to acetic acid in the presence of oxygen.

The anaerobic bacterium *Megasphaera cerevisiae* can also spoil beer by producing isovaleric acid and H_2S.

Spoilage in packaged **beer** is often due to growth of the yeast *Saccharomyces diastaticus*, which grows on **dextrins** that brewers yeast cannot utilize. *Candida valida* is the most important spoilage yeast in wine. In either case, spoilage by yeasts results in the development of turbidity, off flavors and odors.

Wines can also be spoiled by lactic acid bacteria which are able to convert malic acid to lactic acid (**malo-lactic fermentation**). This reduces the acidity of the wine and adversely affect wine flavor. In some areas (e.g. Northwest), wine grapes have too much malic acid so this fermentation is deliberately used to reduce the acidity of grape juice that will be used for wine.

Yeasts, molds and lactic acid bacteria can also spoil fermented vegetables such as sauerkraut and pickles, as well as other acid foods like salad dressings and mayonnaise. Spoilage in fermented vegetables is often manifest by off odors or changes in the color (chromogenic colony growth) or texture (softening) of the product. In mayonnaise or salad dressing, the first signs of spoilage are usually off odors and emulsion separation.

ASSESSING MICROBIAL POPULATION IN FOOD

Microbiological risk assessment (MRA) is an emerging tool for the evaluation of the safety of food and water supplied. Food-borne pathogens are one of the leading causes of illness and death particularly in developing countries. The detection and enumeration of pathogens in food and on that come into contact with food are an important component of any integrated program to ensure the safety of foods throughout the food. Traditional methods of detecting foodborne pathogenic bacteria are often time consuming because of the need for growth in culture media, followed by isolation, biochemical and serological identification and in some cases, sub specific characterization. Advances in technology have made detection and identification faster more sensitive, more specific, and more convenient than traditional assays.

IMPORTANCE:

- It is important to determine the safety and purity of food.
- Rapid detection methods are important particularly in food industry, as they are able to detect the presence of pathogens in raw and processes foods immediately.
- Rapid methods are also sensitive enough to detect pathogens that present in low numbers in food.

METHODS FOR ASSESSING MICROBIAL POPULATION IN FOOD:

- Culture, microscopic and sampling methods
- Physical methods
- Chemical methods
- Immunological methods
- Molecular genetic methods

Culture, microscopic and sampling methods:

The examination of food for the presence, types and numbers of microorganisms and their products is basic to food microbiology. In spite of its importance, none of the methods in common use permits the determination of exact numbers of microorganisms in a food product.

The four basic methods employed for “total” numbers are as follows:

- **Standard plate count (SPC)** or Aerobic plate count (APC) for viable cells or colony forming units:
    - Portions of food samples are blended or homogenized and serially diluted in appropriate diluents. These are then plated in or onto suitable agar medium and incubated at an appropriate temperature for a given time. After that all visible colonies are counted by use of a Quebec or electronic counter.
- The **most portable numbers (MPN) method** as a statistical determination of the viable cells:
    - In this method, dilutions of food samples are prepared as for the SPC.
    - Three serial dilutions are then planted into 9 or 15 tubes of appropriate medium for the three or five tube method, respectively.
    - Numbers of organisms is original sample are determined by use of standard MPN tables. The method is statistical in nature and MPN results are generally higher than SPC results.
- **Direct microscopic counts (DMC)** for both viable and non-viable cells:
    - The organisms are collected on the membranes are viewed and counted microscopically following appropriate staining, washing and treatment of the membrane to render it transparent. This method is especially suited for samples that contain low number of bacteria.
- **Dye reduction techniques** to estimate numbers of viable cells that possess reducing capacities:
    - Two dyes are commonly employed in this procedure to estimate the number of viable organisms in suitable products:
        - ✓ Methylene blue
        - ✓ Resazurin
    - To conduct a dye reduction test, properly prepared supernatants of foods are added to standard solutions of dye for reduction:
        - ➢ From blue to white for methylene blue
        - ➢ From slate blue to pink or white for resazurin

- The time for dye reduction to occur is inversely proportional to the number of organisms in the sample.

PHYSICAL, CHEMICAL AND BIOLOGICAL METHODS:

These are the methods based on metabolic activity of the microorganisms on given substrate, measurements of growth response and measurements of some parts of cells including nucleic acid or combinations of these.

Physical methods:

Biosensors:

A device containing a biological sensing element connected to a transducer. Enzyme-substrate or antigen-antibody reactions may be the component of biosensor.

Biosensor that have been demonstrated to be of value for food born microorganisms are

1. Accoustical biosensor
2. Fiber optics
3. Impedance
4. Microcalorimetry
5. Flowcytometry
6. Biosys instrument

Chemical methods:

The chemical methods used primarily to detect, enumerate or identify food borne organisms or their products are:

1. Thermostable nuclease
2. Limulus amoebocyte lysate (LAL) assay
3. ATP assay (for live cells)
4. Radiometry

Thermostable nuclease:

- The presence of *S. aureus* in significant numbers in a food can be determined by examining the food for the presence of thermostable nuclease (DNase)

- This is possible because of the high correlation between the production of coagulase and thermostable nuclease by S. aureus, especially enterotoxin procedure.
- It has been found to be as good as coagulase in testing for enterotoxigenic strains.

Limulus lysate for endotoxins:

- Limulus amoebocyte lysate (LAL) assay employs a lysate protein obtained from the blood cells of horseshoe crab. The lysate protein is the most sensitive substance known for endotoxins and the presence of endotoxins causes gel formation of the lysate material.
- LAL test is a good, rapid indicator of the total numbers of Gram-negative bacteria.
- The method has been applied successfully to monitor milk and milk products, microbial quality of raw fish.

Adenosine Triphosphate measurement:

- In the presence of ATP, luciferace emits light which is measured with luminometer.
- The amount of light produced by luciferase is directly proportional to the ATP added.
- It is widely used as rapid and on the spot method for monitoring food handling surfaces by swabbing designated areas and reading the relative light unit from luminometer.

Radiometry:

- The radiometric detection of microorganisms is based on the incorporation of a C-labeled metabolite in a growth medium so that when the organisms utilize this metabolite, CO2 is released and measured by the use of a radioactivity counter.
- The time required to detect the labeled CO2 is inversely proportional to the number of organisms in a product.

Immunological methods:

Radioimmuno assay:

This technique consists of adding a radioactive label to an antigen allowing the labelled antigen to react with its specific antibody and measuring the antigen that combined with the antibody by the use of a counter to measure radioactivity.

ELISA:

Enzyme immunoassay or ELISA is an immunological method employing an enzyme coupled to either an antigen or an antibody rather than a radioactive isotope. This technique is widely used to detect and quantitate organism and their products in food.

Electroimmuno diffusion:

The development of precipitin lines can be speeded up by electrically driving the antigen and antibody. This method is also used assess microorganisms.

Immunomagnetic separation:

- This method employs paramagnetic beads that are surface activated and can be coated with antibody by incubating in the refrigerator for varying periods of time up to 24hours. The unabsorbed antibody is removed by washing.
- When properly treated, the coated beads are added to the food slurry that contains the homologous antigen, thoroughly mixed and allowed to incubate for a few minutes to allow the reaction of antigen with antibody coated beads.
- This method may be used for a number of other organisms including virus and protozoa.

Molecular genetic method:

Nucleic acid (DNA) probe:

A DNA probe consists of a DNA sequence from an organism of interest that can be used to detect homologous DNA or RNA sequences. Multiple targets are provided by mRNA, rRNA and plasmid DNA, thus making for a more sensitive detection system.

Polymerase chain reaction (PCR):

This method is fast becoming the most widely used of all molecular genetic methods for detecting and identifying bacteria and virus in food. Its increasing use is due to high sensitivity, specificity, its availability in a number of formats.

This technique is applicable more to the identification of food born organisms than to their enumeration.

Applications of molecular method:

- Detecting and identifying specific genes (GM foods)

- Application to food authenticity and legislation
- Detection of microbial contamination of foods
- Species identification
- Detection of food constituents (Ingredients or contaminants)
- Detect of antibiotics, pesticides etc.

MICROBIAL SPOILAGE OF CEREALS AND BAKERY PRODUCTS

Cereals are essential foods which are responsible for providing a bulk of our dietary requirements. They are the primary source for carbohydrates which are required by the body for energy generation and they also provide proteins, minerals, vitamins.

Microbial spoilage involves the degradation of protein, carbohydrates and fats by the microorganisms or their enzymes.

Cereals, Grains and Flours

Cereals and products made from them are substantial and important food resources for humans and livestock worldwide.

When the cereals, grains and flour made from them become even slightly moistened above the minimum level, microbial growth will arise leading to fungal growth at high humidity levels.

In the beginning stages, the grains are usually contaminated by *Bacillus, Pseudomonas, Micrococci and Lactobacillus.*

The early bacterial population can range from 10^3 to 10^6 per gram and the mold population can be more than 10^4 spores per gram.

Grains and flours usually have a long shelf life due to their low moisture content but only if they are properly harvested and stored under proper conditions such that microbial growth is not supported. However, if they attain moisture, the microbial growth may occur with molds growing at initial stages of moisture while yeasts and bacteria may grow with increasing moisture.

Spoilage of stored grains by molds is attributed to the following factors:

- Type and number of microorganisms
- Moisture content of more than 12-13%
- Storage temperature
- Physical damage
- pH

Most common species of molds found in spoiled grains or flour are Aspergillus, Rhizopus, Mucor, Fusarium. A significant aspect of spoilage due to mold formation is the production of mycotoxins, which has potential to pose danger to health.

Processing of flour, which includes methods like washing and milling, helps reduce the microbial content and the moisture content of less than 15% does not allow growth of molds. Most molds and bacteria in flours are only able grow if the moisture content is above 17%, thus moistening of flours is primary cause for spoilage by microbes.

If the grain is stored under moist conditions then storage fungi like Penicillium, Aspergillus and Fusarium are found on it.

Spoilage of Bread and bakery products

Bread is a major bakery product that is made using flours. Bread dough is prepared from flours and then it undergoes fermentation where desirable microorganisms grow. If the fermentation of bread dough exceeds the required limits then it causes souring. If proteolytic bacteria grows excessively then it reduces the gas holding capacity which is very important for the dough to rise.

Spoilage of bread is categorized into two types

- Moldiness
- Ropiness
- Other

Moldiness

When the bread is made, it is baked at a very high temperature, thus the chances of survival of microorganisms are very low. So the contamination usually happens when cooling is done, from the environment and also during the packing, handling processes.

The molds which are common in bread are Rhizopus stolonifer (bread mold), Aspergillus niger, Penicillium expansum. Mucor and Geotrichum can also develop.

Ropiness

Ropiness in bread is mostly due to the growth of bacteria and it is regarded more common in homemade bread. The main organism responsible for this is Bacillus subtilis or B. licheniformis. They are spore-forming bacteria and their spores survive the high baking temperatures. Once they get suitable conditions (heat treatment activates them) spores can develop into vegetative cells. In ropiness, the hydrolysis of bread flour protein (gluten) happens by employing proteinases. When starch is hydrolysed by amylases it also encourages ropiness in bread. The manifestation of ropiness is the development of yellow to brown color and soft and sticky surface on the bread, accompanied by odor.

Other

Chalky bread is another type of spoilage of bread which is inflicted by growth of yeast like fungi Endomycopsis fibuligera and Trichosporon variable. This type of spoilage is distinguished by the growth of white chalk-like spots.

A rare type of spoilage of bread is Red or Bloody bread, which is influenced by the growth of bacteria Serratia marcescens. This bacterial organism elicits a brilliant red colour on starchy foods giving them a blood-like tinge. Neurospora and Geotrichum could also play a part in imparting pigmentation during spoilage of bread.

Control of microbial growth in bakery products can be done by :

1. Reformulating products to reduce the available water in the product.
2. Freezing
3. Preservatives
    a. Chemical preservatives
    - Sorbic acid and sorbates

- Propionic acids and its salts

b. Bio preservatives

- LAB - lactic acid bacteria

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UNIT – III - FOOD PROCESSING AND PRESERVATION - SBT1607

Benefits & Drawbacks & Trends for Food Processing

Food processing is a transforming course from raw ingredients into foods, or from one form of food into another. It involves many different steps such as raw materials (harvested crops or butchered animal products) treatment, ingredients mixing, transmission, forming and packing, etc., during which are applied a wide variety of sanitary machines and equipment, for example, tanks, ***sanitary valves***, ***fittings*** and ***pumps*** during ingredients mixing and transmission, grinders in the raw materials treatment step and different molds doe forming, etc..

Benefits

Food processing can yield many benefits including:

- Elimination of toxin, bacteria and other unhealthy compositions. Some process can even give foods better mouthfeel and easier absorption.
- Longer shelf-life and facilitation for transportation, storage and preservation, which can enable people enjoy non-seasonal foods.
- More attractive appearance of foods
- A wider variety of food forms that are targeted for different demands. For example, nowadays in the market foods for weight loss, organic foods, certain-ingredient-reinforced foods are all available.

Drawbacks

Every processing of food can have some effect on the food's original nutrition structure, slight or huge. Vitamin C, for example, is destroyed during heating and therefore canned fruits have a lower content of vitamin C than fresh ones. According to a nutrient retention table for several foods created by the USDA in 2004, in the majority of foods, processing reduces nutrients by a minimal amount. On average any given nutrient may be reduced by 5%-20%.Another drawback of food processing is the possibility of food additives. The same addictive may cause varied health effects on different persons. In the USA, only food additives that have been approved as safe for human consumption by authorized organism are allowed, at specified levels, for use in food products.Last, because of the complex process of food processing (mixing, grinding, chopping and emulsification, etc.), processed foods will be exposed to a number of contamination risks.

PROCESSING OF VEGETABLES:

Vegetables consist of a large group of plants consumed as food. Perishable when fresh but able to be preserved by a number of processing methods, they are excellent sources of certain minerals and vitamins and are often the main source of dietary fibre. The consumption of vegetables has increased significantly as consumers have become more health-conscious. Owing to the perishable nature of the fresh produce, international trade in vegetables is mostly confined to the processed forms.

Structure And Composition

Vegetables can be classified by edible parts into root (*e.g.,* potatoes and carrots), stem (asparagus and celery), leaf (lettuce and spinach), immature flower bud (broccoli and brussels sprouts), and fruit (tomatoes and cucumbers).

Aging and spoilage

Depending on the class of vegetable, there are differences in the structure, size, shape, and rigidity of the individual cells. The fresh market shelf life and processing requirements are also very different. Vegetable cells, as plant cells, have rigid cell walls and are glued together by various polysaccharides such as cellulose, hemicellulose, and pectin. Once vegetables are harvested from the fields, the cells, now deprived of nutrient supplies normally obtained from soils and the air, go into senescence, or aging. The most noticeable structural change in senescent vegetables is softening, or loss of texture. Softening is caused by natural enzymatic reactions that degrade the plant cell walls. A large group of enzymes is involved in the senescence stage, including cellulase, pectinase, hemicellulase, proteinase, and others. After these enzymes break open the cells, chemical oxidation reactions take place and the vegetables develop off-flavours and loss of nutritional value. Broken cells are also much more easily subject to microbial attacks, which quickly lead to spoilage. In addition, even though the vegetables may be packaged or bagged, the plant cells continue to respire, or break down carbohydrates for energy needs. Respiration leads to loss of quality, so that eventually the products are unsuitable for human consumption.

Nutritional value

The four quality factors of vegetables are colour, texture, flavour, and nutritive values. Fresh vegetables are purchased on the basis of colour and texture, but repeated purchases are made on the basis of flavour and nutritional content. The major nutrients contributed by vegetables to the human diet are dietary fibre (both soluble and insoluble), minerals (calcium, phosphorus, iron, sodium, potassium), and vitamins (vitamin C, vitamin A, thiamine, niacin, folic acid).

Certain vegetables contribute lipids to the diet, mostly in the form of unsaturated oils. Roots and legumes can be important contributors of dietary proteins—especially in developing countries, where animal proteins are scarce. One potential nutritional problem of obtaining proteins from a single vegetable source is the low concentration of essential amino acids in vegetables. Twenty common amino acids are considered to be building blocks of proteins for the body. Of these 20, the body cannot synthesize eight; these eight must be obtained from foods. Most vegetable proteins are low in one of the eight essential amino acids; for example, corn is low in lysine, and soybeans are low in methionine. However, if proteins are obtained from a proper mixture of vegetables, there will not be a nutritional problem.

It is a common misconception that fresh vegetables are always superior in nutritional value to processed vegetables. Several investigations have shown frozen or canned vegetables can actually have higher nutritional value than fresh products. Fresh vegetables are subject to quality and vitamin losses during transportation and storage, whereas processing before these losses occur can yield a nutritionally superior product. Research has shown that a major cause of nutrient loss in vegetables is in the draining of cooking or processing liquids.

Harvesting and storing

Most leafy vegetables that do not require harvesting by mechanical device are cooled immediately after harvest to remove field heat, sorted to remove debris, washed to remove dirt, and bundled or packed for shipping and retail. In most cases vegetables are bundled as whole plants, since cutting will injure the cells and liberate ethylene, which promotes senescence and shortens shelf life. Low-temperature storage is essential in the handling of quality leafy vegetables. On the other hand, storing below refrigerated temperature may lead to chilling injury of certain vegetables and to rapid loss of quality. In developing countries where refrigeration is not available, postharvest losses of fresh vegetables can be as much as half the total harvest.

For roots and legumes, the harvesting of which is normally done by machines, some sorting and grading are performed either in the field or at collection stations. Bulk handling of these vegetables is common, and few additional steps of preparation are performed before distribution. For vegetables that need to be stored for long periods of time, treatments to avoid microbial spoilage, insects, and small-animal invasion may be necessary. For some vegetables such as cucumbers, a washing and waxing step may be taken to improve the shelf life and the attractiveness of the produce.

Packaging

Provided in response to demands for convenient foods, minimally processed fresh produce has gained popularity in the marketplace. These vegetables go through additional preparation steps of washing, sorting, grading, cutting, and packaging into retail-size containers. In order to extend the shelf life of these products, vacuum packing and modified-atmosphere (MA) packaging are practiced. In most cases air is replaced by an atmosphere high in carbon dioxide and low in oxygen. This modified atmosphere can slow the respiration rate and therefore the senescence of cut vegetables. The most common products in American and European markets are various types of cut lettuces with shredded carrots, cabbages, and other vegetables. Modern packaging techniques employing “clean room” concepts make it possible for such vegetable products as salad mix and stir-fry mix to have shelf lives approaching those of the whole plants. The products can be shipped by refrigerated containers to overseas locations and still have a shelf life long enough to reach consumers.

Minimally processed vegetables normally do not contain any preservatives and have not gone through any heat or chemical treatment. The disadvantage of these products is that refrigeration storage is essential, limiting its practice to developed countries.

Processing Of Vegetables

Because of the varied growing and harvesting seasons of different vegetables at different locations, the availability of fresh vegetables differs greatly in different parts of the world. Processing can transform vegetables from perishable produce into stable foods with long shelf lives and thereby aid in the global transportation and distribution of many varieties of vegetables. The goal of processing is to deter microbial spoilage and natural physiological deterioration of the plant cells. Generally, the techniques include blanching, dehydrating, canning, freezing, fermenting and pickling, and irradiating.

Blanching

After vegetables have been washed clean, they must undergo blanching (heating) in hot water at 88° C (190° F) for two to five minutes or with steam in a conveyor at 100° C (212° F) for one-half to one minute. Blanching inactivates natural enzymes that would cause discoloration and off-flavours and aromas. It also serves to reduce the number of microorganisms and to render vegetables limp for easy packing into containers. For some vegetables, such as spinach, snap beans, and collards, the blanching step also serves to remove harsh flavours.

After blanching the vegetables must go through rapid cooling in either cold water or cold air for better quality retention. The vegetables are then ready for the various food-processing methods described below.

Dehydration

Drying is probably the oldest method of preserving foods. The removal of water from vegetables is accomplished primarily by applying heat, whether it be through the radiant energy of the sun or through air heated by electrical energy. A major advantage of removing water is a reduction in volume and weight, which aids in storage and transportation of the dried products. Modern drying techniques are very sophisticated. Many machines are available to perform tunnel drying, vacuum drying, drum drying, spray drying, and freeze-drying. Although freeze-drying produces a food of outstanding quality, the cost is high, and it has not been used widely in vegetable products.

One of the most familiar dehydrated products is instant potatoes. Almost all the mashed potato dishes served in restaurants and institutions are rehydrated instant potatoes. In restaurants and institutions dehydrated potato granules are used, while dehydrated flakes are preferred for home cooking. Potato granules have high bulk density and are easy to handle in large quantity. However, they produce mashed potatoes with a pasty texture—an effect caused by the rupture of cells during processing, so that starch is released from the cells. Mashed potatoes made from flakes, on the other hand, have a mealy texture comparable to that of freshly prepared mashed potatoes. The major difference in the processing of these two dehydrated products is in the drying steps. For granules, air-lift drying is used to bring the product to 10–13 percent moisture. After screening to proper granule size, the product is dried to 6 percent moisture in a fluidized-bed drier. In the making of flakes, a steam-heated drum drier is used to bring a flattened sheet of potato solids to final moisture content before it is broken into a suitable size for packaging. Although a considerable quantity of the potato cells are ruptured during the breaking of the dried sheet, the reconstituted product has an acceptably mealy texture because the potatoes are subjected to a precooking and cooling treatment as well as the addition of a monoglyceride emulsifier.

A small amount of sulfite may be used in producing certain dried vegetables. The sulfite serves as an antimicrobial agent, aids in heat transfer, and (in the case of potatoes) acts as a blanching agent. A small percentage of the consumer population is allergic to sulfite. Although the rehydrated product contains little or no sulfite, consumer concerns are forcing the industry to search for economically feasible sulfite replacements.

Canning, method of preserving food from spoilage by storing it in containers that are hermetically sealed and then sterilized by heat. The process was invented after prolonged research by Nicolas Appert of France in 1809, in response to a call by his government for a means of preserving food for army and navy use. Appert's method consisted of tightly sealing food inside a bottle or jar, heating it to a certain temperature, and maintaining the heat for a certain period, after which the container was kept sealed until use. It was 50 years before Louis Pasteur was able to explain why the food so treated did not spoil: the heat killed the microorganisms in the food, and the sealing kept other microorganisms from entering the jar. In 1810 Peter Durand of England patented the use of tin-coated iron cans instead of bottles, and by 1820 he was supplying canned food to the Royal Navy in large quantities. European canning methods reached the United States soon thereafter, and that country eventually became the world leader in both automated canning processes and total can production. In the late 19th century, Samuel C. Prescott and William Underwood of the United States set canning on a scientific basis by describing specific time-temperature heating requirements for sterilizing canned food

PROCESSING OF MILK

Milk is the most valuable protein food that widely consumed by people all over the world. The milk as a raw food is easily available on various dairy farms that are processed to the increases the variety of nutrients.

Milk is collected from the farmers and trasnported to milk plants for its processing into mass market milk and other dairy products such as: cream, butter, cheese, casein, yogurt, etc.

Milk Reception units

The milk is transported on tank trucks and delivered to the different dairy and milk plants. Milk is then pumped from the milk tanks into the milk reception units, where the milk is de-aerated and tested and then pumped over again to the storing units or the processing line. In the milk reception units, milk is measured and tested, air is eliminated and the milk is cooled before further processing or storing.

Milk Storage units

Milk can be then stored into tanks or pumps, or can go directly into the processing line from the milk reception units. Milk will be stored in tanks or silos along different phases of the processing line, these inter processing tanks will be automated into the processing line. Aseptic milk storage is required if the milk has followed an aseptic process.. Storage systems can vary from a very basic system that is manually handled , combined alongside CIP systems and sterilization units.

CIP or SIP

CIP**(cleaning in place**) systems are a requirement throughout the whole manufacturing process so as to guarantee hygienic maintenance of the installations and milk hygiene.

Milk sterilization

The process of reducing the microorganism is called sterilization. Depending on the amount and type of microorganism that need to be killed, and the shelf life of the product it is achieved using different processes like pasteurization, UHT, HTST or filtration.

For the production of **fresh milk**, the chosen process is **pasteurization**

for the production of **ESL milk, UHT** or several filtration systems can be used.

The most marketable **fluid milk** nowadays is either **UHT or HTST**.

Pasteurization is the process of treating the milk at a high temperature, and then chilling it so as to extend its shelf-life and reduce microbial growth, whilst retaining the maximum natural qualities possible.

HTST (High Temperature/Short Time).

Milk is put through a continuous process of very high temperatures for a very short time. This process conserves milk qualities better than more aggressive processes such as UHT or aseptic processing, although it leaves it with a shorter shelf life.

UHT (Ultra High Temperature).

Although pasteurization deactivates most of the microbial growth, to extend milk shelf-life further, milk needs to be further sterilized. The most commonly used method in the industry nowadays is UHT (ultra-high temperature) which consists of a continuous sterilization process where milk is heated at very high temperatures and then chilled numerous times in a continuous process. The aim is to kill all micro-organisms and prolong milk shelf-life. Most of the milk you can buy today is put through a UHT process.

ESL (Extended Shelf Life) Milk is fresh milk with an extended shelf life. Other microbiological reduction methods are used versus heat methods such as pasteurization, HTST or UHT.

Milk Standardization - Cream separation

The fat content of raw milk varies depending on the type of cow, cow feeding, age, timing, etc. This is why milk follows a standardization process where either raw milk or even sterilized or pasteurized milk is separated into cream and skimmed milk by the cream separation machines. Part of the cream is added back into the skimmed milk in exact proportions in order to precisely define the fat content of the milk and standardize it. The rest of the cream is processed to produce products such as cream, condensed milk, butter, etc, using technologies such as evaporation, mixing, drying, etc.

Mixing

Milk can be enriched with vitamins, calcium or other types of ingredients. These should be mixed and blended in batch or continuous processes in mixing units.

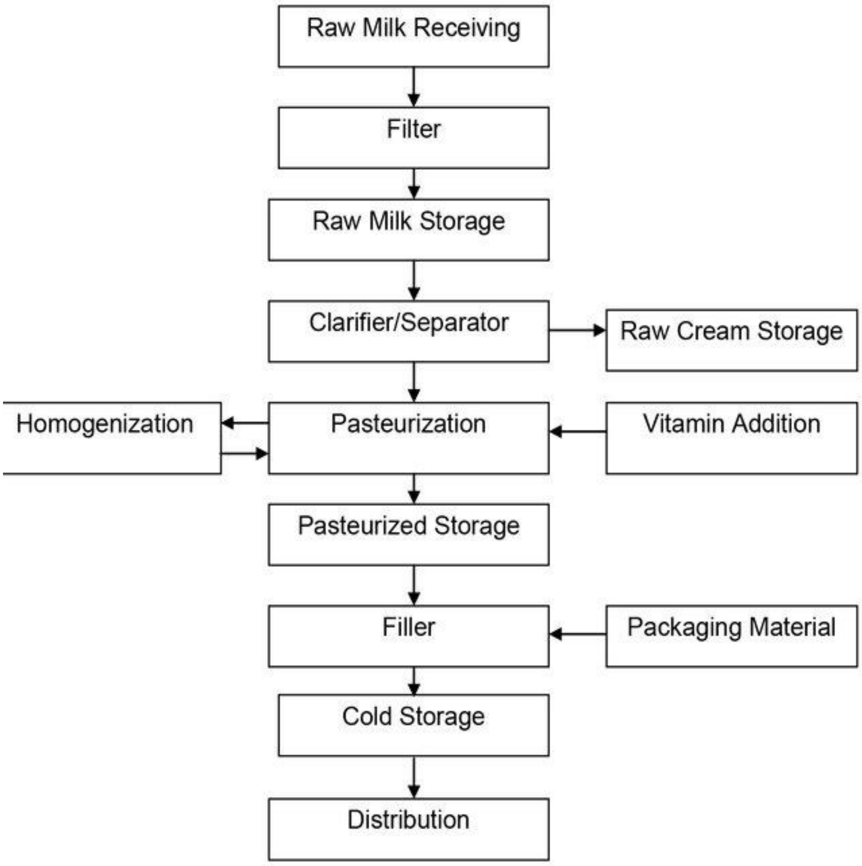
Homogenization

This process is done by machines called homogenizers, whose objective is to prevent the cream from seperating from the rest of the liquid once the milk is stored.

Milk Filling and Packaging technologies

Once the product manufacturing process is finished, the milk passes to the filling and packaging process. Milk can be packed into different types of packages: carton, glass, pouches, PET bottles, etc. Sterilized milk that needs to have a long shelf life should be filled and packed using aseptic technologies. In this case, previous sterilization of the package should also be done.

Flowchart on processing of milk:



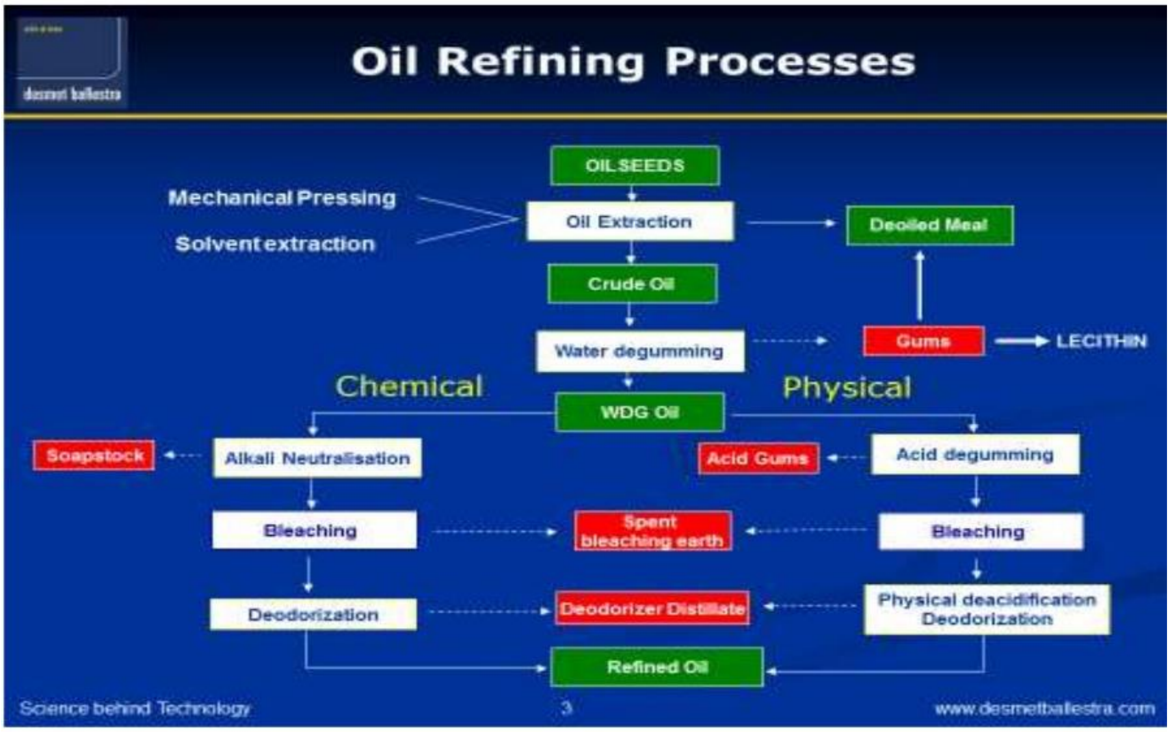
Edible Oil Processing

INTRODUCTION:

- Crude vegetable oil obtained from various oil milling units is further refined before use for edible purposes.
- Refined edible oil is a process where free fatty acids are volatized, condensed and recovered simultaneously with vacuum de-colouring operation.
- Sometimes, refining process is limited to simple physical treatment such as heating and filtering in regard to refining of superior quality of crude oil.

MANUFACTURING PROCESS:

- Special pre-treatment steps which are a combination of
- De-gumming and Blending under special operating conditions eliminate all impurities and render oil fit to be processed at elevated temperature under vacuum.
- Various steps involved in refining are:
    1. Super cleaning
    2. Contobleaching
    3. De-acidification
- All these processes are very well standardized and practiced in the country since long.



Specifications of Edible Oil Refinery:

- Capacity 5 tons per day i.e. 4 batches of 1250 kg each
- All the main vessels i.e. two neutralizers, one bleacher and one deodorizer are properly arranged on the first floor of the steel structure. So all these vessels are hanging on the steel structure. Just below the two neutralizers, two soap pans are resting on the ground floor in which soap stocks is collected. There is a steam is a steam pipe arrangement in the soap pans also.
- Steel structure has size of 14ft.x 14ft. First floor is 9ft. above the ground level. There are 8 columns of double channel which supports the entire steel structure. It has proper staircase and raining on all the slides of steel structure at the first floor and also on staircase. Two filter presses are also accommodated on the first of the steel structure.
- Two oil tanks i.e. raw oil tank and bleached oil tank are accommodated under the structure on the ground floor. Then cooler, thermic fluid boiler, two stream generators, vacuum pumps, water pumps, oil pumps and refined oil tank are

arranged on the ground floor around the steel structure outside the square of 14ft. x14ft. of the steel structure. So total space occupied is about 30ft. * 30ft.

- 40ft, tower is erected just near the deodorizer and its complete structure is supported from the ground floor and also it is attached with the refinery structure. Barometric condenser is arranged at 40ft. hight to create proper vacuum.
- All types of pipelines are interconnected as per the requirement of the refinery oil pipelines, vacuum pipelines, steam pipelines water pipelines, thermic fluid pipelines. At all appropriate places, proper valves are provided in the pipelines.
- Neutralizer is provided with thermic fluid coil for heating the oil.
- Bleacher is provided with double pipe coil. One is for thermic fluid and another is for cooling water.
- Cooler is provided with double pipe coil. Both for cooling water.
- Neutralizer is open on the top having conical bottom.
- Bleacher has dished ends on the both the sides. Similarly, deodorizer has dished ends on both the sides. Cooler has also dished ends on both sides.

Process Description of Edible Oil Refinery:

For refining the edible oil, there are these basic processes in the refinery.

- First process is neutralizing the oil in the neutralizer to remove the free fatty acids (FFA) by adding caustic soda.
- Oil is heated up to about 60 degree C by thermic fluid coils and oil is stirred by stirrer.
- Then soap stock formed due to chemical reaction is allowed to settle at the bottom of the neutralized from where it is taken out into soap pan.
- Neutralized oil is drawn into the second vessel called bleacher where colour of oil is removed by bleaching process with aid of chemicals such as carbon black and bleaching earth. Oil is generally heated up to 110degree C by thermic fluid coils. Stirring is also continued. Bleaching process is done under vacuum.

Process Description of Edible Oil Refinery:

- Bleached oil then goes to the filter press where bleaching earth and chemicals are separated and clean bleached oil is then drawn to deodorizer where oil is heated above 110degree C through thermic fluid coils and then live steam is given to the oil from the bottom steam nozzles and temperature of oil is raised up to 200 to 220 degree C through thermic fluid coils. Entire process is done under high vacuum. Thus, smell is removed from the oil in the deodorizer. Then it goes to cooler where water circulating coils take away heat and oil is cooled. Again, it goes to second filter press where completely refined and transparent colour less oil is obtained.

- Thermic fluid boiler, vacuum pump, barometric condenser, catchalls, steam generator etc. play their role in the refining process. So, these equipment's are part of the refinery and connected with the vessels through pipelines.

REFINING:

- Refining produces an edible oil with characteristics that consumers desire such as:
- Bland flavour
- Odor
- Clear appearance
- Light color
- Stability to oxidation
- Suitability for frying.

REFINING:

- The following precautionary measures are taken during refining in order to avoid undesirable autoxidation and polymerization reactions:
    1. Absence of oxygen
    2. Avoidance of heavy metal contaminations
    3. Maintaining the processing temperature as low and duration as short as possible.

REFINING:

- Refining process comprising the following steps:
    1. Lecithin removal
    2. Degumming
    3. Free fatty acid removal
    4. Bleaching
    5. Deodorization

Removal of lecithin:

- This processing step is special importance for soybean oils.

- Water (2-3%) is added to crude oil, there by enriching the phospholipids in the oil/water interface.
- The emulsion thus formed is heated up to 80 degree C and then separated or clarified by centrifugation.

Degumming:

- Finely dispersed protein and carbohydrate are coagulated in oil by addition of phosphoric acid (0.1 % of oil weight).
- A filtering aid is then added and the oil is clarified by filtration.

Removal of free fatty acids (deacidification):

- The removal of fatty acids with 15% sodium hydroxide (alkali refining) is most frequently used method.
- Technically, this is not very simple since fat hydrolysis has to be avoided and moreover the sodium soap which tends to forms / stable emulsions, has to be washed out by hot water.
- After vacuum drying, the fat or oil may contain only about 0.05% free fatty acids and 60 to 70 ppm of sodium soaps.
- When fat or oil is treated with diluted phosphoric acid, the content of sodium soaps decreases to 20 ppm and part of the trace heavy-metal ions is removed.

Bleaching:

- In order to remove the plant pigment (chlorophyll, carotenoids) and autoxidation products, the fats or oil is stirred for 30 min in the presence of Al-silicates in a vacuum at 90degree C.
- The bleached oil is removed from the adsorbent by filtration.
- The retained by the absorbent can be recovered by hexane extraction and recycled into refining process.

Deodorization:

- Deodorization is essentially vacuum steam distillation.
- The volatile compounds, together with undesirable odorants present in the fat or oil, are separated in refining steps.

- Deodorization takes place min 20 in to 6h depending on the type of fat or oil and content of volatile compunds.

Parameters of Food Processing

Food Processing

Food processing is the transformation of agricultural products into food, or of one form of food into other forms. Food processing includes many forms of processing foods, from grinding grain to make raw flour to home cooking to complex industrial methods used to make convenience foods.

Primary food processing is necessary to make most foods edible, and secondary food processing turns the ingredients into familiar foods, such as bread.

Tertiary food processing has been criticized for promoting overnutrition and obesity, containing too much sugar and salt, too little fiber, and otherwise being unhealthful in respect to dietary needs of humans and farm animals.

To ensure purity, freshness and safety of the food products at the time of consumption. BENEFITS OF FOOD QUALITY PARAMETERS. Benefits of food processing include toxin removal, preservation, easing marketing and distribution tasks, and increasing food consistency. We should take parameters in food processing.

When designing processes for the food industry the following performance parameters may be considered:

- Hygiene, e.g. measured by number of micro-organisms per mL of finished product
- Energy efficiency measured e.g. by “ton of steam per ton of sugar produced”
- Minimization of waste, measured e.g. by “percentage of peeling loss during the peeling of potatoes”
- Labor used, measured e.g. by “number of working hours per ton of finished product”
- Minimization of cleaning stops measured e.g. by “number of hours between cleaning stops”.

Adding Sodium

One of the main sources for sodium in the diet is processed foods. Sodium is added to prevent spoilage, add flavor and improve the texture of these foods.

Food Quality

Quality is an important **food** manufacturing requirement, because **food** consumers are susceptible to any for **Food quality** is the **quality** characteristics of **food** that is acceptable to consumers. **Food** of contamination that may occur during the manufacturing process.

Quality Parameters

Several **quality parameters**, which differ in chemical composition, can define the makeup of each product. These **parameters** refer to the chemical, microbiological, nutritional and physical factors that make up the coconut liquid products its unique properties, which also influences the products shelf life.to any form of contamination that may occur during the manufacturing process.

Intrinsic and Extrinsic Factors of Food Spoilage

Intrinsic factors of food spoilage are those inherent factors that are associated with the food and which in several ways affect the overall physical and chemical composition of the food. Intrinsic factors are food related factors; and they are generally referred to as the physiochemical properties of food. These intrinsic factors of food spoilage include the nutrient makeup of the food, the acidity or alkalinity of the food, water activity, moisture content, buffering capacity and the pH of the food.

Intrinsic and Extrinsic Factors

Intrinsic factors act from within an individual, **extrinsic factors** wield their influence from the outside (i.e., they are environmental, cultural, or related to lifestyle). **Extrinsic factors** can have a sizeable impact on a person's health and can affect medical decision-making.

Intrinsic and Extrinsic Parameters of Food Processing

All foods possess a set of conditions called intrinsic parameters. These parameters can be influenced by another set of conditions called extrinsic parameters. Together, these two groups of parameters have great influence on the number and kinds of microorganisms occurring in and on a food and their physiologic activities. Intrinsic parameters All foods conditions called of food include pH, *moisture, oxidation-reduction potential (presence or* possess a set of *absence of oxygen), nutrient content, occurrence* of antimicrobial constituents, and biologic structures.

All microorganisms have a minimum, maximum, and optimal pH tolerance a moisture requirement an oxygen-tension requirement and a nutrient requirement. By knowing these parameters, one can predict the presence and growth potential of specific microorganisms in certain types of foods. A pH of 4.5 is considered the demarcation line between acidic foods (<pH 4.5) and basic foods (>pH 4.5). Yeast and molds can grow down to pH 1 whereas bacteria cannot grow below pH 3. Thus, acidic foods such as citrus fruits and carbonated soft drinks will be spoiled more by yeasts and molds than by bacteria. On the other hand, in a more basic food (>pH 4.5) bacteria will outgrow yeasts and molds owing to their higher metabolic rates in a favorable growth environment. Moisture content is another important parameter. This is usually expressed as water activity (Aw). Most moist foods are in the range of 0.95 to 1.00 Aw). When the Aw drops to 0.9, most spoilage bacteria reach their minimum level. Most spoilage yeasts have their minimum at 0.88, and molds have theirs at 0.80.

pH	Optimum	Min	Max
Bacteria	6-8	4.5-5	9
Yeast	4.5-6	2-3	11
Mold	3.5-4	2-3	11

Thus, in dry food products yeasts and molds grow much better than bacteria, and in moist food bacteria will outgrow yeasts and molds. The role of oxygen tension in and around food also has a great impact on the type of organisms growing there. Bacteria can be aerobic, anaerobic, or facultative anaerobic, so they can grow in a variety of oxygen levels (although different types will grow in different oxygen-tension environments). Yeast can grow both aerobically and anaerobically. Most molds, however, cannot grow anaerobically. In a properly vacuum-packaged food, for example, one should not find mold growing. The amount of oxygen measured in terms of oxidation-reduction potential also dictates the types of bacteria that can grow in the food. Disrupting the oxygen tension of a food (e.g., grinding a piece of meat to make ground beef from a steak) makes it easier for aerobic organisms to spoil the food.

Nutrient content (water; source of energy for metabolism; source of nitrogen, vitamins, and growth factors; and minerals) of different foods will support different types of microbes. In general, a food nutritious for human consumption is also a good source of nutrients for microbes. Some foods have natural antimicrobial compounds, such as eugenol in cloves, allicin in garlic, and lysozyme in egg, that can suppress the growth of some microbes. Biologic structures of some foods are also important for the prevention of microbial invasion. An example is the skin of an apple. When the apple is bruised, microbes can easily enter the fruit and spoil it.

Extrinsic parameters of food also play an important role in the activities of microbes. Temperature of storage greatly influences the growth of different classes of microbes. The amount of moisture in the environment (relative humidity) also influences the absorption of moisture or the dehydration of the food during storage and thus also influences the growth of different organisms. Varying the gaseous environment in storage will also change the types and growth rates of different organisms during storage of the food items. And last, the length of time of food storage also influences the spoilage potential by microbes in the food.

Aerobic and anaerobic bacteria can be identified by growing them in test tubes of thioglycolate broth:

1: **Obligate aerobes** need oxygen because they cannot ferment or respire anaerobically. They gather at the top of the tube where the oxygen concentration is highest.

2: **Obligate anaerobes** are poisoned by oxygen, so they gather at the bottom of the tube where the oxygen concentration is lowest.

3: **Facultative anaerobes** can grow with or without oxygen because they can metabolize energy aerobically or anaerobically. They gather mostly at the top because aerobic respiration generates more ATP than either fermentation or anaerobic respiration.

4: **Microaerophiles** need oxygen because they cannot ferment or respire anaerobically. However, they are poisoned by high concentrations of oxygen. They gather in the upper part of the test tube but not the very top. 5: **Aerotolerant organisms** do not require oxygen as they metabolize energy anaerobically. Unlike obligate anaerobes however, they are not poisoned by oxygen. They can be found evenly spread throughout the test tube.

Conclusion

Thus, intrinsic and extrinsic parameters of food are of great concern to food microbiologists. Skillful manipulation of these parameters by food microbiologists will result in more stable, more nutritious, fresher, and safer foods for the consumer.

MEAT PROCESSING

Introduction

The meat processing involves the slaughter of animals and fowl, processing of the carcasses into cured, canned, and other meat products, and the rendering of inedible and discarded remains into useful by-products such as lards and oils. Meat is exposed to a series of wide range of processes viz. curing or preserving processes such as salting, wet pickling, drying, cooking and canning, sausage manufacture, ham curing. All these processing techniques are aimed at inhibiting the microbial spoilage and increasing the shelf life of the meat. Major principles involved in meat processing are use of heat, low temperature, smoking, modified atmosphere packaging and ionizing radiations. The methods of preservation are mainly grouped in three categories i.e. control by temperature, by moisture and by lethal agents (bactericidal, fungicidal etc.)

Preservation of Meat

Use of low temperatures

Chilling and freezing are most commonly used preservation system for meat and meat products.

a. Chilling

Chilling is most widely used technique to preserve raw and processed meat. Chilling preserves muscle tissue by retarding the growth of microorganisms and by slowing many chemical and enzymatic reactions. Storage temperature may vary from - 1.4 to 2.2�C for storage of beef for 30 days depending upon the number of microorganisms. Carcass should go to the cooler as soon as possible and its inner most part should be able attain below 10�C within 12 hrs of slaughter in order prevent undesirable off-flavours and bone taints due bacterial growth. An ideal temperature of storage for meat should 1�C above its freezing point.

During post mortem cooling and subsequent refrigerated storage, control of relative humidity (around 90%) is very important. The undesirable moisture is lost from the surface, the weight reduction becomes of economic important and meat pigments myoglobin might get oxidized to brown metamyoglobin. However, a small amount of moisture loss from the surface is desirable since this tends to retard growth of microorganisms.

Freezing

Freezing is an excellent process for preserving the quality of meat for long periods. Freezing is often used to preserve meats during shipment over long distances or for holding until long times of storage. Its effectiveness depends on ice crystal formation and rate of lowering of temperature. When the temperature of storage is below - 18�C, changes occur at a very slow rate in the muscle of warm blooded animals. Quality of frozen meat depends on various factors such as rate of freezing, packaging etc. When muscle tissue is frozen rapidly, small both intra � and extra � cellular ice crystals are formed which cause little damage to the meat structure. While large ice crystals are formed in slow rate of freezing causing compactness of muscle fiber. The process of denaturation can be accelerated with a resulting decrease in water holding capacity of tissue. Loss of water holding capacity of the muscle along with mechanical damage to cells by ice crystals is responsible in large parts of thaw exudates. To protect quality loss due to changes in protein, anti-freezing compounds or cryoprotectants i.e. polydextrose, polyphosphate are added to meat formulations. Rapid freezing can be obtained by using air blast freezers either on batch or continuous basis which employs -20 to -40�C cold air. Large size meat cuts are vacuum packaged to prevent lipid oxidation and discoloration due to formation of metmyoglobin. Retail meat is packed in low permeability films with better mechanical strength e.g. Sarlyn.

Use of heat

The canning of meat is a very specialized technique in that the procedure varies considerably with the meat product to be preserved. Since meat products are low acid foods so the rate of heat penetration is fairly low. Commercially canned meats can be divided into two groups on the basis of heat processing used ;

(a) Meats that are heat processed in an attempt to make the can contents sterile.

(b) Meats that are heated enough to kill part of spoilage organisms but must be kept refrigerated to prevent spoilage.

Processing temperature for shelf stable canned cured meat is 98�C. Treatment of meat surfaces with hot water to prolong the storage time has been suggested. Although this may result in loss in nutrients and damage in colour. Actin is the most heat labile muscle protein becoming insoluble at 50�C. Denaturation of muscle proteins decreases their water holding capacity. This decrease in water holding capacity may produce desirable juiciness, Provided free water is not expelled from the tissue. During heating, fat is melted. Adipose tissue cells are ruptured and there is a significant redistribution of the fat. When meat is eaten warm, the melted fat serves to increase palatability of the product by giving desirable mouth feel, especially at the end of chewing period, when most of the aqueous juices are lost. Myoglobin also undergoes denaturation. The red pigment heme is oxidized to brown pigment hemin. Canned meat loaf can be manufactured substituting a part of the meat with high calcium coprecipitate. It is observed that 20% meat can be replaced with high calcium milk protein coprecipitate in chicken meat loaf without affecting the quality of the end product.

Dehydration

Deprivation of available moisture (reduction of water activity) for microbes not only prevent their growth but also kills them, thus results in increased shelf life and better quality product. Water may be made unavailable either by dehydration, freeze drying or by increasing exrtacellular osmotic pressure as is done in curing. Drying meats can be successfully employed for both raw and cooked meat. However, the quality of the final reconstituted product is superior when meat is cooked prior to dehydration. There is a loss in native structure of protein as measured by loss of water holding capacity during temperature from 0 to 20 C. This is caused by denaturation of sarcoplasmic proteins. The next major loss in water holding capacity begins in the temperature range of 40 to 50 C due to denaturation of contractile proteins. Collagen is rapidly converted to gelatin at around 100 C. Texture is most severely altered by dehydration. The tough texture of dehydrated meat can be overcome by preparing products of intermediate levels of water.

Smoking

Smoking is often used with salting and curing. It gives desired flavour, aroma and aids in preservation. It was noted that preservative substances added to the meat together with the action of heat during smoking have a germicidal effect and that drying of the meat together with chemicals from the smoke inhibit microbial growth during storage. Smoke consists of phenols, alcohols, organic acids, carbonyl compounds and hydrocarbons. The desirable effects of smoking of meat can be listed as below:

- Meat preservation through aldehydes, phenols and acids (anti-microbial effect)
- Antioxidant impact through phenols and aldehydes (retarding fat oxidation)
- Smoke flavour through phenols, carbonyls and others (smoking taste)
- Smoke colour formation through carbonyls and aldehydes (attractive colour)
- Surface hardening of sausages/casings through aldehydes (in particular for more rigid structure of the casing)

Production of smoke

Smoke is produced by burning of wood or its saw dust which consist of 40-60% cellulose, 20-30% hemicelluloses, 20-30% lignin. A temperature gradient exists during thermal decomposition of wood. Outer surface temperature is generally above 212^{o}F during dehydration process. Co, CO_2 and volatile medium chain organic acids e.g. acetic acid are released during dehydration and distillation process. When internal moisture level reaches to zero, the temperature rapidly rises to 570-750�F. Once the temperature falls within this range thermal decomposition occurs and smoke is given off.

Nature of smoke

Although the smoke at the point of generation exists in a gaseous state, it rapidly goes into a vapor & particle phase. The vapor phase contains the more volatile component & is largely responsible for the characteristic flavor & aroma of smoke. As soon as smoke is generated numerous reactions and condensation occurs. Aldehyde & phenol condense to form resins which represent about 50% of the smoke component & are believed to provide most of color is smoked meats. Polyphenols are also formed by condensation.

The amount and ratio of smoke deposition on the product is influenced by smoke density, smoke house air velocity and its RH, and surface of product being smoked

Cooking during smoking

Cooking is often done simultaneously with smoking of meat. In fact cooking is often more important than smoking in meat processing. Cooking equines careful control of the smoking and heating process to give best results.

Liquid smoke preparations

Liquid smoke is used by some processors. It is sprayed on the product before cooking. It has some positive effects over natural wood smoke.

(1) It doesnt require the installation of a smoke generator and which usually requires a major financial outlay.

(2) Process is more repeatable, as the composition of liquid smoke is mane constant.

(3) Liquid smoke can be prepared so the particle phase is removed and thereby possible problems from the carcinogens can be alleviated.

Liquid smoke is generally prepared from hardwoods; The final product is composed primarily of the vapor phase & contains mainly phenols, organic acids, alcohols & corbonyl compounds. They dont contain poly hydro carbons (PHC).

The there are two types of smoking cold at 15 to 18 C (up to 26 C) and hot temperatures of +60 to 80 C. Cold smoking is used for fermented meat products (raw-cured ham, raw-fermented sausage) and precooked-cooked sausage (liver and blood sausages). Hot smoking is used for a range of raw-cooked sausages, bacon and cooked ham products.

Modified atmospheric storage

Fresh meat held at refrigerated temperature has a limited shelf life because of microbial growth. Modified atmosphere refers to the adjustment in the composition of the atmosphere surrounding the product. At higher concentration of CO_2 surface browning of meat occurs due to the oxidation of myoglobin and hemoglobin pigments to ferric state. The most desirable concentration of CO_2 to use in a modified atmosphere is a compromise between bacterial inhibition and product discoloration

Ionising radiation

Ionising radiation constitutes the potentially useful form of preservation. Besides from its desirable ability to inactivate micro � organisms, it also has the undesirable effect of altering meat pigments. Sterilizing doses of ionizing radiation results in the breakdown of various lipids and proteins to often undesirable odours. Tenderization of muscle may also occur during this treatment. Temperature of $\leq$ 80�C or below greatly reduces undesirable effect without affecting lethal effect on microorganisms. Generally enzymes are not inactivated by irradiation treatment, it is necessary to heat approximately 70�C prior to irradiation and storage.

Processing of Meat Products

Comminuted meat products

Comminution is the mechanical process of reducing raw materials to small particles called as minced meat. Depending upon the final use of the communited meat the degree of comminution is done which differs among various processed products and is often a unique characteristic of a particular product ranging from very coarsely comminuted (to produce non-emulsified sausages like salamis and summer sausages), to finely comminuted, (to produce emulsified sausages like frankfurters, bologna, etc). Sausages are usually defined as comminuted seasoned meats, stuffed into casings; they may be smoked, cured, fermented and heated. They are made from any edible part of the slaughtered, veterinary-inspected animal, and a series of nonmeat ingredients.

Sausages

Sausages are meat products that are salted & usually seasoned or spiced and are an example of comminuted meet products that are generally recognized as emulsified, stuffed, linked, smoked, and cooked meat products. Based on the product characteristics and processing methods, they are broadly divided into three categories: **fresh sausages, cured sausages and fermented sausages**. In all cases meat is communited to reduce meat and fat particle size (grinding, mincing, chopping, or flaking), mixing with ingredients, stuffing into specific casing, linking to obtain specific lengths and finally, packaging. Sausages might be of ground and emulsion type. In the ground variety of sausages discrete particles of meat are seen on the other hand, in emulsion type sausages fat is emulsified & stabilized by lean component. Sausages were developed to utilize low- quality meats such as trimmings head, shoulder & by- products of the meat. The processing of sausages is a continuous sequence of steps (Fig 23.1), which are all equally important.

Selection of Ingredients

Sausage ingredients include:

- Meat - based on consideration of fat/protein; moisture/protein and myoglobin concentration

- Moisture - added as ice at time of chopping in a number of fresh and smoked sausages
- Curing ingredients - salt, sodiuim nitrite and/or nitrate and sugar
- Seasonings - may include spices, such as black peper, paprika, mace and cinamon; herbs that may include thyme and savory; vegetables such as�� garlic and onion and other substances, such as flavor enhancers
- Fillers and binders - occasionally used to improve color, binding properties, slicing characteristics, altering flavor or reducing costs
- Ascorbic acid - used to improve color in smoked sausages
- Other additives - may include liquid smoke

Milk protein have been utilized as fillers, binders and extenders in cooked, comminuted meat products to reduce cook shrink and formulation cost, as well as to improve emulsifying capacity, emulsion stability, water binding, potential nutritive value and slicing characteristics. These proteins significantly increase the gel strength of meat proteins and it has been shown that there has a synergistic effect between milk proteins and salt soluble meat proteins, through covalent cross linkages.

Addition of caseinate stabilizes the meat emulsion as required in the sausage mix. It thickens the gravy during frying and prevents it running out, but excess incorporation of caseinate may result in drying up of the sausages. Further addition of water absorbent materials becomes essential when sodium caseinate concentration in sausages exceeds 5%. The greater water holding capacity, lower viscosity and lower cooking losses of sausage batters containing 2% sodium caseinate in comparison to all meat control were observed.

The coprecipitates have good potential in various meat products such as frankfurters, sausage batter and luncheon meats as meat replacers or extenders. Sausage acts as a good medium for the use of coprecipitates. The finely, dispersed dairy protein matrix in sausages also can act as a moisture binding agent, thus, developing the desirable chewy texture besides controlling shrinkage during storage and deformation while slicing. Addition of milk coprecipitate in combined boiled sausages resulted in increased pH, reduced nitroso pigments and increased residual nitrites content in the end product. It is found that both high and low calcium coprecipititates improved the emulsifying capacity, emulsion stability and water holding capacity of meat emulsion in fresh sausages at the 20% replacement level. Supplementation with dairy coprecipitates into boiled beef pork sausage batters up to

30% of meat protein yields emulsion with increased pH, enhanced water binding ability and improved adhesion properties.

ii. Grinding

Meat chunks of variable size and shape with variable fat contents are ground to form uniform cylinders of fat and lean. The screw feed in the barrel of the grinder conveys the meat & presses it in to holes of the grinder plate. The rotating blade cut the compressed meat and aids in filling the grinder plate holes.

iii. Mixing

Cylinders of fat and lean obtained by grinding are tumbled in a mixer to give a uniform distribution of fat and lean particles. This can be used for coarse ground sausages or for emulsion type sausages by utilizing a chopper or emulsifier and with suitable additions of required ingredient to obtain the desired texture & uniformity of composition.

iv. Chopping

It is often used as a means of batching the sausage mix, the mixed batch being transferred to an emulsifier or acquiring the desired texture.

v. Emulsifying

This machine combines the principle of grinding and chopping. Emulsifier machine handles large volumes of meat rapidly to produce a desired texture. Speed of handling material and high degree of disintegration of meat tissue help in obtaining desired textures. In the preparation of sausage, the protein and water of the meat mixture form a matrix than encapsulates the fat portion. In a meat emulsion the protein myosin acts as the primary emulsifying agent. The addition of salt to the product is to release the myosin from the muscle fiber. The emulsion is generally formed by mixing the meat with salt and other ingredients in a chopper, which aids in disrupting the fibers and facilitates the release of myosin.

vi. Stuffing

Sausage emulsion also known in the trade as mix sausage dough or batter is transferred to stuffers for extending the mix or emulsion into **casings**. At this point, the size and shape of the product is determined. Generally three type of stuffing devices are used.

- Piston

- Pump
- Combination of piston & pump

In the past, the casing of the sausages were made from animal casings, however this was a limiting factor for the production of sausages. Today, the casings are made of cellulosic and regenerated collagen. The limiting factor now, is the supply of meat and the cost of it. Fermented sausages are further subjected for the fermentation and maturation. Fermentation of meat constituents results in flavor development, improvement of shelf life and improved quality and food safety. Sausage batter is inoculated with the started bacteria composed of **selected lactic acid bacteria (LAB)** i.e. homofermentative lactobacilli *(Lb pentosus, Lb plantarum, Lb sake, Lb curvatus),* pediococci (*Pediococcus acidilactici*, *Pediococcus cerevisiae*) and gram positive catalase positive cocci (GCC) i.e. non-pathogenic, coagulase-negative staphylococci (*Staphylococcus carnosus, Staphylococcus xylosus, Staphylococcus piscifermentans)* . Small manufacturers use spontaneous fermentation without adding starter culture.

vii. Linking and tying

After the emulsion is stuffed in to casings, the encased mass is tied with thread of fastened with metal clips. In the case of small sausages such as Frankfurters stuffed casing are twisted or drawn together to produces links either by hand or with mechanical devices.

Large sausages items are tied or slipped on one end with a hanging tie and suspended from a smoke stick or hook so the entire surface is free from contact with the equipment. This permits a good flow of air around the sausage in the smoke house and prevents touch marks and spotting due to contact with adjacently hanging product.

viii. Smoking & cooking

The draped smoker picks are placed on smoke trees or trolleys with 12-18 specs per tree. The smoke house operation is essentially a specialized drying and cooking operation in which sausage emulsion is coagulated. Encased sausage at the time of introduction in to the smoke house usually has an internal temp of 60-70F. During cooking this rises to 155 to 160F.

ix. Chilling

After smoking and cooking the product is showered with cold water and than chilled by refrigeration chilling is frequently done with a brine solution by dipping or spraying the products. (a 6% salt brine) balanced within leaching of salt from the sausage and imbibing of water by the sausage.

x. Peeling & packaging

After properly chilling the product usually to an ultimate temp of 35 to 40F, the cellulosic casings on frankfurter and slicing bologna are removed. This is known as the peeling operation.

b. Semi dry sausages

Semi dry sausages are usually made from pork or beef or a mixture of the two and are characterized by a moisture content ranging from 40- 45%, e.g. summer sausage, G�teborg Sausage, Cerevelat, Thuringian, Holsteiner. They have excellent keeping quality with need of little refrigeration because

(1) Some reduction in microbiogical contamination is achieved in the cooking process
(2) A high salt to moisture ratio contributes to retarding bacterial growth
(3) A low pH (5.3 or less) provides the tangy flavor and serves a protective food and good keeping quality is achieved with a pH of 4.8 to 5.0 and with a total acidity of 0.75 to 1% lactic acid.

Grind pork trimmings

↓

Place the trimmings in a mixer; add the salt sugar spices, cure and starter culture and mix for 2 to 3 minute.

↓

Regrind the mix

↓

Hold the mix for 12- 72 hr at 40°F

↓ stuff

Warm water shower for 2 min to wash the sausage surface free of any adhering particles

↓

Smoke the encased sausage for 16 hr at 110°F

↓ Shower with cold water /15 min

Allows to stand at room temp so the surface dies and then chill to 40°F

Fig. Manufacturing method of semi-dry sausages

Dry sausages

Semi-dried sausages are smoked and cooked to varying degrees, whereas dry sausages are not cooked and only with some products smoke is applied. The manufacture of dry sausages is more difficult to control than that of semidried sausages. Overall processing time may require up to 90 days. As a result of this prolonged holding the sausages are vulnerable to chemical, microbiological degradation. However, when prepared properly the finished sausages are usually stable and can be held with little or no refrigeration. Examples of dry sausages are Geneva salami, Pepperoni, mortadella etc.

Cured meat products

Curing of meat involves the essentially addition of **sodium chloride, sodium nitrite or sodium nitrate** and adjuncts to meat for increasing shelf-life and to obtain desirable colour and flavour. Sugar may or may not be added along with other ingredient to improve flavour. Curing can be done for both raw/cooked meats cut products as well for comminuted meat products e.g. sausages and similar preparations. Most popular raw cured meat includes ham and bacon which are pork products. However, the technique can be applied to any meat group.

Ingredients used in curing

Essential curing ingredients:

(i) Salt
(ii) Sugar
(iii) Nitrate or nitrite

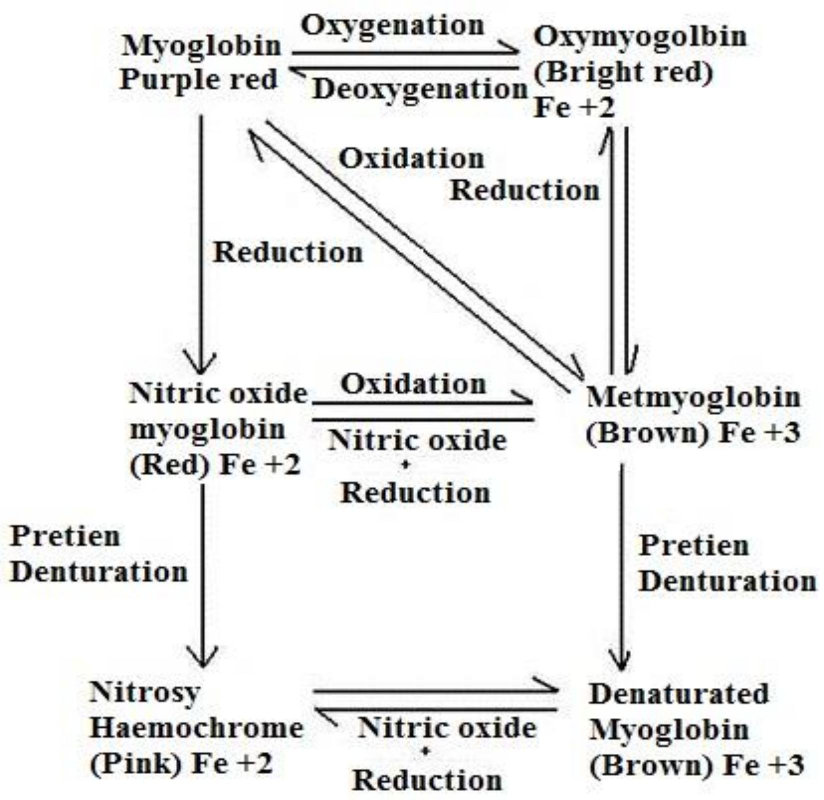
Optional ingredients/curing adjuncts:

(iv) Phosphates
(v) Spices
(vi) Baking Soda
(ii) Sodium erythroborate
(iii) Ascorbic acid
(iv) Mono sodium glutamate
(v) Hydrolysed vegetable proteins,
(vi) vinegar

Commonly used salt sodium chloride (occasionally KCl) is most essential ingredients and it significantly inhibits growth of microorganism including *Clostridium botulinum* due to increase in the osmotic pressure of the medium and dehydration of the muscle. Salt if used alone results in dark coloured, unpalatable dry harsh and salty product. Therefore, it is recommended to be used in combination with sugar and nitrite and nitrate. Salt should be of good quality. Generally dry salting utilizes higher levels of salts; however, acceptable level of salt is about 3% for most of the meats and about 2% for bacon. Nitrite/nitrate has as well a small inhibitory effect on *C. botulinum*. However, it plays very important role in colour fixation of the cured meat. On the other hand sugar contributes to flavour and colour development due to mailard browning and also helps in increasing shelf life by controlling of bacterial growth. Endogenous low molecular weight components in the sarcoplasma of the meat promote the formation of nitric oxide, myoglobin and nitrite decomposition.

Chemistry of curing process and meat colour development

During the dry curing process salt in dry form is rubbed on the surface of the meat whereas in meat wet curing meat portion is immersed in the curing solution. The latest techniques of curing includes use of artery pumping, multiple needle injection, thermal or hot cures, tumbling, massaging, are employed to accelerate the curing the processes. In all cases, salt diffuses into the meat, causing some of the expelled protein to diffuse back in and the meat to swell. The salt � protein complex binds the water well thus the water holding capacity of proteins generally increases during curing. The final meat contains increased ash due to the absorbed salts. Generally salting results in darkening of the colour. To counteract the effect of salt nitrite/nitrates are added to salt which fix the desirable pink colour of the meat. In the curing, nitrite reacts with muscle pigment myoglobin to give purple-red coloured nitroso-myoglobin. On the cooking this is further converted into nitrosomyochrome which gives typical pink clour to the meat. It is further claimed that nitrite has a significant beneficial effect on the flavour of cured meats by preventing oxidation through the antioxidative activity of nitric oxide-myoglobin and s nitrocysteine, a component found during the curing process.



Colour fixation in meat

A major detrimental change that can occur in cured meat during storage is the oxidation of nitric oxide hemochromagen (pink) or nitric oxide myoglobin (red) to brown metamyoglobin. The rate of oxidation increases with increasing oxygen content, therefore cured meat should be preferably packaged in a container from which oxygen is excluded.

Acceptable levels of nitrite used in meat and meat products are 100-200 ppm. The use of nitrite in cured meat may be hazardous if it is used at higher concentration with improper mixing, as it reacts with amines, especially secondary amines, to form N � nitrosamines, which may be carcinogenic. High temperature may also induce nitrosamine formation.

Grind Milling

Grinding:

Grinding (milling) is used for the size reduction of solid dry material. It may also improve the eating quality and/or suitability of the material for further processing.

Milling:

Milling is also used to crush cane sugar, to facilitate the extraction of sugar in sugar and rum factories.

Crushing:

Crushing covers, for instance, breaking the skin of berries and then crushing the berries to liberate the must. This process is necessary to facilitate the yeasts' multiplication and also to conduct traditional macerations before pressing.

Field of application:

Grinding/milling is applied in sectors in the food industry where dry solid materials are processed, for example, the animal feed industry, food products in flour milling industry, breweries, sugar industry, dairy industry (milk powder, lactose), etc.

Description of processing techniques, methods and equipment:

A whole range of grinding/milling techniques and equipment are available for application with different types of food.

Grinding/milling can be carried out dry or wet. In wet grinding/milling smaller particle sizes can be attained. Often dry grinding (milling) is combined with sieving or air classification, this results in particle size fractions.

Generally, cyclones are used as an integral part of the process to recover the particulate matter (dust) in extracted air. The recovered material is then reprocessed.

Common types of mills used in the food industry are:

a) Hammer mills:

A hammer mill consists of a horizontal or vertical cylindrical chamber lined with a steel breaker plate and contains a high-speed rotor fitted with hammers along its length. The material is broken apart by impact forces as the hammers drive it against the breaker plate.

b) Ball mills:

The mill consists of a slowly rotating, horizontal steel cylinder, half filled with steel balls (2.5 – 15 cm in diameter). The final particle size depends on the speed of rotation and on the size of the balls.

c) Roller mills:

The mill consists of two or more steel rollers which revolve towards each other and pull particles of the food material through the space between the rollers, the space being known as “the nip”. The size of the nip can be adjusted for different food materials

d) Disc mills:

Disc mills consist of either a single rotating disc in a stationary casing or two discs rotating in opposite directions. The food material passes through the adjustable gap between the disc and the casing or between the discs. Pin and disc mills have intermeshing pins fixed on the discs and casing. This improves the effectiveness of the milling.

e) High pressure grinding rolls:

A high pressure grinding roll, often referred to as HPGRs or roller press, consists out of two rollers with the same dimensions, which are rotating against each other with the same circumferential speed. The special feeding of bulk material through a hopper leads to a material bed between the two rollers. The bearing units of one roller can move linearly and are pressed against the material bed by springs or hydraulic cylinders. The pressures in the material bed are greater than 50 MPa (7,000 PSI). In general, they achieve 100 to 300 MPa. By this the material bed is compacted to a solid volume portion of more than 80%.

The roller press has a certain similarity to roller crushers and roller presses for the compacting of powders, but purpose, construction and operation mode are different.

Extreme pressure causes the particles inside of the compacted material bed to fracture into finer particles and also causes micro fracturing at the grain size level. Compared to ball mills HPGRs achieve a 30 to 50% lower specific energy consumption, although they are not as common as ball mills since they are a newer technology.A similar type of intermediate crusher is the edge runner, which consists of a circular pan with two or more heavy wheels known as mullers rotating within it; material to be crushed is shoved underneath the wheels using attached plow blades.

FOOD ADDITIVES SAFETY AND EFFECTS

Introduction:

With the advent of food processing, food additives play an important role in providing a food supply as well as meeting the consumers need.

Food Additives:

Food additives means any substance either natural or synthetic intentionally added to food for a

technological purpose in the processing, packaging, transport or storage of such food. Food additive is not normally consumed as a food by itself and not normally used as a typical ingredient of food.

The term does not include contaminants or substances added to food for maintaining or improving nutritional qualities as well as seasonings such as salt, herbs and spices.

Functions of Food Additives:

 Extending the shelf-life by protection against any oxidative deterioration

 Enhancing the flavor and odor

 Improving the texture and consistency of a food

 Stabilizing or retaining the color

 Enhancing the safety and quality by the inhibition of microbial growth.

Principles for using food additives:

 The food additives being used should present no risk to the health of the consumer at the levels of use.

 All food additives shall be used under conditions of good manufacturing practice(GMP)

 GMP includes the quantity of additive added to food shall be limited to the lowest possible level necessary to accomplish its desired effect

 The additive is prepared and handled in the same way as a food ingredient.

 The use of food additives is justified only when such use has an advantage, does not present a hazard to health of and does not deceive the consumer.

Types of Food Additives:

The different types of food additive and their uses are:

 Anti-caking agents – stop ingredients from becoming lumpy.

Examples: Table salt, milk powder, baking powder, cake mixes, grated cheese and instant soup mixes.

 Antioxidants – prevent foods from oxidizing or going rancid.

Examples: Vitamins C and E, selenium, and carotenoids such as beta-carotene, lycopene and lutein.

 Artificial sweeteners – increase the sweetness.

Examples: Aspartame, sucralose, saccharine.

 Emulsifiers – stop fats from clotting together.

Example: Lecithin, mono- and di-glycerols, ammonium phosphatide and xanthan gum.

 Food acids – maintain the right acid level.

Examples: Soft drinks, citrus fruits.

 Colors – enhance or add color.

Examples: Lycopene (E160d), Turmeric (E100)

 Humectants – keep foods moist.

Examples: Glycerin, sorbitol, propylene glycol.

 Flavors – add flavor.

Examples: Spices, herbs, edible yeast, wine.

 Mineral salts – enhance texture and flavor.

Examples: Calcium, sulphur, chlorine

- Preservatives – stop microbes from multiplying and spoiling the food.

Examples: Benzoates, sorbates, nitrates, vit E

- Thickeners and vegetable gums – enhance texture and consistency.

Examples: Agar, collagen, cornstarch

- Glazing agent – improves appearance and can protect food.

Example: Stearic acid, beeswax, shellac

- Gelling agents – alter the texture of foods through gel formation.

Example: Alginates, carrageenans

Effects of Food Additives:

It is often the additives that are used to give a food a marketable quality such as color that most commonly cause allergic reactions. Some of these hypersensitive reactions include:

- Digestive disorders – diarrhoea
- Nervous disorders – hyperactivity, insomnia and irritability
- Respiratory problems – asthma and sinusitis
- Skin problems – hives, itching, rashes and swelling.

It is important to realize that many of the symptoms experienced as a result of food sensitivities can be caused by other disorders. Medical diagnosis is important.

Applications of Food Additives:

The application of food additives has a rich history.

 Before the development of refrigeration and thermal processing, meat and fish were often salted to be preserved.

 The addition of sugar and vinegar was often used to retain the safety, flavor, and texture of fruits and vegetables.

 These and other practical food ingredients are readily used in the typical home kitchen and include baking soda, baking powder, yeast and food colorings.

Safety Assessment of Food Additives:

1. The toxicity of food additives is generally low.

2. The Joint Food Agriculture Organization / World Health Organization Expert Committee on Food Additives (JECFA) is the international food safety authority responsible for collecting and evaluating scientific data on food additives and allocate a safety reference to the food additives evaluated.

3. The Acceptable Daily Intake (ADI) of a chemical is the estimate amount of a substance in food or water expressed on a body weight basis that can be ingested daily over a lifetime without any health risk.

4. A dietary intake above the ADI does not automatically mean that health is at risk. Transient excursion above the ADI would have no health consequences provided that the average intake over long period is not exceeded as the emphasis of ADI is a lifetime exposure.

5. A small proportion of the population may be intolerant to some food additives and may have acute effects

Example: Small amount of sulphur dioxide may cause bronchoconstriction and asthmatic reaction for certain people with allergic conditions.

Precautions:

JECFA recommended some precautions regarding food additives to the people. They are:

- The public were recommended to buy foods from reputable sources.
- The label of prepackaged food can be read carefully in particular the ingredient list for food additives added.
- In choosing foods those which have abnormal color, odor and texture should be avoided and the food which tastes abnormally cannot be consumed.
- Any abnormalities of foods can be reported to the authority for investigation and other follow-up actions.
- Members of the public are advised to take a balanced diet so as to avoid excessive exposure to food additives from a small range of food items.

SEPERATION AND CONCENTRATION OF FOOD COMPONENTS

INTRODUCTION

Foods are complex mixtures of compounds and the extraction or separation of food components is fundamental for the preparation of ingredients to be used in other processes for e.g., cooking oils from oilseeds, sugar from cane or beet, or gelatine from connective tissue. For retrieval of high-value compounds, such as essential oils and enzymes e.g., papain from papaya for meat tenderisation or rennet from calf stomachs for cheese making. Each operation is used as an aid to processing and is not intended to preserve the food. Changes to both the organoleptic and nutritional qualities of products are caused by the intentional separation or concentration of food components, but generally the processing conditions cause little damage to these properties of foods.

There are other types of separation methods such as,

- Those used to clean foods by separating contaminating materials.
- Those used to sort foods by separating them into classes based on size, colour or shape.
- Those used to selectively remove water from foods using heat by evaporation.
- Those by dehydration.
- Those by crystallisation.
- By alcohol by distillation.
- Osmotic dehydration of fruits and vegetables, by soaking in concentrated solutions of sugar or salt respectively.

There are several types of separation. In physical separation of food components, by centrifugation, filtration, expression, solvent extraction and membrane separation are described.

There are two main categories:

1. Separation of liquids and solids where either one or both components may be valuable (e.g. fruit juices, pectin and coffee soluble), or liquid-liquid separation (e.g. cream and skimmed milk

2. Separation of small amounts of solids from liquids. The main purpose is purification of water or clarification of liquids such as wine, beer, juices, etc. and the solids are not a product.

CENTRIFUGATION

There are two main applications of centrifugation: separation of immiscible liquids and separation of solids from liquids. Separation of solid particles from air by centrifugal action in the `cyclone' separator is described in more detail in the section describing spay drying.

Centrifuges are classified into three groups for:

1.separation of immiscible liquids;

2 clarification of liquids by removal of small amounts of solids (centrifugal clarifiers);

3 removal of solids (desludging, decanting or dewatering centrifuges).

SOLID-LIQUID SEPERATION

The fruit fibres are suspended in juice. Sugar is crystallized from the solution and separated thereafter. The solid matter either floats or settles in the tank in due course of time because of the density difference between the two phrases. To achieve quick setting centrifugal force is used and the process is called centrifugal settling.

LIQUID-LIQUID SEPERATION

Because of density differences, the lighter liquid seperates from the heavier liquid, if allowed to stand for some time. Milk is a good example of emulsion where fat is in the finely dispersed state whereas the skim milk is in continuous phase.

SOLID-GAS SEPERATION

Solid particulates separation from agas stream is very common phenomenon in food processing operations. The seperaion of milk powder from the drying air stream coming from the drying chamber of a spray dryer after drying is a good example of solid-gas separation. The peripheral attachment required for this operation to accomplish is called cyclone separator.

FILTRATION

Filtration is the removal of insoluble solids from a suspension or feed slurry by passing it through a porous material a filter medium. The resulting liquor is termed the ‘filtrate’ and the separated solids are the ‘filter cake’. Filtration is used to clarify liquids by the removal of small amounts of solid particles (e.g. from wine, beer, juices, oils and syrups).

SIEVING

Sieving is a method of using a sieve to distinguish small particles from bigger particles. It is used in flour mills or building sites. Impurities such as husks and stones are extracted from wheat at flour mill. They remove pebbles and stones from sand through sieving. It is a separation technique based on the difference in particle size. The sieve is responsible for retaining the larger particles. The sample is subjected to horizontal or vertical motion during sieving according to the method chosen. This causes a relative movement between the particles and the sieve; the individual particles either pass through the sieve mesh, or are retained on the sieve surface depending on their size.

MAGNETIC SEPERATION

Metal pieces in food products pose a safety risk to consumers and can damage processing equipment. Detection and removal of metal contaminants is becoming common practice in the food processing industry. One approach to reduce or eliminate metallic contamination is the use of magnetic separators. Sources of Metal Contamination Metal contamination may come from a variety of sources including:

- Incoming ingredients and raw materials.
- Processing equipment (grinders, crushers, etc.) general abrasion or vibration causing the loss of nuts and bolts.
- Inadequate personnel practices and environmental causes.

There are several types of materials used for magnetic separation such as,

Alnico magnets, Ceramic magnets, Rare earth magnets.

MEMBRANE CONCENTRATION

The separation or concentration of food components using membranes is well established, especially in the fruit processing, dairy processing and alcoholic beverage industries. It is also used to purify process water and treat wastewaters in a wide variety of food industries. There are seven types of membrane systems in use in food industries, grouped as follows according to the driving force for transport across the membranes.

Hydrostatic pressure systems: reverse osmosis, nanofiltration, ultrafiltration, microfiltration and pervaporation.

Systems where a concentration difference is the driving force: ion-exchange and electrodialysis.

NANO FILTERATION MICRO FILTERATION AND ULTRA FILTERATION:

The term nanofiltration is used when membranes remove materials having molecular weights in the order of 300±1000 Da. This compares to a molecular weight range of 2000±300 000 Da for ultrafiltration membranes, although there is overlap with microfiltration. Nanofiltration is capable of removing ions that contribute significantly to the osmotic pressure and thus allows operation at pressures that are lower than those needed for reverse osmosis. Ultrafiltration membranes have a higher porosity and retain only large molecules (e.g. proteins or colloids) that have a lower osmotic pressure. Smaller solutes are transported across the membrane with the water. Ultrafiltration therefore operates at lower pressures (50±1500 kPa). The most common commercial application of ultrafiltration is in the dairy industry to concentrate milk prior to the manufacture of dairy products or to selectively remove lactose and salts. In cheese manufacture, ultrafiltration has advantages in producing a higher product yield and nutritional value, simpler standardisation of the solids content, lower rennet consumption and easier processing.

PERVAPORATION

Pervaporation is a membrane separation technique in which a liquid feed mixture is separated by partial vaporisation through a non-porous, selectively permeable membrane. It produces a vapour permeate and a liquid retentate. Partial vaporisation is achieved by reducing the pressure on the permeate side of the membrane (vacuum pervaporation) or less commonly, sweeping an inert gas over the permeate side. There are two types of membrane, which are used in two distinct applications: hydrophilic polymers (e.g. polyvinyl alcohol or cellulose acetate) preferentially permit water permeation, whereas hydrophobic polymers.

EFFECTS ON FOODS AND MICRO-ORGANISM

Each of the unit operations described in this chapter is intended to remove components of the food and they are therefore used to intentionally alter or improve the sensory properties of the resulting products. The effects on nutritional value are difficult to assess in most operations and are usually incidental to the main purpose of altering eating qualities. However, with the exception of some types of solvent extraction, these operations take place at ambient temperatures and loss of heat-sensitive nutrients is not significant.

The main changes occur as a result of the physical removal of food components. In milk processing for example, the fat-soluble vitamins, retinol, carotene and vitamin D, are removed in the milkfat when it is separated from skimmed milk and concentrated in cream and butter. Conversely, water soluble vitamins and minerals are largely unchanged in skimmed milk, but substantially reduced in cream and butter. Both types of membrane retain proteins, fats and larger carbohydrates, but the larger pore size of ultrafiltration membranes allows sugars, vitamins and amino acids to be lost.

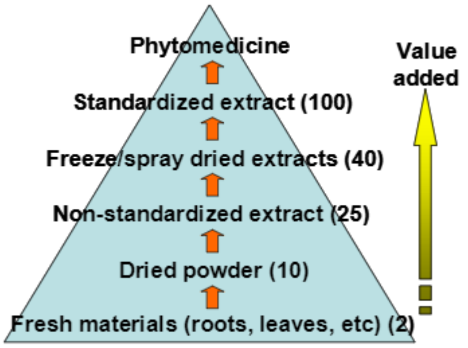
PHYTOCHEMICAL PROCESSING:

PHYTOCHEMICAL – comes from the Greek word “Phyto” for plant. It refers to every naturally occurring chemical presents in plants. Plant are also the source many modern pharmaceutical (drugs). It is estimated that approximately one quarter drugs contain plant extract or active ingredients obtained from plant substances. COSMECEUTICAL – is the term used to describe cosmetic containing ingredients that are bioactive, exerting effects on people. It is a blend of cosmetic and pharmaceutical which has appeared only in the nineties. Examples are anti-wrinkles creams, baldness treatments, moisturizers and sunscreens.

NUTRACEUTICAL – can be any substance that may be considered a food or part of a food that provide medical and health benefits, including the prevention and treatment of disease. Under this broad definition, nutraceutical might be isolated nutrients, dietary supplements or diets, processed foods, herbal products or genetically engineered “designer foods”.

OLEORESIN – are pure extractives of a spice or herb which contain concentrated natural liquid flavourings that contain both volatile and non-volatile flavour components. ESSENTIAL OILS – volatile part of the plant that are largely responsible for its characteristic aroma. It can be applied to enhance health through its holistic effects on the body.

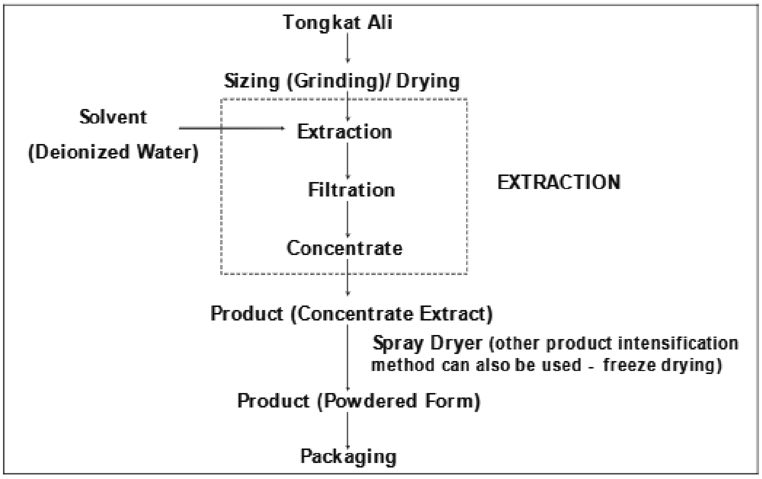
There are several major steps in herbal product manufacturing starting from herbal crop planting to herbal product manufacturing and marketing. Chemical engineers are involved once the herb is harvested where quick preprocessing and correct storage is required. Preprocessing involves reducing the size of the herb through chopping and grinding to prepare for processing while good storage method ensures that the active phytochemicals are maintained before processing. Processing is a critical aspect of herbal production, especially due to the low yield of extracts. Processing methods are usually based on traditional methods such as high pressure water extraction for herbs which are traditionally boiled as decoctions. New innovative methods such as Supercritical Fluid Extraction (SFE) where supercritical fluids such as carbon dioxide under high pressure are utilised to produce herbal extracts need to be developed to produce herbal products of higher yield, lower operating costs, and faster production times. Packaging and sale follow processing. Herbal products can be sold in a variety of forms such as capsules, tablets, tea bags, extracts and essential oils. Good Manufacturing Practice (GMP) is a code of practice used by the medical and health related industries including the pharmaceutical industry in an effort to maintain the highest standards of quality in the development, manufacture and control of medicinal products. In Malaysia, the GMP certification is issued by National Pharmaceutical Control Bureau (NPCB), which is issued as an annual Manufacturing License to which it can be revoked at any time if the facilities are found not to meet the standards of GMP. Herbal medicine products can only be sold by manufacturers who utilize GMP as it ensures that the herbal product safety and purity. In addition, manufacturers intending to export their products must ensure that their target markets accept their GMP practices.

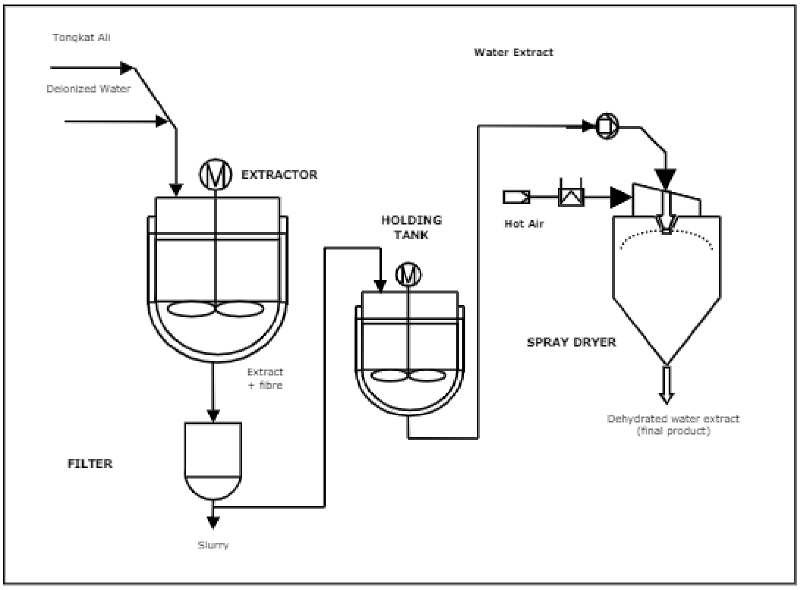


Unit Operation	Chemical Engineering	Phytochemical Processing
Mass Transfer	• Distillation • Solid Liquid Extraction • Supercritical Fluid Extraction	• Essential Oil extraction • Herbal leaching • Supercritical Fluid Extraction
Process Design	• Model based design • Process synthesis and design • Optimisation	• Model based design • Process synthesis and design • Optimisation
Bioprocess Engineering	• Downstream processing • Scale up	• Phytochemical approach • Scale up
Powder Technology	• Mixing	• Capsule preparation
Instrumentation and Measurement	• On line analysis • Process Control	• Phytochemical analysis • Process Control
Environmental Engineering	• Pollution prevention through substitution • Biomass conversion • Waste reduction	• Solvent design and substitution • Biomass conversion • Waste reduction

The Chemical Engineering Pilot Plant (CEPP) at Universiti Teknologi Malaysia (UTM) was set up in 1998 for the following objectives: • To bridge the funding gap between research findings and commercialised products • To assist Malaysia in building indigenous products and processes • To assist Malaysia in building up indigenous expertise Phytochemical processing was chosen as a focus area in the Fine Chemical section at the Pilot Plant. The primary emphasis in this area is on improving processing techniques for local herbal products as well as developing products for market testing as well as small scale production Several major equipment used for phytochemical processing include: • 300 litre Extraction vessel for producing extracts • Low Pressure Super Critical Extractor, a novel supercritical extraction process that uses Tetrafloroethane as a supercritical fluid which requires a lower pressure than carbon dioxide • Hydro distillation unit for essential oil production • Spray Dryer for herbal extract production • Freeze Dryer for herbal extract production • Centrifuge for concentrating and separating extracts • Homogenizer for mixing extracts • Turbo Extractor Distiller, an extractor that combines a grinder, extractor and distiller which can be used in producing essential oils more efficiently As the analysis of the raw material, herbal extract, pure phytochemical and final products are critical to quality assurance and process development, several analytical equipment are available at CEPP which comprise of: • High Performance Liquid Chromatograph (HPLC) • Liquid Chromatography – Mass Spectrometer • Spectrophotometer Significant CEPP Research Projects and Industrial Collaborations In the short time since it's formation in 1998, CEPP has been involved in several projects which include: 1. MHCP production from Cinnamon 2. Phytochemical production from Zingiber Zerumbet and Curcuma Xanthorhizza 3. Production of oleoresins and essential oils from Zingiber officinale 4. Tongkat Ali production process development 5. Aromatherapy product development 6. Vitamin E product formulation A key concept in many of CEPP's projects is the biorefinery concept where raw plant material is totally fractionated and converted into a spectrum of valuable products. Cinnamon (kayu manis), a common spice used in Asian cooking, is one such plant where this concept can be applied. Among products

from Cinnamon include essential oils, oleoresins, extracts, and purified phytochemicals. One high value product from Cinnamon is Methyl Hydroxy Chalcone Polymer (MHCP), a phytochemical with scientifically proven anti diabetic properties. MHCP has been found to increase cellular glucose oxidation by a factor of up to 20 fold, improve the function of insulin receptors in cells, and has a strong anti-oxidant effect (Anderson and Schmidt 2002). An IRPA funded project entitled 'Production of Speciality Phytochemicals from Cinnamomum Zeylanicum' CEPP together with the UTM Science faculty as well as industry collaborators started in 2002. Its primary aim was to develop an environmentally safe and economically viable process to produce standardised Cinnamon extracts and purified MHCP. These extracts would be then used as functional food additives or phytomedicines. Apart from Cinnamon, CEPP has also been involved in the production of phytochemicals from members of the zingiberase (ginger) family, Zingiber Zerumbet (lempoyang) and Curcuma Xanthorrhiza (temu lawak). Another IRPA funded project together with the Science faculty and industry collaborators was started in 2001 to develop process design to extract these two species. The active ingredients in Lempoyang and Temu Lawak are zerumbone, which has anti viral and potentially anti HIV properties, and xanthorrizol, which has anti bacterial properties. The process design project involves process detailed design, scale up studies, total plant utilisation through biorefinery approach, and phytochemical purification. An example of the Turbo Extraction Distillation device and its applications is shown in Figure 6. Another product from the ginger family developed at CEPP are the essential oils and oleoresins from the household ginger, zingiber officinale. Ginger is freely available in Malaysia at a low price, therefore value added products can increase the value of this crop. In addition, many traditional cures in Malay, Indian, Chinese, and Indigenous groups are based on ginger (Ahmed and Sharma 1997). In collaboration with Universiti Malaysia Sabah, CEPP focused on the process design, process optimisation, and product commercialisation of essential oil and oleo resin production from ginger. Besides IRPA funded projects, CEPP also focuses strongly on industry based development projects. A key and visible success process development at CEPP is the development of the Tongkat Ali water extract production process, which is currently utilised by Phytes Biotek Sdn Bhd and the Forest Research Institute of Malaysia (FRIM). Phytes Biotek, the country's first Malaysian Venture Capital (MAVCAP) investment, is currently the largest commercial producer of Tongkat Ali extracts. ongkat Ali extraction by Phytes Biotek previously had an extraction time of over 4 hours and low yield. After process development at CEPP, it was found that high pressure and temperature extraction increased the yield and reduced the extraction time to part from herbal extracts such as Tongkat Ali, CEPP has also developed aromatherapy products, as shown in Figure 9. CEPP has helped created several formulations in different forms such as lotions, sprays, and candles. A successful set of formulations are currently being marketed by Fyto-Elegance, another MAVCAP funded company. CEPP has also done product formulations for spray dried Vitamin E from Palm Oil sources. The product formulation proved to be of high demand in countries such as Japan where in powder form it proved to be easily formulated and standardised.





Effects of food processing on food nutrition.

Nearly every food preparation process reduces the amount of nutrients in food. In particular, processes that expose foods to high levels of heat, light, and/or oxygen cause the greatest nutrient loss. Nutrients can also be "washed out" of foods by fluids that are introduced during a cooking process. For example, boiling a potato can cause much of the potato's B and C vitamins to migrate to the boiling water. You'll still benefit from those nutrients if you consume the liquid (i.e. if the potato and water are being turned into potato soup), but not if you throw away the liquid. Similar losses also occur when you broil, roast, or fry in oil, and then drain off the drippings.

Consuming Raw Foods

The amount of nutrient loss caused by cooking has encouraged some health-conscious consumers to eat more raw foods. In general, this is a positive step. However, cooking is also beneficial, because it kills potentially harmful microorganisms that are present in the food supply. In particular, poultry and ground meats (e.g. hamburger) should always be thoroughly cooked, and the surface of all fruits and vegetables should be carefully washed before eating. To learn more about preventing common food-borne diseases,

Grilling Meats

Outdoor grilling is a popular cooking method, primarily because of the wonderful taste it imparts on meats. It can also be a healthy alternative to other cooking methods, because some of the meat's saturated fat content is reduced by the grilling process. However, grilling also presents a health risk. Two separate types of carcinogenic compounds are produced by high-temperature grilling:

- **heterocyclic amines (HCAs)**
  HCAs form when a meat is directly exposed to a flame or very high-temperature surface. The creatine-rich meat juices react with the heat to form various HCAs, including amino-imidazo-quinolines, amino-imidazo-quinoxalines, amino-imidazo-pyridines, and aminocarbolines. HCAs have been shown to cause DNA mutation, and may be a factor in the development of certain cancers.
- **polycyclic aromatic hydrocarbons (PAHs)**
  PAHs form in smoke that's produced when fat from the meat ignites or drips on the hot coals of the grill. Various PAHs present in the resulting smoke, including benzo[a]pyrene and dibenzo[a,h]anthracene, adhere to the outside surface of the grilled meat. PAH exposure is also believed to be linked to certain cancers.

HCA and PAH content in meats can be dramatically reduced by slight alterations in your grilling method. In particular, the following practices will reduce the amount of HCAs and PAHs formed:

1. **Select leaner meats.**
   Leaner cuts of meat are less likely to drip fat on the grill and produce PAH-laden smoke.

2. **Marinate meats before grilling.**
   Researchers have determined that marinating meat prior to grilling, even for just a few minutes, can reduce HCA formation by 90% or more. It's believed that the marinade forms a protective barrier for the meat juices that prevents the HCA reaction from occurring.
3. **Grill at lower temperatures.**
   Lower temperature "roasting" also greatly reduces HCA formation.
4. **Prevent flare-ups.**
   Flames from grill flare-ups cause the formation of both HCAs and PAHs. Keep an eye on your grill and turn meats frequently to minimize the chance of flare-ups.
5. **Don't overcook meats.**
   While it's important to cook poultry and ground meats thoroughly, be careful not to overcook any meat. Well-done or burnt meats contain higher levels of HCAs than less cooked meats. For thicker cuts of meat, use a meat thermometer to measure doneness rather than just guessing.

Typical Maximum Nutrient Losses (as compared to raw food)

Vitamins	Freeze	Dry	Cook	Cook+Drain	Reheat
Vitamin A	5%	50%	25%	35%	10%
Retinol Activity Equivalent	5%	50%	25%	35%	10%
Alpha Carotene	5%	50%	25%	35%	10%
Beta Carotene	5%	50%	25%	35%	10%
Beta Cryptoxanthin	5%	50%	25%	35%	10%
Lycopene	5%	50%	25%	35%	10%
Lutein+Zeaxanthin	5%	50%	25%	35%	10%
Vitamin C	30%	80%	50%	75%	50%
Thiamin	5%	30%	55%	70%	40%
Riboflavin	0%	10%	25%	45%	5%
Niacin	0%	10%	40%	55%	5%
Vitamin B6	0%	10%	50%	65%	45%
Folate	5%	50%	70%	75%	30%
Food Folate	5%	50%	70%	75%	30%
Folic Acid	5%	50%	70%	75%	30%
Vitamin B12	0%	0%	45%	50%	45%
Minerals	**Freeze**	**Dry**	**Cook**	**Cook+Drain**	**Reheat**
Calcium	5%	0%	20%	25%	0%
Iron	0%	0%	35%	40%	0%
Magnesium	0%	0%	25%	40%	0%
Phosphorus	0%	0%	25%	35%	0%
Potassium	10%	0%	30%	70%	0%
Sodium	0%	0%	25%	55%	0%
Zinc	0%	0%	25%	25%	0%
Copper	10%	0%	40%	45%	0%

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DEPARTMENT OF BIOTECHNOLOGY

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UNIT – IV - FOOD PROCESSING AND PRESERVATION - SBT1607

Food preservation by low temperature

It is a physical method of food preservation lowering the storage temperature of the food will reduce or prevent spoilage by microorganisms and/or chemical reactions.

Methods of food preservation by temperature

Refrigeration Temperatures typically between 45 – 32°F (7.2 – 0°C). Preferably below 38°F(3.34°C). Refrigeration or cold storage of food is a gentle method of food preservation. It has minimum adverse effects on the taste, texture, and the nutritional value of foods. It must be kept in mind, however, that refrigeration has a limited contribution towards preserving food. For most foods, we can expect refrigeration to extend the shelf-life by a few days. In many cases, refrigeration is not the sole means of preserving the food. Refrigeration temperature is a key factor in predicting the length of the storage period. For example, meat will last 6-10 days at 0° C, one day at 22° C and less than one day at 38° C. Household refrigerators are usually run at 4.7 -7°C. Commercial refrigerators are operated at a slightly lower temperature. On an average day, the room temperature is 25° C, so the longer you leave food on the kitchen counter, the sooner it will spoil. Most spoilage microorganisms prefer warmer temperatures, but there are a group of microorganisms called **psychrophilic (**are extremophilic organisms that are capable of growth and reproduction in low temperatures, ranging from −20 °C to +10 °C. They are found in places that are permanently cold, such as the polar regions and the deep sea**),** which will grow at refrigerated temperatures.

Refrigeration and freezing are used on almost all foods: meats, fruits, vegetables, beverages, etc. In general, refrigeration has no effect on a food's taste or texture. Freezing has no effect on the taste or texture of most meats, has minimal effects on vegetables, but often completely changes fruits (which become mushy). Refrigeration's minimal effects account for its wide popularity.

- **Chilling**

Chilling is a processing technique in which the temperature of a food is reduced and kept at a temperature between –1°C and 8°C. The objective of cooling and chilling is to reduce the rate of biochemical and microbiological changes in foods, in order to extend the shelf life of fresh and processed foods, or to maintain a certain temperature in a food process, e.g. in the fermentation and treatment of beer. Cooling is also used to promote a change of state of aggregation, e.g. crystallization. In the wine industry, cooling (chilling) is applied to clarify the must before fermentation. The objective of cold stabilization is to obtain the precipitation of tartrates (in wines) or fatty acids (in spirits) before bottling.

Advantages of Chilling

- There is very little change in flavour, colour, texture or shape.
- Fresh foods can be kept at maximum quality for a longer time.
- The consumer can be offered a much larger range of fresh and convenience foods.
- Nutrients are not destroyed.

Freezing

In food processing, method of preserving food by lowering the temperature to inhibit microorganism growth. The method has been used for centuries in cold regions, and a patent was issued in Britain as early as 1842 for freezing food by immersion in an ice and salt brine. Except for beef and venison, which benefit from an aging process, meat is frozen as promptly as possible after slaughter, with best results at temperatures of 0 °F (−18 °C) or lower. Fruits are frozen in a syrup or dry sugar pack to exclude air and prevent both oxidation and desiccation.

Principles of Freezing

- Does not sterilize food.
- Extreme cold (0^{o}F or -18^{o}C colder):
    - Stops growth of microorganisms and
    - Slows chemical changes, such as enzymatic reactions.
- Freezing is the unit operation in which the temperature of a food is reduced below its freezing point and a proportion of the water undergoes a change in state to form ice crystals. The immobilization of water to ice and the resulting concentration of dissolved solutes in unfrozen water lower the water activity (a_w) of the food
- Preservation is achieved by a combination of *low temperatures*, *reduced water activity* and, in some foods, pre-treatment by blanching.

Advantages of Freezing

- Many foods can be frozen.
- Natural colour, flavours and nutritive value retained.

- Texture usually better than other methods of food preservation.
- Foods can be frozen in less time than they can be dried or canned.
- Proportions can be adapted to needs unlike other home preservation methods. Kitchen remains cool and comfortable
- Frozen food can be kept for a very long period of time. Usually about 3 months.

Deep freezing is the reduction of temperature in a food to a point where microbial activity cease

Disadvantages of Freezing

- Texture of some foods is undesirable because of freezing process.
- Initial investment and cost of maintaining freezer is high.
- Storage space limited by capacity of freezer

Methods of freezing

Freezing techniques include:

- The use of cold air blasts or other low temperature gases coming in contact with the food, e.g. blasts, tunnel, fluidized bed, spiral, belt freezers.
- Indirect contact freezing, e.g. plate freezers, where packaged foods or liquids are brought into contact with metal surfaces (plate, cylinders) cooled by circulating refrigerant (multi-plate freezers).
- Direct immersion of the food into a liquid refrigerant, or spraying liquid refrigerant over the food (e.g. liquid nitrogen, and freon, sugar or salt solutions).

TYPES OF FREEZING:

AIR FREEZING – Products frozen by either "still" or "blast" forced air.

- Cheapest (investment)
- "still" slowest, more changes in product
- "blast" faster, more commonly used

INDIRECT CONTACT – Food placed in direct contact with cooled metal surface.

- Relatively faster
- More expensive

DIRECT CONTACT – Food placed in direct contact with refrigerant (liquid nitrogen, “green” Freon, carbon dioxide snow)

- Faster
- Expensive
- freeze individual food particles

Freezing equipment

- **Mechanical Freezers**

– Evaporate and compress the refrigerant in a continuous cycle

- **Cryogenic Systems**

– Use solid and liquid CO_2, N_2 directly in contact with the food

Cooled-air freezers

Blast freezers

Fluidized-bed freezers

Rapid Freezer

Cooled-surface freezers

Plate freezing, Cooled-liquid freezers, Immersion freezing, Cryogenic freezers

MOIST HEAT PERSERVATION

BLANCHING

Blanching is a process used prior to freezing, canning or drying in which fruits or vegetables are heated for inactivating natural / endogenous enzymes, improving texture, maintaining colour, flavour, nutritional value and removing entrapped air. So, blanching serves a variety of functions -- the main function is to destroy enzymatic activity in vegetables and some fruits before main thermal processing. Peroxidase and catalase are the most heat resistant enzymes and the activity of these enzymes indicates the effectiveness of a blanching treatment. If both are inactivated then it is assumed that other enzymes must be inactivated. It is not a method of preservation but it is a pre-treatment normally given in between the preparation of the raw material and processing treatment (sterilization, dehydration and freezing). Blanching is also combined with peeling and / or cleaning of food to achieve savings in energy, space requirement and equipment costs.

The factors which influence blanching time are:

• type of fruit or vegetable

• size of the pieces of food

• blanching temperature

• method of heating

PASTEURIZATION

It heat-treatment process that destroys pathogenic microorganisms in certain foods and beverages. It is named for the French scientist Louis Pasteur, who in the 1860s demonstrated that abnormal fermentation of wine and beer could be prevented by heating the beverages to about 57° C (135° F) for a few minutes. Pasteurization of milk, widely practiced in several countries, notably the United States, requires temperatures of about 63° C (145° F) maintained for 30 minutes or, alternatively, heating to a higher temperature, 72° C (162° F), and holding for 15 seconds (and yet higher temperatures for shorter periods of time). The times and temperatures are those determined to be necessary to destroy the *Mycobacterium tuberculosis* and other more heat-resistant of the non-spore-forming, disease-causing microorganisms found in milk. The treatment also destroys most of the microorganisms that cause spoilage and so prolongs the storage time of food.

Ultra-high-temperature (UHT) pasteurization involves heating milk or cream to 138°to 150° C (280° to 302° F) for one or two seconds.

TYNDALLIZATION

It also called fractional sterilization and discontinuous heating, is a form of sterilization that involves boiling goods in cans or jars for about 20 minutes a day, for three days in a row.

Tyndall's method is relatively simple but somewhat time-consuming. Food is placed in a can or heat-proof storage container, which is then boiled for about 15 to 20 minutes each day, for three days in a row. The rest of the time, it just sits on the counter at room temperature. The boiling temperature must be at least the boiling point of water, or 100 degrees Centigrade (212 degrees Fahrenheit). The idea behind this is that any microorganisms that don't get killed by the first day's boiling session will germinate from the warmth and get released from their spore coatings, and then get killed in the next day's boiling session, or, if they survive that one, then on the third day's boiling session.

DRY HEAT PRESERVATION

Microwave Sterilization

Microwave sterilization of food is a thermal process and performed by passing non ionizing microwave radiation usually at a frequency of 2.125 GHz (a wavelength of 12.212 cm) through the food. Microwave radiation frequency used in food industry is in between common radio and infrared frequencies. Microwave heating takes place due to the polarization effect of electromagnetic radiation at frequencies between 300 MHz and 300 GHz. It delivers energy to the food package under pressure and controlled temperature to achieve inactivation of bacteria harmful for humans and also enhance shelf life of foods.

DRYING

Drying (dehydrating) food is one of the oldest method of food preservation. Dehydration is the process of removing water or moisture from a food product. Removing moisture in Dehydrated foods are ideal for packing, transportation and storage because they weigh much less than their non-dried form of food and do not require refrigeration. Drying food is also a way of preserving seasonal foods for later use.

How dehydration preserves foods?, They can be spoiled by food microorganisms or through enzymatic reactions within the food. Bacteria, yeast and molds require sufficient amount of moisture in food for their growth and thus causing spoilage problem. Reducing the moisture content of food restricts the growth of spoilage-causing microorganisms and slower down enzymatic reactions within the food. The combine effect of this helps to prevent spoilage in dried food.

Dehydration / Sun drying is a Good Method of Food Preservation

- Not Required Electricity.
- Less Time Consuming
- Makes Winter Meals Easier.
- Requires Less Storage Space.
- Easy to handle

Solar Drying

It is differentiated from sun drying by the use of instruments / equipment to collect the sun‘s radiation in order to use radiative energy for drying applications. • The use of solar drier traps the freely available sun energy ensuring good product quality

Food preservation by Fermentation

The French chemist Louis Pasteur founded zymology, when in 1856 he connected yeast to fermentation. When studying the fermentation of sugar to alcohol by yeast, Pasteur concluded that the fermentation was catalyzed by a vital force, called "ferments", within the yeast cells. The "ferments" were thought to function only within living organisms. "Alcoholic fermentation is an act correlated with the life and organization of the yeast cells, not with the death or putrefaction of the cells" he wrote. Fermentation is the breakdown of carbs like starch and sugar by bacteria and yeast and an ancient technique of preserving food. Common fermented foods include kimchi, sauerkraut, kefir, tempeh, kombucha, wine, beer and yogurt. These foods may reduce heart disease risk and aid digestion, immunity, and weight loss.

Uses

Food fermentation is the conversion of sugars and other carbohydrates into alcohol or preservative organic acids and carbon dioxide. All three products have found human uses. The production of alcohol is made use of when fruit juices are converted to wine, when grains are made into beer, and when foods rich in starch, such as potatoes, are fermented and then distilled to make spirits such as gin and vodka. The production of carbon dioxide is used to leaven bread. The production of organic acids is exploited to preserve and flavor vegetables and dairy products. Food fermentation serves five main purposes: to enrich the diet through development of a diversity of flavors, aromas, and textures in food substrates; to preserve substantial amounts of food through lactic acid, alcohol, acetic acid, and alkaline fermentations; to enrich food substrates with protein, essential amino acids, and vitamins; to eliminate antinutrients; and to reduce cooking time and the associated use of fuel.

How Fermentation Techniques Preserve Food

The desirable bacteria cause less deterioration of the food by inhibiting the growth of the spoiling types of bacteria. Some fermenting processes lower the pH of foods preventing harmful microorganisms to live with too acidic an environment. Controlled fermentation processes encourage the growth of good bacteria which starves, or fights off, the bad microbes. Depending on what is fermented, or the manner of fermentation, foods can remain consumable for years.

The fermentation process can be stopped by other means of preserving, such as, canning (heating), drying, or freezing. Heat (pasteurization, 145° F), and low temperatures (freezing, 32° F or below) stops the fermenting process by slowing, or killing, the preferred microorganisms, and other bacteria. A few undesirable bacteria are not killed by either means, and continue to grow. When the beneficial bacteria are gone, the unfavorable bacteria take over, growing exponentially. This causes rotting disease, illness and inedible foods. When the good guys are present and happy, the food remains edible.

Additional Benefits of Fermenting

Fermenting enhances the flavors of some foods, as with the extended fermentation of black teas, aged cheese, wine, and beer, which creates their distinctive flavors. Cocoa beans have to be fermented (composted) for a few days to remove the pods and to enhance the flavor of chocolate.

Fermenting makes foods more edible by changing chemical compounds, or predigesting, the foods for us. There are extreme examples of poisonous plants like cassava that are converted to edible products by fermenting. Some coffee beans are hulled by a wet fermenting process, as opposed to a dry process.

Fermentation increases nutritional values with the biochemical exchange it produces, and allows us to live healthier lives. Here are a few examples:

- The sprouting of grains, seeds, and nuts, multiplies the amino acid, vitamin, and mineral content and antioxidant qualities of the starting product.
- Fermented beans are easier for our bodies to digest, like the proteins found in soy beans that are nearly indigestible until fermented.
- Fermented dairy products, like, cheese, yogurt, and kifir, can be consumed by those not able to digest the raw milk, and aid the digestion and well-being for those with lactose intolerance and autism.
- Porridge made from grains allowed to ferment increases the nutritional values so much that it reduces the risk of disease in children.
- The news is full of reports about the health benefits of probiotic supplements (beneficial bacterial cultures for microbial balance in the body) fighting cancer and other diseases.
- Vinegar is used to leach out certain flavors and compounds from plant materials to make healthy and tasty additions to our meals.

Wine

Wine is an alcoholic beverage or liquid which is significant for both industries as well as for commercial purpose. Wine making starts with fruit selection – grapes which have important acids, esters and other compounds which are required to make wine naturally. Wine making starts with fruit selection – grapes which has important acids, esters and other compounds which are required to make wine naturally. Then squashing is done (mashing of grapes) to obtain pulp. Then it's the turn for fermentation which occurs naturally within some hours (6-12 hrs) by addition and action of yeast present in air. Fermentation is continued till dry wine is obtained by the transformation of sugar present in grapes to alcohol. Fermentation occurs for longer period of time so it is stopped before whole of the sugar is converted to alcohol to get sweet wine. Lastly classification, bottling and aging process completes produced the final product. Fermentation of wine results in its longer shelf- life and if the wine is kept in a proper manner in appropriate conditions then it can stay unspoiled up to some days to years depending the type of wine.

Beer

To start the fermentation process, beer yeast is added while the fermentation vessel is feeling filled. During fermentation, yeast converts the sugary wort into actual beer by producing alcohol, a wide range of flavours and carbon dioxide (which is used later in the brewing process to carbonate the beer. After fermentation is complete, the liquid is called “Green Beer”. Wort is the bittersweet sugary solution that is the result of mashing the malt and boiling in the hops. Wort becomes beer through the process of fermentation. The duration of the fermentation process varies from batch to batch. The length it takes for beer to ferment can depend on factors such as temperature and strain of yeast (generally dry yeasts ferment faster). On average, fermentation takes at least two weeks to complete.

Food preservation by Fermentation

The French chemist Louis Pasteur founded zymology, when in 1856 he connected yeast to fermentation. When studying the fermentation of sugar to alcohol by yeast, Pasteur concluded that the fermentation was catalyzed by a vital force, called "ferments", within the yeast cells. The "ferments" were thought to function only within living organisms. "Alcoholic fermentation is an act correlated with the life and organization of the yeast cells, not with the death or putrefaction of the cells" he wrote. Fermentation is the breakdown of carbs like starch and sugar by bacteria and yeast and an ancient technique of preserving food. Common fermented foods include kimchi, sauerkraut, kefir, tempeh, kombucha, wine, beer and yogurt. These foods may reduce heart disease risk and aid digestion, immunity, and weight loss.

Uses

Food fermentation is the conversion of sugars and other carbohydrates into alcohol or preservative organic acids and carbon dioxide. All three products have found human uses. The production of alcohol is made use of when fruit juices are converted to wine, when grains are made into beer, and when foods rich in starch, such as potatoes, are fermented and then distilled to make spirits such as gin and vodka. The production of carbon dioxide is used to leaven bread. The production of organic acids is exploited to preserve and flavor vegetables and dairy products. Food fermentation serves five main purposes: to enrich the diet through development of a diversity of flavors, aromas, and textures in food substrates; to preserve substantial amounts of food through lactic acid, alcohol, acetic acid, and alkaline fermentations; to enrich food substrates with protein, essential amino acids, and vitamins; to eliminate antinutrients; and to reduce cooking time and the associated use of fuel.

How Fermentation Techniques Preserve Food

The desirable bacteria cause less deterioration of the food by inhibiting the growth of the spoiling types of bacteria. Some fermenting processes lower the pH of foods preventing harmful microorganisms to live with too acidic an environment. Controlled fermentation processes encourage the growth of good bacteria which starves, or fights off, the bad microbes. Depending on what is fermented, or the manner of fermentation, foods can remain consumable for years.

The fermentation process can be stopped by other means of preserving, such as, canning (heating), drying, or freezing. Heat (pasteurization, 145° F), and low temperatures (freezing, 32° F or below) stops the fermenting process by slowing, or killing, the preferred microorganisms, and other bacteria. A few undesirable bacteria are not killed by either means, and continue to grow. When the beneficial bacteria are gone, the unfavorable bacteria take over, growing exponentially. This causes rotting disease, illness and inedible foods. When the good guys are present and happy, the food remains edible.

Additional Benefits of Fermenting

Fermenting enhances the flavors of some foods, as with the extended fermentation of black teas, aged cheese, wine, and beer, which creates their distinctive flavors. Cocoa beans have to be fermented (composted) for a few days to remove the pods and to enhance the flavor of chocolate.

Fermenting makes foods more edible by changing chemical compounds, or predigesting, the foods for us. There are extreme examples of poisonous plants like cassava that are converted to edible products by fermenting. Some coffee beans are hulled by a wet fermenting process, as opposed to a dry process.

Fermentation increases nutritional values with the biochemical exchange it produces, and allows us to live healthier lives. Here are a few examples:

- The sprouting of grains, seeds, and nuts, multiplies the amino acid, vitamin, and mineral content and antioxidant qualities of the starting product.

- Fermented beans are easier for our bodies to digest, like the proteins found in soy beans that are nearly indigestible until fermented.
- Fermented dairy products, like, cheese, yogurt, and kifir, can be consumed by those not able to digest the raw milk, and aid the digestion and well-being for those with lactose intolerance and autism.
- Porridge made from grains allowed to ferment increases the nutritional values so much that it reduces the risk of disease in children.
- The news is full of reports about the health benefits of probiotic supplements (beneficial bacterial cultures for microbial balance in the body) fighting cancer and other diseases.
- Vinegar is used to leach out certain flavors and compounds from plant materials to make healthy and tasty additions to our meals.

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HEAT RESISTANCE OF MICROBES AND SPORES INTRODUCTION

Heat treatments are widely used in food processing often with the aim of reducing or eliminating spoilage microorganisms and pathogens in food products. The efficacy of applying heat to control microorganisms is challenged by the natural diversity of microorganisms with respect to their heat robustness. This review gives an overview of the variations in heat resistances of various species and strains, describes modeling approaches to quantify heat robustness, and addresses the relevance and impact of the natural diversity of microorganisms when assessing heat inactivation. This comparison of heat resistances of microorganisms facilitates the evaluation of which (groups of) organisms might be troublesome in a production process in which heat treatment is critical to reducing the microbial contaminants, and also allows fine-tuning of the process parameters. Various sources of microbiological variability are discussed and compared for a range of species, including spore-forming and non-spore-forming pathogens and spoilage organisms. This benchmarking of variability factors gives crucial information about the most important factors that should be included in risk assessments to realistically predict heat inactivation of bacteria and spores as part of the measures for controlling shelf life and safety of food products. Highly heat-resistant spore-forming Bacillus cause nonsterility problems in canned food and reduce the shelf life of many processed foods. The aim of this research was to evaluate the thermal inactivation of Bacillus sporothermodurans , Bacillus subtilis IC9, and Geobacillus stearothermophilus T26 under isothermal and nonisothermal conditions. The data obtained showed that B. sporothermodurans and B. subtilis were more heat resistant than G. stearothermophilus. The survival curves of B. sporothermodurans and B. subtilis showed shoulders, while the survival curves of G. stearothermophilus showed tails. Under nonisothermal treatment, at heating rates of 1 and 20 °C/min, time needed to completely inactivate G. stearothermophilus was shorter than that required for B. sporothermodurans and

B. subtilis. In complex heat treatments (heating–holding–cooling), the survival curves of B. sporothermodurans and B. subtilis showed the same activation shoulders than those obtained under isothermal treatments and the activation shoulders were again absent in the case of G. stearothermophilus. Predictions fitted quite well the data obtained for B. sporothermodurans. In contrast, the data for B. subtilis showed half a log cycle more survival than expected and in the case of G. stearothermophilus, the survival curve obtained showed much higher inactivation than expected. One of the most common methods of control of spore-formers is by heat. The most recent and comprehensive text on thermal processing is that by Holdsworth4 . The UK Department of Health has also produced guidelines for the safe production of heat preserved foods5 . Information on control of spore-formers by disinfectants is best obtained from the manufacturers of these chemicals. Formulation of disinfectants is constantly evolving to meet the demands of the food industry and to meet international disinfectant tests. The most widely used disinfectant is probably chlorine, but it is only slowly sporicidal and is readily inactivated by organic matter, although there are organic chlorine release agents which are more effective in the presence of soiling. UV light is finding increased use in the food industry for the destruction of micro-organisms on surfaces and in water and air. UV lamp technology has improved considerably in the last 8-10 years and it is now possible to obtain very powerful lamps, which can produce significant reduction of spore-formers. Much of the recent work is not yet published and is held by manufacturers of the lamp systems or their customers. Multi-lamp arrays are also being developed to fit around conveyor systems so that the surfaces of product and packaging can be 'sterilised' before transfer to high care areas. Bacterial spores isolated from ingredients, intermediate and final products obtained from dairies: thermal resistance in microbes. The ingredients used for the development and production of milk-based products pose the risk of the introduction of new, emerging spore-formers producing highly thermoresistant spores. Therefore, the aim of this study was to examine the heat resistance of spores isolated from dehydrated ingredients, intermediate and final products. Furthermore, the influence of the heating medium (milk or phosphate buffer) on the heat resistance was determined in order to assess which medium is best to use in the context of dairy processing. Sixteen spore-forming strains from seven different species (Bacillus amyloliquefaciens, Bacillus flexus, Bacillus subtilis, Bacillus thermoamylovorans, Bacillus smithii, Geobacillus pallidus, Geobacillus stearothermophilus) producing thermoresistant spores were selected after their isolation from diverse food products obtained from local dairies such as cocoa powder, milk powder, spices, and dessert products. Spores produced from the chosen strains were tested regarding their heat resistance at 110, 120, and 125 °C for 30 min. Highly thermoresistant spores surviving a heat treatment for 30 min at 125 °C in milk were produced by B. amyloliquefaciens and G. stearothermophilus. The inactivation of the spores was higher in milk than in phosphate buffer. This study highlights that not only raw milk but also dehydrated ingredients are important sources of thermoresistant spores in dairy processing. Since the inactivation of spores in milk and phosphate buffer turned out to be significantly different, milk rather than laboratory media or buffers should be employed as the model heating system when designing thermal processes for new milk-based products. Conclusion This study confirmed that dehydrated ingredients are an important source of thermoresistant spores in the dairy industry. The usage of exotic, new ingredients can introduce emerging HTRS, which are a threat to the process safety. These spores exhibited a higher heat resistance in phosphate buffer than in milk. For the design of sterilization processes in dairy companies, it is therefore preferable to use milk instead of laboratory buffer systems as the heating medium when examining spore inactivation.

FOOD IRRADIATION

Food irradiation is a processing and preservation technique with similar results to freezing or pasteurisation. During this procedure, the food is exposed to doses of ionising energy, or radiation. At low doses, irradiation extends a product's shelf life. At higher doses, this process kills insects, moulds, bacteria and other potentially harmful micro-organisms.

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 40 countries including Australia, the United States, Japan, China, France and Holland.

To date, in Australia and New Zealand, only herbs and spices, herbal infusions and some tropical fruits are approved for irradiation by Food Standards Australia New Zealand (FSANZ), in accordance with the FSANZ *Food Standards Code*. For each of these, FSANZ has established that there are no safety concerns and no significant nutritional changes to the food as a result of food irradiation. Irradiated foods will be clearly labelled so that consumers can make an informed choice.

Irradiated foods and radioactivity

There is a common misconception that irradiated food is radioactive. The radiation used to process foods is very different from the radioactive fallout that occurs after, for example, a nuclear accident.

In food processing, the radioactive sources permitted do not generate gamma, electrons or x-rays of sufficient high energy to make food radioactive. No radioactive energy remains in the food after treatment.

The World Health Organization (WHO), the American Dietetic Association and the Scientific Committee of the European Union are three internationally recognised bodies that support food irradiation.

Food irradiation procedure

The food is exposed to ionising radiation, either from gamma rays or a high-energy electron beam or powerful x-rays. Gamma rays and x-rays are a form of radiation that shares some characteristics with microwaves, but with much higher energy and penetration.

The rays pass through the food just like microwaves in a microwave oven, but the food does not heat up to any significant extent. Exposure to gamma rays does not make food radioactive. Electron beams and x-rays are produced using electricity, which can be switched on or off, and they do not require radioactive material.

In both cases, organisms that are responsible for spoiling foods – such as insects, moulds and bacteria, including some important food poisoning bacteria – can be killed. Food irradiation cannot kill viruses.

Benefits of food irradiation

Some of the benefits of this food processing technique include:

- extended shelf life of some products

- less food spoilage
- reduced risk of food-borne diseases caused by micro-organisms such as *Campylobacter*, *Salmonella, E. coli* and *Listeria* (especially in meat, poultry and fish)
- less need for pesticides
- less need for some additives, such as preservatives and antioxidants
- lower risk of importing or exporting insect pests hidden inside food products
- reduced need for toxic chemical treatments, such as those used to kill bacteria found in some spices
- as an alternative to current treatment for disinfecting imported fruits, grains and vegetables, which uses an ozone-depleting gas
- reduced sprouting in potatoes, onions, herbs and spices.

Effects of irradiation on food

Some foods, such as dairy foods and eggs, cannot be irradiated because it causes changes in flavour or texture. Fruits, vegetables, grain foods, spices and meats (such as chicken) can be irradiated.

Irradiation causes minimal changes to the chemical composition of the food, however, it can alter the nutrient content of some foods because it reduces the level of some of the B-group vitamins. This loss is similar to those that occur when food is cooked or preserved in more traditional and accepted ways, such as canning or blanching.

CHEMICAL PRESERVATION:

Introduction Food preservation includes a variety of methods that allow food to be kept for extended periods of time without losing its nutritional quality and avoiding the growth of unwanted microorganisms. In general, there are three basic objectives for the preservation of foods: a) Prevention of contamination of food from damaging agents (microbes, insects etc., b) Hinder or prevention of growth of microbes in the food and c) Delay of enzymic spoilage such as self-decomposition of the food by naturally occurring own enzymes. Hence, our purpose is to select the appropriate food preservation procedures which effectively manage the microbial content of foods with affecting the nutritional qualities of food. To achieve this objective, there are several chemicals (synthetic or artificial) and natural compounds are available which may be added. A food additive is a substance or mixture of substances, in addition to the basic food stuff present in food as a result of any aspect of production processing, storage or packaging such as vitamins, mold inhibitors, bactericides, emulsifiers, minerals, food coloring, synthetic flavors and sweeteners etc. Those food additives which are specifically added to prevent the deterioration or decomposition of food have been referred to as chemical preservatives (intentional additives). Some chemicals that get into food accidentally are referred to as 'unintentional additives' like the unavoidable residues of agricultural chemicals like weedicides, pesticides, antibiotics etc. Nowadays, a number of conventional methods of food preservation are used at the household level that can be categorized as chemical methods such as sugar, salt, brine, vinegar; spices and wood-smoke are generally regarded as safe and natural preservatives. Mainly, salting, sugaring and wood smoking are all methods of curing foods. Most of chemical preservatives may inhibit microorganisms by interfering with their cell membranes, their enzyme activity or alteration in their genetic mechanisms. Other kind of preservatives may be used as antioxidants to hinder the oxidation of unsaturated fats, as neutralizers of acidity, as stabilizers to prevent physical changes in food and as coatings or wrappers to keep out microbes, prevent loss of water or delay undesirable microbial enzymatic and chemical reactions in food. 2. An ideal antimicrobial preservative and added preservatives In general, preservatives are substances which prolong the shelf-life of foodstuffs by protecting from microorganism attack. As per list, the preservatives are one of the 26 major additives categories that are used in the food processing and have been evaluated many times and confirmed to be safe by the food regulatory authorities like Scientific Committee on Food (SCF) and the European Food Safety Authority (EFSA) at maximum levels. Preservatives, both naturally occurring and synthetically made, According to the Canadian Food Inspection Agency (CFIA), preservatives are grouped into classes (I-IV), with each class having similar microbiological or chemical activity.

Class I: Curing preservatives in cheeses and meats Class II: Antimicrobials (which inhibit the activity or growth of microorganisms) Class III: Antifungals (which inhibit the activity or growth of yeast and mold) and Class IV: Antioxidants and its synergists (which are used to prevent the oxidation of vitamins, minerals and lipids of foods and ant browning agents which prevent both enzymatic and non-enzymatic browning of foodstuffs).

An ideal antimicrobial preservative should have following attributes: • Demonstrate broad spectrum of microbial activity, so that wide range of microbes can be killed or destroyed.

• It should be non-toxic to handlers and consumers.

• The cost of production should be low (economical) • It is expected that it should not affect organoleptic properties of food to be preserved and should not be inactivated by food.

• Preservative should not promote the growth of resistant strains and • It should kill microbes effectively rather than inhibit multiplication. There are certain factors that influence the effectiveness of chemical preservatives in killing microorganisms or inhibiting their growth and activity like concentration of the chemical, kind, number, age, temperature, duration, and other chemical and physical characteristics of the substrate in which the organism is found (intrinsic and extrinsic parameters etc.) must be taken into consideration while applying them. Antimicrobial preservatives used in food can be categorized in four groups: 1) Natural organic acids and their salts, vinegars, sodium chloride, sugars, spices and their oils, woods smoke, carbon dioxide, and nitrogen. Such added preservatives were not defined as such by law. 2) Substances having generally recognized as safe (GRAS) status for addition to food such as propionic acid and its salts, sorbic acid and their salts, benzoic acid and benzoates and their derivatives, sulfur dioxide and sulfites etc. However, some restriction on the use of few on them must take into consideration during their application,.

3) Certain chemicals considered to be food additives, which are not listed in the first two groups. Though, they can be used only when proved safe in clinical trials for humans or animals and later on they can then fall into group 4.

4) Chemicals proved safe and approved by the Food and Drug Administration (FDA) from time to time.

Keeping in view of public health safety, all additive and preservatives must have to be approved for use in foods before they can be used. Specifically, expert organizations like the Scientific Committee for Food, the European Food Safety Authority and the Joint FAO/WHO Food Additives Committee have examined the safety concern of each preservative and made some guidelines and recommendations on their use including maximum levels. These recommendations are taken up by governments both nationally and internationally level so that foods can be preserved commendably along with ensuring that food is safe to consumption.

Organic acid and their salts Preservatives are intensely added in food to inhibit or kill microorganisms. The classification of preservative is based on various other criteria: such as their chemical composition and nature, their mode of action, specificity, effectiveness and legality. Generally, organic acids (i.e. lactic, acetic, propionic, sorbic, benzoic, citric, caprylic, fumaric, malic acids etc.) and their salts may be added to or developed in food by the processof microbial fermentation. It has been demonstrated that undissociated form of organic acids penetrates cell membrane more easily than dissociates form. Organic acids inhibitory to food borne pathogens such as Bacillus, Campylobacter jejuni, Escherichia coli, Clostridium, Listeria monocytogenes, Salmonella, Pseudomonas, Staphylococcus aureus. For example, citric acid is applied as a substitute for fruit flavors and for preservation of drinks, jams, jellies etc.

Propionates Propionic acid is a short-chain fatty acid like some other fatty acids. In general, up to 1% propionic acid is naturally produced in Swiss cheese by Propionibacterium freudenreichii. It most effective in undissociated form as compare to dissociated. However, activity of propionic acid depends on pH of substance to be preserved. It is used to inhibit molds (mainly) and to inhibit yeasts and bacteria, for example sodium or calcium propionate is used most widely in the inhibition of mold growth and rope development in baked goods and for mold prevention in many cheese food and spreads. In bread, 0.1 to 5% concentration propionates are added to prevent Bacillus subtilis growth, which is responsible for ropiness. Propionates are s used for preservation of baked foods, cheese etc.

Benzoates The sodium salt of benzoic acid has been used extensively as antifungal agent in food. It is very effective against Talaromyces, Pichia 0.1% level, pH 3.6 to 4.0 and reduces E.coli by 3 to 5 log in 7 days at 8oC. Their effective range of pH 3.0 to 8.0. Benzoates are most effective against yeast and molds at pH 5.0-6.0. It has been used into jams, jellies, carbonated beverage, margarine, fruit salads, pickles, fruit juices etc. Though, the mechanism of action of the benzoates is still not clear, it is known, however, that the effectiveness of the benzoic acid esters increases with an increase in the chain length of the ester group. They are more effective against fungi (molds and yeasts) and to gram positive bacteria. They may interfere with function of cell membrane and have permeabilizing effect and induce potassium efflux related to porin expression in outer membrane of E. coli.

Sorbates Sorbic acid is a chemical compound (occurs naturally), first isolated in the berries of the Rowan tree. It shouldn’t be confused with asorbic acid or vitamin C. Salts of sorbic acid such as the calcium sorbate, sodium sorbate, or potassium sorbate, is used as a direct antimicrobial additive in food and as a spray, dip or coating on packaging materials. Sorbic acid and its salts prevent the growth of mold, yeast but less effective against bacteria. In addition, Sorbate preservatives:

• Are very effective inhibitors of most common microorganism types that can attack foods and responsible for spoilage.

It is s a naturally occurring polyunsaturated fatty acid, which is completely metabolized in human system.

• Do not affect taste, color, texture or flavour of foods.

• Are very effective over a wide range of pH. When used at the pH levels of most mildly acidic food products (pH 5.5-6.0)

. • Sorbates are the most effective preservatives against a wider spectrum of food spoilage microorganisms than benzoates or propionates. In general, sorbate efficacy increases with greater acidity. Above pH 4.0, usually sorbates are more effective than sodium benzoate and sodium or calcium propionate. Sorbates are at their optimum effectiveness used below pH 6.0 and are comparatively ineffective at pH 7.0 and above. Sorbate and its salts widely used in preservation of fruit cocktails, dried fruits, pickles, cheeses, cheese products, baked goods, beverages, syrups, fruit juices, jams, jellies etc.

Acetates Acetic acid is a primary component of vinegar. It is in the form of vinegar may be used in mayonnaise, pickles, catsup, pickled sausages and pigs' feet. Acetic acid is more effective against yeasts and bacteria than against molds. The derivatives of acetic acid are monochloroacetic acid, peracetic acid, dehydroacetic acid and sodium diacetate, have been recommended as chemical preservatives. Sodium acetate is the sodium salt of acetic acid. Sodium acetate is used for preservation of mainly acidified food, refrigerated food and meat products food and it controls pH. It has been proved that 0.1% concentration of sodium acetate in bread, pH 5.1, and shelf life 6 days at 30oC, inhibits Bacillus subtilis growth and 1% concentration of sodium acetate increases shelf life of catfish by 6 days at 4oC.

Nitrites and Nitrates Such chemical compounds occur naturally in the environment and are considered important plant nutrients. Nitrites and nitrates can also be applied to some food products as a preservative. In general, combinations of these various salts have been used in curing solutions for meat. Though, nitrates and nitrites have been used to preserve food for hundreds of years but there is concern that they may be linked to some kind of cancers. Normally, nitrite decomposes to nitric acid and forms nitrosomyoglobin with heme pigments in meats and a stable red color is given to meat. Further, nitrites can react with secondary and tertiary amines to form nitrosamines amines to form nitrosamines (known to be carcinogenic). They have shown the inhibitory potential to Clostridium botulinum and used for preservation of bacon, ham. As nitrates have only a limited effect on little number of organisms and hence, would not be considered a good chemical food preservative.

Sulfur dioxide and sulfites

In past, the Egyptians and Romans burned sulfur to form sulfur dioxide as a means of sanitizing their winemaking equipment and storage vessels. They were basically used as disinfectants, but nowadays sulfur dioxide and sulfites are used in the wine industry to sanitize equipment and to reduce the normal flora of the grape must. Salts of SO2 such as potassium sulfite and sodium sulfite are commonly used for preservation of vegetables and fruits by controlling spoilage and fermentative fungi (yeasts and molds) in wine, malolactic and acetic acid bacteria. In aqueous solutions, sulfur dioxide and various sulfites form sulfurous acid, which is the most active antimicrobial compound. Sulfites are inorganic salts that have antioxidant and preservative properties. Several compounds capable of producing sulfite, called sulfiting agents, that can be used to prevent enzymatic and nonenzymatic browning, control growth of microbial cells and act as bleaching agents, antioxidants or reducing agents. Sulfites are used on fruits and vegetable to prevent unpleasant browning and on lobster to prevent melanosis or “black spot”, in wines to suppress bacterial growth and to bleach certain food starches and cherries. Beside food applications, sulfites are used in pharmaceuticals to maintain the stability and potency of some medications. Though, sulfite treatment levels in foods vary widely by application and residual levels do not usually exceed several hundred parts per million (ppm) but may approach 1000 ppm in certain fruit and vegetable products. At pH 4.0, it is 500 times more active as well as effective and used to inhibit E. coli, yeasts and mold like Aspergillus sp.

Ethylene and propylene oxide Ethylene oxide exists as gas, kills all microorganisms. Propylene oxide can also kills many microorganism, is not as effective as that of ethylene oxide. They are thought to acts as an alkylating agent and employed as fumigant in warehouses and applied to dried fruits, eggs, dried yeast, cereals, spices etc. Hydroxyl ethyl group blocks reactive groups within microbial proteins and inhibits them. Ethylene oxide is used as gaseous sterilant (500 to 700 mg/L) and used for flexible and semirigid containers. Destruction of Clostridium botulinum, Cl. sporogenes, Bacillus coagulans, B. stearothermophilus and Deinococcus radiodurans occurs by ethylene and propylene oxide gases. However, propylene oxide is permitted only as packaging fumigant for cocoa, gums, dried fruits, spices and starch.

Sugar and salt Salt is one of the world's ancient food preservatives, used since antiquity to preserve meat and fish. The food products that are treated with salt can remain in good condition for several years, as it dehydrates the food and the microbes present in the food. Hence, microbes can't contribute to decomposition or spoilage. It also keeps food dry enough to prevent the growth of mold and yeast. It causes high osmotic pressure, which leads plasmolysis of cells; the percentage of salt needed to inhibit growth or harm the cells is varying with the kind of microorganism. Generally, NaCl is used in brines and curing solutions or is applied directly to the food and it has been reported to have its other following actions:

- Salt may ionizes to yield the chlorine ion, which is detrimental to microbes present in food.
- It can create anaerobic environment by reduces the solubility of oxygen in the moisture and
- Salt may interferes with the action of proteolytic enzymes. Like salt, sugar (glucose or sucrose) removes moisture from food and owe their usefulness as preservatives to their ability to make water unavailable to microorganisms and to their osmotic effect checking the growth microbes that contribute to spoilage or decomposition. There is sufficient evidence that sugar has been used as a preservative for thousands of years (the ancient Egyptians were even known to preserve food in jars of honey). Typically, foods preserved in sugar are sweet and may be stored in sugary syrup such as honey or cooked in sugar until they crystallize. Sweetened condensed milk, fruits in syrups, jellies and candies are examples of some of food preserved by use of sugars.

Alcohol It is a perfect antiseptic as it kills microbes and used to preserve fruits. Although, the fruit won't keep all their qualities as their sugar and flavor will dissolve in alcohol. Therefore, sugar must be added to the preserve. Generally, the fruits are preserved in flavorless spirit in large corked jars or sealed with a glass lid and a rubber band. The most commonly used alcohol is ethanol, a coagulant and denaturizer of cell proteins. The most effective germicidal concentrations of ethanol is in between 70 and 95%. Vanilla and lemon extracts (flavoring extracts) are preserved by their content of alcohol. 2.7 Formaldehyde It is also known as methanal, which is a colorless gas but with a pungent and irritating smell. It is extremely reactive and readily soluble in H2O. Pure formaldehyde is not commercially available while formalin (about 40% formaldehyde) is the most commonly used formaldehyde-containing solution. Formaldehyde is used as a food preservative illegally since it can prolong the shelf-life of a food by protecting against deterioration caused by microbes. In 2007, high level of formaldehyde (1200 mg/kg) detected in the concerned noodle fish is likely to be added deliberately as a preservative after the fish was caught, during transportation or storage. The texture of noodle fish adulterated with formaldehyde is likely to be stiff subsequently formaldehyde would react with the fish protein and result in muscle toughness and reduce its deliciousness. Hence, the addition of formaldehyde to food is not permitted, except as a minor constituent of woods smoke because this compound is very effective against wide range of microorganisms such as molds, bacteria and viruses can be used where its poisonous nature and irritating smell are not objectionable.

WOOD SMOKING:

It is one of the ancient food preservation methods that perhaps arose after the development of cooking with fire. Simply, smoking is used to increase the shelf life of perishable food items and adding desired flavors to them. It is achieved by exposing the food to smoke released from burning plant materials (wood). Woods smoke contains a several number of volatile compounds, which may have bacteriostatic and bactericidal effect i.e. formaldehyde, aliphatic acids, primary and secondary alcohols, ketones, acetaldehyde, other aldehydes, waxes, resins, catechol, methyl, pyrogallol and its methyl ester etc. Normally, wood smoke is much more effective against vegetative cells than against bacterial spores and the temperature varies with the kind of wood employed. Mostly, this method is applied for the preservation meats and fish that have undergone curing and mainly for cooking or flavoring of some fruits as well as vegetables (i.e. paprika, cheeses, spices) and ingredients for making drinks (i. e. malt) and tea leaves are also smoked. 2.9 Spices and other condiment Spices and condiments are defined as "Vegetable products or mixtures, free from extraneous matter, used for flavoring, seasoning or imparting aroma in foods. Though, spices and other condiments do not have any noticeable bacteriostatic effect but may help other agents in preventing or suppressing the microbial growth in food. Generally, the inhibitory spectrum of spices varies with the kind of spice and the microorganism being tested (for example: mustard flour and the volatile oil of mustard are very effective against yeast Saccharomyces cerevisiae but are not as effective as cinnamon and cloves against most bacteria). It has been proved that the essential oils of spices are more bacteriostatic than the corresponding ground spices. For example cinnamon (containing cinnamic aldehyde) and clove (containing eugenol) usually are much more inhibitory than are other spices. 2.10 Other food additives The purpose of use of additives in food is to improve the keeping quality of a food by making it last longer on the shelf or in the fridge.

Some commonly used other food additives are as follows: • Halogens are added to water for washing food (washing butter), equipment, for cooling and for addition to some products (bromine is used as a food additive in flour and some fruit-flavored soft drinks. Unluckily, bromine can have an adverse impact on your thyroid gland). Normally, water for drinking may be chlorinated by the direct addition of chlorine, or hypochlorites or chloramines may be used. Such halogens kill microbes by oxidation, injury to cell membranes, or direct combination with cell proteins.

• Wrappers of fruits impregnated with iodine have been employed to increase the keeping time of fruits. Iodophors (combinations of iodine with non-ionic wetting agents and acid) are being used in the decontamination of dairy utensils.

Antibiotics Antibiotics are secondary metabolites produced by microorganisms that inhibit or kill a wide spectrum of other microorganisms. In general, antibiotics are used in the feed of cattle's or in treating their disease them. Occasionally if cattle's and poultry are fed on antibiotics, residues may be found in milk. According to the Food and Drug Administration, that milk from such infected animals should not be used for human consumption for at least three days following the treatment of the animal with the antibiotic. However, most of the better-known antibiotics have been tested on raw food, mainly proteinaceous ones i.e. meats, fish, and poultry, in an attempt to lengthen the storage time at chilling temperatures as shelf life increases two to three times, due to reduced growth of the microorganisms. Antibiotic Aureomycin (chlortetracycline) has been found superior to other antibiotics tested because of its broad spectrum of activity. Another antbiotic Terramycin (oxytetracycline) is almost as good for increasing the time of preservation of food. Both Chlorotetracycline (Aureomycin) and Oxytetracycline (Terramycin) have been used in the cooling water for dressed poultry. Likewise, antibiotics are added in packing of raw fish and shell fish and later its cooking of destroy the antibiotic residues, making them safe for human consumption. Sometimes developed preservatives such as lactic acid, alcohol, bacteriocins (Nisin, a polycyclic antibacterial peptide with 34 amino acid residues used as a food preservative produced by Lactoccous lactis) etc. could be produced in food by microbes.

SCHOOL OF BIO AND CHEMICAL ENGINEERING

DEPARTMENT OF BIOTECHNOLOGY

B.TECH – BIOTECHNOLOGY

UNIT – V - FOOD PROCESSING AND PRESERVATION - SBT1607

FOOD PACKAGING

Food packaging serves many purposes, from protecting the food to creating portion sizes to offer information on the product.

However, what is not well known about **food packaging** is the different types of packaging available. There are nine types, and are described below.

Packaging of food products have seen a vast transformation in technology usage and application from the stone age to the industrial revolution. Packaging and package labeling have several objectives:

1. **Physical protection** - The food enclosed in the package may require protection from, among , shock vibration , compression, temperature, bacteria, etc.

2. **Barrier protection** - A barrier from oxygen , water, dust, etc., is often required permeation a critical factor in design. Some packages desiccants oxygen absorbers to help extend shelf life. Modified atmosphere or controlled atmospheres are also maintained in some food packages. Keeping the contents clean, fresh, and safe for the intended shelf life is a primary function.

3. **Containment or agglomeration** - Small items are typically grouped together in one package to allow efficient handling. Liquids, powders , and granular materials need containment.

4. **Information transmission** - Packages labels how to use, transport, recycle, or dispose of the package or product. Some types of information are required by governments.

5. **Marketing** - The packaging and labels can be used by markers to encourage potential buyers to purchase the product. Aesthetically pleasing and eye-appealing food presentations can encourage people to consider the contents. Package design has been an important and constantly evolving phenomenon for several decades. Marketing graphic design applied to the surface of the package and (in

many cases) the point of sales reply. The colour of the package plays a significant role in evoking emotions that persuade the consumer to make the purchase.

6. **Security** - Packaging can play an important role in reducing security of shipment. Packages can be made with tamper deter tampering and also can have tamper evident features to help indicate tampering. Packages can be engineered to help reduce the risks package pilferage; some package constructions are more resistant to pilferage and some have pilfer-indicating seals. Packages may authentication to help indicate that the package and contents are counterfeit. Packages also can include anti-theft devices, such as dye packs ,RFID, electronic article surveillance, that can be activated or detected by devices at exit points and require specialized tools to deactivate. Using packaging in this way is a means of retail loss prevention.

7. **Convenience** - Packages can have features which add convenience in distribution, handling, stacking, display, sale, opening, reclosing, use, and reuse.

8. **Portion control** - Single-serving packaging has a precise amount of contents to control usage. Bulk commodities (such as salt) can be divided into packages that are a more suitable size for individual households. It also aids the control of inventory: selling sealed one-litre bottles of milk, rather than having people bring their own bottles to fill themselves.

PRIMARY PACKAGING

Primary packaging is the packaging in direct contact with the product itself and is sometimes referred to as a consumer unit. The main purpose of primary packaging is to contain, protect and/or preserve the finished product, particularly against contamination. This is the first layer containing the finished product, such as a plastic pouch holding whole-grain cereal or the cardboard box containing the pouch of cereal. This type of packaging is often intended for the end user or consumer. In addition to making it easier for consumers to handle products, it makes the products look more appealing and can be used for communication purposes to convey printed information about the products to consumers.

SECONDARY PACKAGING

This type of packaging is used outside of primary packaging to group a certain number of products to create a stock-keeping unit, commonly referred to as a SKU. It facilitates the handling of smaller products by collating them into a single pack. This type of packaging also provides supplementary protection to help maintain the integrity of the primary packaging. In addition, it can serve as a shipping container for small shipments, making it highly useful in e-commerce. Secondary packaging is frequently made up of multiple components (box, padding, separators, reinforcements, bags, paper, etc.). It may also be customized to make a product easily identifiable in the warehouse setting. In the case of cereal, for example, the secondary packaging would be the corrugated cardboard box containing multiple individual boxes of cereal.

TERTIARY PACKAGING

Often also referred to as bulk or transit packaging, this type of packaging is used to group larger quantities of SKUs to transport them from point A to point B (e.g. from production facility to point of sale). During this stage, products are handled as distribution units. This type of packaging makes it easier to transport large and/or heavy loads safely and securely. In addition to helping prevent damage, it consequently facilitates the handling, storage and transport of goods. An example of tertiary packaging is a stretch-wrapped pallet containing a quantity of cardboard boxes (secondary packaging) to enable efficient product shipping.

SOLID FOOD PACKAGING

This is for foods that are sterile and are to be maintained sterile. These items include liquid eggs, milk and milk product drinks, along with other foods that are processed and need to be preserved for longer periods of time. Aseptic packages are made of a mixture of paper, polyethylene, and aluminum and contain a tight inside layer of polyethylene. Sterile pharmaceuticals are mostly packaged in plastic or glass, such as syringes and vials.

Trays

This is mostly self-explanatory. Trays are what meats, plant seeds, and drinks can be carried in. They are mostly flat with raised edges to keep the product in place, and are made of various materials such as paperboard.

Bags

Like trays, bags are a common form of food packaging. Most commonly known are bagged snacks (chips, pretzels) and fruit (apples, potatoes). “Bagging” separates the food from the environment, namely the air.

Boxes

Boxes are used for the most easy form of transportation of a food product. Most common materials found in boxes are metal, corrugated fiberboard, and wood. Frozen pizzas, cereals, and snack crackers are examples of foods packaged in boxes.

Cans

Cans are also an excellent way of preserving and transporting foods. Most cans are made of steel or other thin metal when found in stores, as well as glass jars when foods are canned in the home.

Cartons

Boxes and cartons are oftentimes interchangeable. Like boxes, cartons are also made out of corrugated fiberboard and are used for transporting food. Within the food packaging type of cartons, there are four sub-categories. The most well-known is the egg carton which is molded to the shape of the egg to add protection while the food product is mobile. Aseptic cartons also lie in this category. Examples of this are milk, juice, and soup cartons. Another sub-category of cartons are the folding cartons, which begin as flat pieces of corrugated fiberboard and then assembled by the food manufacturer. Lastly, there are gable tops. These cartons usually hold milk or juice and require the gables at the top to be pinched then pulled in order to be opened.

Flexible packaging

Similar to bags, flexible packaging protects the food protect from the environment and create an adequate means of transporting foods. Bagged salad is a common food found in flexible packaging.

Pallets

Pallets are used for mass transportation of a product. Boxes of the product are placed and stacked on the pallet, then wrapped to secure and decrease food movement.

Wrappers

Used for individual items, wrappers provide protection between the food and the environment or the food and a person's hands. Candy bars are most commonly thought of.

LIQUID FOOD PACKAGING

Liquid packaging board is a multi-ply paper board with high stiffness, strong wet sizing and a high barrier coating, e.g. plastic . Only virgin paper fibers are used. The barrier coating must hold the liquid and prevent migration of air and flavors through the paperboard.

MANUFACTURING

A liquid packaging board might be up to five plies and is formed on a multi-ply paper machine with online coating. The most common is to use three plies with a basic weight of about 300 g/m^2. The base or middle ply is normally made of pulp from bleached or unbleached chemical pulp, CTMP or *broke* (waste paper from a paper machine). CTMP gives more bulk and stiffness. The top ply (inside) is made of bleached chemical pulp. The barrier coating depend of the application and might be applied on both sides. Induction welding employed aluminium foil is used for barrier protection and for heating.**[3]** The back side of the board is the printing side and might have an extra ply made from chemical pulp of quality that is suitable for the printing applications. Liquid packages are heat sealed.

Cartons filled with short shelf dairy products board that are barrier coated on both sides with one layer of low polyethylene. For long shelf life products it is common to aluminium foil

barrier coating together with polyethylene. Commonly the plastic coating on the top side is 12 - 20 g/m^2 and on the reverse side 15 - 60 g/m^2.
Liquid packaging board are used for two package types: brick and gable top cartons.

Assemblies Unlimited offers a wide variety of liquid packaging into flexible pouches as well as rigid bottles for food grade products. We are a full turnkey provider and will source and supply and of the packaging materials including bottles, caps, labels, printed rollstock film, premade pouches, chipboard retail cartons, shipping cases and any other packaging materials required for your project. We collaborate with your packaging team to formulate, blend, fill, pack-out and drop ship the finished goods complete.

Part of this our service includes defining the pouch size based on your liquid fill weights, then creating the die lines for your graphic artist based on what type of equipment we will use to fill and convert it. For bottles, we can guide you to the right packaging partners who can provide you with options and ideas on bottle size, design, closure and materials. Thru 25 years of flexible packaging and bottle liquid filling experience, we will work closely with your team and help determine all that is needed to ensure that your project is being run consistent with cGMPs of the industry.If needed, Assemblies Unlimited can provide any **secondary packaging** necessary to complete your project, including display design & assembly, multi-packs, **shrink wrapping**, **club packs**, PDQ displays, tray pack-outs, **product fulfillment** and more.

Some of the liquid ingredients that we fill in pouches as well as in bottles include:

1. CBD Oil
2. Liquid supplements
3. Hot Fill / Pasteurization (into center spout and tear-top single-serve pouches)
4. Flavoring
5. Honey
6. Syrups
7. Gels
8. Sauces
9. Energy shots/drinks

10. Jojoba Oil
11. Marinades
12. Juices
13. Dressings
14. Condiments
15. Toppings

LABELLINING OF FOOD

Food labelling is primary means of communication between the producer and seller on one hand and purchaser and consumer in the other. The labels provide viable information about the food products and its components. Adding additional information like the cooking process or serving suggestions can also help the customer/consumer. The information given in the labels should be clear and understandable to the reader. The bar code system is not of importance to the law but, it is important in the arrangement and identification of the products. Therefore, a label is the most important marketing tool in the food industry. There are certain things a label should abide from displaying or doing such as, a label cannot make a statement, claim, fancy name, design, device, or abbreviation that is false and misleading regarding the food contained in the package or of its quality or in relation to the origin of the food.

IMPORTANCE OF FOOD LABELLING

There are various important reasons for the use of labels for conveying information about the product from its price, nutritional value, allergens present, place of origin etc. Some other reasons of using labels are 1) the protect and promote health of the consumer by providing the most valuable information in the market 2) protecting the consumer from misleading information and poor quality 3) for the purpose of fair marketing so other competition can sell their products 4) to promote sustainable food production 5) to protect the environment from dumping and safe recycling procedure to help the consumer understand his/her contribution in the conservation of our environment 6) to protect the social well-being and to protect culture.

THE COMMON INFORMATION FOUND ON EVERY FOOD PRODUCT

Every food company has to make sure that certain information is to be treated with high importance as it is what every person seeks out. Displaying this information can help the consumer/purchaser to decide whether the product is what they want or otherwise. Some of the common information that must be on the label are: -

A) Name of the food

B) List of ingredients (in descending order)

C) Date and storage conditions

D) Preparation instructions

E) Place of origin

F) Lot or batch number

G) Allergen information

Additional information can also be provided such as cooking instructions and serving suggestions.

Certain food products are derived from animal products and it is mandatory for all food manufacturers to mention if their food is suitable for all masses, particularly the vegans and vegetarians. The brown circle is to indicate the presence of non-vegetarian ingredients, while the green circle indicates the use of vegetarian ingredients.

CONCLUSION

Food labelling is an important public health tool needed to promote a balanced diet and hence enhancing the public's health. Information of the food product can help make the consumers make healthy eating decisions which can help them feel good. Labelling helps consumers understand the nutritional value of certain food. Using the information provided we can help others make healthy decisions this can help improve the diets of the public which in turn can provide many benefits such as increased productivity, increased mental capacity, boost in immunity and so much more can come from knowing and utilizing the information provided by the manufacturing companies.

Modified Atmosphere Packaging

Modified Atmosphere Packaging (MAP) is well established in the food industry and continues to gain in importance. MAP means, simply put, that the natural ambient air in the package is replaced by a gas or gas mixture, often nitrogen and carbon dioxide. This packaging under a protective atmosphere preserves the quality of fresh produce over a longer period of time, prolongs shelf-life, and gives food producers access to a geographically larger market for perishable products. This is suitable for meat and sausage products, dairy products, bread, fruits and vegetables, fish or convenience products.

Modified atmospheres are not only used in packaging. They can feature as part of the production process, e.g. in the case of minced meat, or of storage and transport, for example of fruit and vegetables in halls or containers.

The standards required by Modified Atmosphere Packaging are comparatively high, and have to be controlled and monitored to ensure safety. Therefore, food manufacturers rely on modern MAP gas technology and various levels of quality assurance for maximum process safety.

Benefits of modified atmospheres

- **Longer shelf life / higher quality**

Food packaged under a protective atmosphere spoils much slower. Combined with continuous cooling, Modified Atmosphere Packaging can significantly extend the freshness and shelf life. This effect varies depending on the product type. However, a doubling of the shelf life is usually possible. Normally, MAP products keep a high quality over a longer period of time and arrive at the consumer in the best possible condition.

- **Less waste**

Longer durability is often associated with fewer problems during long distance shipment, and longer shelf life. As a result, waste disposal due to spoiled food can often be reduced.

- **More sales opportunities**

Because of the longer shelf life, Modified Atmosphere Packaging typically opens up new geographic markets to manufacturers. Particularly with perishable goods, longer shipment distances can be achieved. A global market can become a reality.

- **Fewer preservatives**

Packaging under a protective atmosphere extends the shelf life of food, meaning in many cases that the use of preservatives can be reduced or even completely eliminated. Consumers get products that do not contain artificial additives.

- **Appealing package design**

Next to functional aspects, the design of the packaging plays a significant role in the competition for consumers. The look-and-feel and the quality impression influence the purchasing behaviour. Modified Atmosphere Packaging is very well suited for the most appealing packaging design and presentation of the food product.

Limitations of modified atmospheres

- **Comparatively high complexity**

The modified atmosphere packaging process involves comparatively high requirements. Possible failures: incorrect gas composition or leaks due to faulty temperature or pressure distribution, contaminated or worn tools, seal contamination or defective material. However, with modern MAP technology and comprehensive quality assurance, the risks can be mastered.

- **Relatively high cost**

In addition to high-quality films, the consumption of gas and the personnel costs for quality control are particularly costly. However, these costs can be minimised with efficient use of resources.

- **Influence on product quality**

Unlike using preservatives, in most cases, the protective gases are not absorbed by the food and thus do not alter the nature or taste of the product. But there are exceptions to this rule. For example, an excessively high concentration of CO_2 can be absorbed by the food and make it sour. However, these effects can be avoided with adapted gas mixtures. The influence of very high oxygen concentration on the quality of meat is controversial. Modified atmospheres are supposed to make the meat more chewy. Data to support this is, however, sparse.

Factors influencing the shelf life of food, and the influence of modified atmospheres

From the time that fruits and vegetables are harvested or animals are slaughtered, the spoilage process begins. This process is often accelerated the more the products are processed, such as cut fruit or minced meat. How long foods are durable, which means suitable for consumption, is very different and depends on various factors, e.g. the content of water and salt, pH value, hygiene conditions during production, storage conditions such as temperature or humidity, packaging. Depending on the characteristics and combinations of these factors, food products are differently sensitive to microbial or chemical / biochemical spoilage.

Chemical and biochemical spoilage

Directly after harvesting of plant or slaughter of animal material, chemical processes begin to change the structure or quality. Sometimes this is useful, e.g. dry-aging of meat, which can be seen as a maturation to improve quality. In principle, however, the quality of organic material decreases. For example, the oxidation of fats quickly leads to a rancidity of the product.

Microbial spoilage

Microorganisms are a major threat to the shelf life and quality of food. On the one hand, they influence colour and smell, but they can also lead to health hazards and make the products uneatable. The source of the microorganisms is either the food itself or an impurity that cannot be completely excluded in the production and packaging process.

The changes due to chemical / biochemical and microbial spoilage can be significantly slowed by MAP techniques together with cooling. Various gases and mixtures with different properties are used to slow the process of spoilage as much as possible.

Typical gases for Modified Atmosphere Packaging

Carbon dioxide (CO_2) and nitrogen (N_2) are mainly used as protective gases in food packaging. Carbon monoxide (CO) or argon (Ar) is also common in some countries. Oxygen (O2) is also used in some cases.

Oxygen (O_2) essentially causes food to spoil due to oxidation and forms the ideal preconditions for aerobic microorganisms to grow. As a result, oxygen is frequently excluded from modified atmosphere packaging. In some cases – typically red meat – processing is deliberately carried out with high oxygen concentrations, in order to prevent the red colour from becoming ,pale, and to inhibit the growth of anaerobic organisms.

Carbon dioxide (CO_2) is colourless, odourless and tasteless. It has an oxidation-inhibiting and growth-inhibiting effect on most aerobic bacteria and moulds. The gas is frequently used to increase the shelf life of food. The shelf life of packaged or stored food is normally longer, the higher the CO2 content. Nevertheless, many products can become sour if the dosage is too high. In addition, the gas can diffuse out of the packaging or be absorbed by the product – and the packaging thereby collapses. The use of supporting or filling gases can slow down this effect.

Nitrogen (N_2) is an inert gas and owing to its production process, is typically relatively high purity. It is usually used for displacing air, especially atmospheric oxygen, in food packaging. This prevents the oxidation of food and inhibits the growth of aerobic microorganisms. It is frequently used as a supporting or filling gas, as it diffuses very slowly through plastic films and hence remains longer in the packaging.

Carbon monoxide (CO) is colourless, odourless and tasteless. Similar to oxygen, carbon monoxide is sometimes used to retain the red colour of, primarily, meat. The required concentrations are very low. In some countries, including the EU, the use of carbon monoxide for modified atmospheres is nonetheless prohibited in foods.

Argon (Ar) is inert, colorless, odorless and tasteless. Owing to the similarity of its properties to those of nitrogen, argon can replace nitrogen in many applications. It is believed that certain enzyme activities are inhibited and argon slows metabolic reactions in some types of vegetables. Due to the marginal effects and the higher price compared to nitrogen, its use is rather rare.

Hydrogen (H_2) and helium (He) feature in modified atmospheres in some applications. However, these gases are not used to extend shelf life. They are used as trace gases for some leak detection systems available on the market. The relatively small molecular size of the gases allows rapid escape through packaging leaks. Since these gases otherwise have no positive properties on the food products and are expensive and not easy to handle, their use is rare.

Foodstuffs suited to Modified Atmosphere Packaging

Modified Atmosphere Packaging is suitable for a wide range of food product. While traditionally mainly dairy products, meat products or bread were packaged under protective atmosphere, now MAP is more and more used for other foods like fish, coffee, fruit or vegetables. In addition, Modified Atmosphere Packaging is driven by the growing popularity of ready-made meals and convenience products.

Meat and sausage products

Meat and sausage products, especially raw meat, are very prone to spoiling due to microbial growth, on account of their high moisture and nutrient content. No matter whether beef, pork or poultry – spoilage begins from the moment of slaughter and especially after butchering. Besides high hygiene standards and permanent cooling, modified atmospheres can significantly extend the shelf life of meat and sausage products. CO_2 is the most important among the protective gases. At concentrations above 20 %, CO_2 can considerably reduce microbial growth. In the case of red meat, there is also the risk of oxidation of the red colour pigments. The meat will lose its red colour, becoming grey and unappetising in appearance. This oxidation is especially prominent with beef. A high oxygen content in protective gas packaging can prevent oxidation. A low carbon monoxide content (approx. 0,5 %) can also help to retain the red colour of meat. However, the use of this gas is not allowed in the EU, for example. Poultry is especially sensitive to rapid spoilage and is therefore subject to higher requirements for permanent cooling. Here too, a modified atmosphere with CO_2 content will extend the shelf life. A high oxygen content is also used for poultry without skin so as to retain the colour of the meat. The CO_2 can partly be absorbed by the foods. To prevent the packaging from collapsing, nitrogen is used as a supporting gas.Sausage and meat products, e.g. marinated or smoked meat pieces, react very differently depending on the preparation. Longer shelf-lives can be afforded by the use protective gases right from the start. The CO_2 content should not be too high with these products, in order to prevent a sour taste.

Fish and Seafood products

Fish and seafood are some of the most sensitive foods. They are at risk of rapidly declining in quality and spoiling even shortly after the catch. The reason for this lies in the neutral pH value as an ideal precondition for microorganisms as well as special enzymes that negatively

affect taste and odour. Fish, which is rich in fatty acids, also becomes rancid quickly. The most important element for a longer shelf life is cooling close to 0° Celsius. Modified atmospheres with minimum 20 % CO_2 also retard the growth of bacteria. CO_2 components around 50 % are frequently used. Higher CO_2 concentrations can lead to undesirable side effects such as liquid loss or a sour taste. In the case of low-fat fish and shellfish, O_2 is also used in the packaging. This prevents a fading or loss of the colour, while at the same time serving as a growth inhibitor for some types of bacteria. When dealing with shellfish and crustaceans, special attention should be paid to ensuring a CO_2 content that is not too high. This can be discerned most clearly by a sour taste, while these products absorb CO_2 the most, as a result of which the packaging can collapse. Nitrogen as an inert supporting gas prevents this effect.

Dairy products

Cheese is predominantly spoiled by microbial growth or rancidness. A continuous cooling chain essentially extends the shelf life of products. With hard cheese, there is a rsk of mould formation upon contact with oxygen. As a result, vacuum packaging was frequently used in the past, even though these are awkward to open and can leave unattractive marks behind on the product at the same time. CO_2 effectively prevents mould formation, but does not otherwise affect the maturation of the cheese. Soft cheese can quickly become rancid. This problem can also be tackled with CO_2 modified atmospheres. However, as soft cheese absorbs CO_2 to a significantly higher extent, there is a risk of the packaging collapsing. A correspondingly lower CO_2 content should therefore be chosen. In the case of milk products such as yoghurt or cream, there is a risk of the products absorbing too much CO_2 and becoming sour. A lower CO_2 content should therefore be chosen.

Milk powder, above all for use in baby food, is a highly sensitive product. It is especially important to ensure that oxygen is displaced from the packaging in order to extend the shelf life. In practice, packaging is carried out in pure nitrogen with as low a residual oxygen content as possible.

Pasta and ready-made meals

The nature and composition of fresh pasta and, in particular, readymade meals are very different. Above all, multi-component products such as ready-made pizzas or sandwiches contain many different foods with differing shelf lives and spoilage properties. In the majority of cases, modified atmospheres can significantly extend the shelf life without using oxygen. Mixtures of CO_2 and nitrogen are used here. The concentration of the gases is oriented to the content of the product. If, for example, there is a risk that large volumes of CO_2 will be absorbed by the product, the nitrogen content should be chosen higher to prevent the packaging from collapsing.

Snacks and Nuts

Snack products, for example potato crisps or peanuts, primarily involve problems associated with the fat content of the food. There is a risk of oxidation, whereby the products can quickly become rancid if the packaging is not optimal. To extend the shelf life, it is therefore important to minimise the contact with oxygen. Modified atmospheres with 100 % nitrogen are frequently used. In this way, a premature spoilage can be prevented, while these atmospheres also provide protection from mechanical damage to sensitive products, e. g. potato crisps in conventional packets.

Wine

Gases or gas mixtures are often used to protect wine in the different phases of its production process and to retain the quality of the product. They are mainly used to avoid contact with

oxygen and prevent microbial deterioration. The tank headspace is replaced with an inert gas or a gas mixture, for example of CO_2, N2 or Ar. The composition of the gases is chosen according to the type of wine.

Coffee

As a dried product, coffee is relatively insensitive to spoilage by microorganisms. However, the risk of the fatty acids it contains oxidising and making the product rancid is greater. To prevent this, oxygen is excluded from coffee packaging. Instead, a modified atmosphere comprising pure nitrogen is frequently used in coffee sachets or capsules.

RETORT POUCH

A retort pouch or retortable pouch is a type of food packaging made from a laminate of flexible plastic and metal foils. It allows the sterile packaging of a wide variety of food and drink handled by aseptic processing, and is used as an alternative to traditional industrial canning methods. Packaged foods range from water to fully cooked, thermo-stabilized (heat-treated) high-caloric (1,300 kcal on average) meals such as Meals, Ready-to-Eat (MREs) which can be eaten cold, warmed by submersing in hot water, or through the use

of a flameless ration heater, a meal component introduced by the military in 1992. Retort pouches are used in field rations, space food, fish products, camping food, instant noodles, and brands such as Capri Sun and Tasty Bite.

A retort pouch as "a flexible package in which prepared food is hermetically sealed for long-term unrefrigerated storage. Retort is a process that uses heat and pressure to cook food in a strong, sealed package. It is the most acceptable form of food preservation in rigid, semi rigid and flexible packaging system.

Retort pouch is a flexible package made from multilayer plastic films with or without aluminum foil as one of the layers. • Their most important feature is that, unlike usual flexible pouches they are made of heat resistant plastics, thus making them suitable for processing in retorts at temperature of around 121°C normally encountered in thermal sterilization of food.

Aim Of Retort Packaging :

- To Destroy Microorganisms By Heating
- Thermal Processing Of Food with Package Itself
- To Protect the Food Form Chemical Enzymes
- To Provide the Food Commercially Sterile
- To Cook Food Ready For Consumption

Structure Of Retort Pouch:

These flexible pouches are constructed with 4 ply laminate consisting of following:

- Polyester outside layer (High Temperature Resistance, Toughness and Printability)
- Nylon 2nd Layer (Abrasion Resistance)
- Aluminum Foil (Barrier to Light, Gases, Microorganisms, Odors. Extends Shelf life, Stiffness allows for the Tear notch)
- Polypropylene Inside Food contact layer (Good heat seal surface, Flexibility, Strength and Food Capability)

Plastic Layers Used In Retort Pouches Include:

- polyester (PET) – provides a gloss and rigid layer, may be printed inside
- nylon (bi-oriented polyamide) – provides puncture resistance
- aluminum (Al) – provides a very thin but effective gas barrier
- food-grade cast polypropylene (CPP) – used as the sealing layer
- polyethylene (PE) – can be used instead of PP as a sealing and bonding layer

This multi-layer structure prevents the retort pouch from being recycled into other retort pouches or food packaging. However, the material can be recycled into an aluminized resin or up-cycled into textile materials. The weight of a pouch is less than regular cans or bottles, and the energy required to produce each pouch is less than competing packaging from metals, paper, and glass.

Why retort pouch is better than other forms?:

- The easy to open “notch” has eliminated the need to use can openers and reduces the risk of cuts after opening.
- Labels can be printed into the laminate, making them permanent.
- Flexible pouches are easier to distribute and therefore have lower transportation costs and require less disposal space.
- Storage space for empty flexible pouches is also reduced. A 45 ft. trailer holds 200,000 8 oz cans or 2.3 million retort pouches.
- Regular waste disposal no special recycling bins required

Characteristics essential to a satisfactory retort pouch are:

- Low gas permeability (oxygen).
- Low moisture permeability.
- Low hydrophilic properties.
- Heat sealable and sterilisable.
- Resistant to penetration by fats, oils and other food components.
- Physical strength to resist physical abuse during packing.
- Absence of solvent residues. Chemically inert polypropylene films require manufacturing catalysts, which must be removed with solvents before the film can be used for foods.
- Bonding materials for the laminates must not migrate into the foods.
- High light barrier

Types Of Retort Pouches:

- Preformed pouch
- In line formed Pouches
- Pillow Pack (3-side sealed, 4-side sealed)
- Stand up pouch

Processing of Food in Retort Pouches :

- **Printing:**

  The first step in the manufacture of laminate for pouches involves printing the polyester film.

- **Filling:**

  Filling the pouches with raw material is the first step in the process.
- **Air Removal:**

  Removal of air from the filled pouch is done to remove the bulk of the air from retort pouches before they are sealed
- **Sealing:**

  by impulse sealing.
- **Traying:**

  After the pouches are sealed, it is transferred to a retort rack or tray on which each pouch is accommodated in a separate compartment or slot.
- **Processing:-**

  The pouches are then heat processed in an over pressure autoclave

Advantages of Retort Pouch From Consumers Point of View :-

- Easy to handle
- Easy to cook
- Easy to open
- The thin profile permits reduced heating time & less chance of overcook.
- Self-stable and requires no refrigeration
- Reduced storage space
- Larger surface area for marketing information
- Lighter and less expensive to ship
- Easier for customer to open, heat and use product
- Flexible pouches are easier to distribute and less logistic costs.

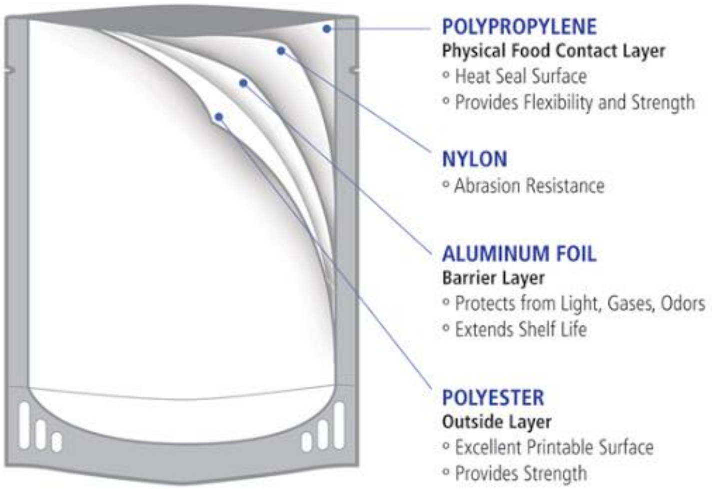
Limitations of retort pouch:

- The first obstacle is that processors often require a large capital investment for the unique machinery. Filling is slower and more complex compared to metal can lines.
- The thermal process is complex due to the number of critical processing parameters which must be monitored (e.g., residual air, pouch thickness, steam/air mixture). Also, special racking systems may need to be set up in order to provide optimal heating media flow and prevent pouch to pouch contact.

- Since pouches are more easily punctured they may require over-wrapping for distribution.
- Specialized equipment such as a burst tester, or a tensile tester is required for leak detection and container

Conclusions:

The retort food industry with its accelerated growth rate and product diversification has entered in a new phase of growth. These packs are now putting tough competition to the canned food. Because of their flexibility and easy storage and handling the retort pouches will find niche market in the near future



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FAO: Food and Agriculture Organization of the United Nation

Achieving food security for all is at the heart of FAO's efforts – to make sure people have regular access to enough high-quality food to lead active, healthy lives.

Our mandate is to improve nutrition, increase agricultural productivity, raise the standard of living in rural populations and contribute to global economic growth.

To meet the demands posed by major global trends in agricultural development and challenges faced by member nations, FAO has identified **key priorities** on which it is best placed to intervene. A comprehensive review of the Organization's comparative advantages was undertaken which enabled strategic objectives to be set, representing the main areas of work on which FAO will concentrate its efforts in striving to achieve its vision and global goals.

Help eliminate hunger, food insecurity and malnutrition

FAO's challenge: there is sufficient capacity in the world to produce enough food to feed everyone adequately; nevertheless, in spite of progress made over the last two decades, 870 million people still suffer from chronic hunger. Among children, it is estimated that 171 million under five years of age are chronically malnourished (stunted), almost 104 million are underweight, and about 55 million are acutely malnourished (wasted).

Make agriculture more productive and sustainable

The world's population is predicted to increase to 9 billion people by 2050. Some of the world's highest rates of population growth are predicted to occur in areas that are highly dependent on the agriculture sector (crops. Livestock, forestry and fisheries) and have high rates of food insecurity. Growth in the agriculture sector is one of the most effective means of reducing poverty and achieving food security.

Reduce rural poverty

Most of the world's poor live in rural areas. Hunger and food insecurity above all are expressions of rural poverty. Reducing rural poverty, therefore, is central to FAO's mission. Many living in rural areas have been lifted out of poverty in recent decades. In 1990, 54% of those living in rural areas in developing countries lived on less than $1.25 a day and were considered extremely poor. By 2010, this share had dropped to 35%. Rural poverty remains widespread especially in South Asia and Africa. These regions have also seen least progress in improving rural livelihoods.

Ensure inclusive and efficient agricultural and food systems

With increasing globalization, agriculture as an independent sector will cease to exist, becoming instead, just one part of an integrated value chain. The value chain exits both upstream and downstream, or from production through to processing and sales, in which the whole is now highly concentrated, integrated and globalized. This poses a huge challenge for smallholder farmers and agricultural producers in many developing countries where even the most economically valid smallholders can easily be excluded from important parts of the value chain.

Protect livelihoods from disasters

Each year, millions of people who depend on the production, marketing and consumption of crops, livestock, fish, forests and other natural resources are confronted by disasters and crises. They can strike suddenly – like an earthquake or a violent coup d'état – or unfold slowly – like drought-flood cycles. They can occur as a single event, one can trigger another,or multiple events can converge and interact simultaneously with cascading and magnified effects. These emergencies threaten the production of, and access to, food at local, national and, at times, regional and global levels.

FAO: Food and Agriculture Organization of the United Nations

Introduction:

Food and Agriculture Organization (FAO),oldest permanent specialized agency of the United Nations, established in October 1945 with the objective of eliminating hunger and improving nutrition and standards of living by increasing agricultural productivity. The FAO coordinates the efforts of governments and technical agencies in programs for developing agriculture, forestry, fisheries, and land and water resources

History:

The idea of an international organization for food and agriculture emerged in the late 19th and early 20th century, advanced primarily by the US agriculturalist and activist David Lubin. In May– June 1905, an international conference was held in Rome, Italy, which led to the creation of the International Institute of Agriculture.

FAO What it is, What it does:

Information :

FAO collects, analyses, interprets and disseminates information ¬ Advice: FAO provides independent advice on agricultural policy and planning Development Assistance: FAO provides practical help to developing countries through technical assistance.

food and agriculture organization mission statement:

• Help eliminate hunger, food insecurity and malnutrition

• Make agriculture, forestry and fisheries more productive and sustainable

• Reduce rural poverty • Enable inclusive and efficient agricultural and food systems

• Increase the resilience of livelihoods to threats and crises.

Vision:

• In contributing to a world free from hunger and malnutrition, the Statistics Division of FAO serves as the foremost

• authoritative source of standards and methods as well as timely and reliable data on hunger, food and agriculture.

• develop, implement and promote international statistical standards, methods and tools in collecting,

• analysing and disseminating data.

FAO in Bangladesh

Bangladesh joined FAO on 12 November 1973 within two years of gaining its independence from Pakistan. Since that time, Bangladesh and FAO have worked closely together in the areas of agriculture, food, forestry, fisheries, livestock, rural development and climate change. These efforts were strengthened with the establishment of the FAO Representative Office in Dhaka in 1978.

Bangladesh and FAO Achievements and success stories

• Sustainable food security and adaptation to climate change

•Comprehensive approach towards increasing agricultural production

• Development of fisheries

• Development of the livestock and dairy sectors

• Policy assistance and intervention.

FAO's future goals in INDIA

• Farmer's water school in Uttar Pradesh- Ground water utilization in surface irrigation

• Grand project of IFAD (International fund for agriculture development) in Odisha and north-eastern states for diversification of livelihoods into sustainable forest based agro-enterprises.

• Nutrition sensitive agriculture, hygiene and sanitation practices targeted at tribal population of Odisha

• Green agriculture project for biodiversity conservation

• Assistance in combating anti-microbial resistance

• Promotion. of biomass based energy generation pilot projects

• Focus on grazing based livestock production

• Highlighting importance of small ruminant and backyard poultry farming.

Other programmes

• Climate change issues in agriculture

• Agricultural development tools prepared and installed

• Integrated Pest Management (IPM)

• Special Programme for Food Security (SPFS).

Conclusion:

• FAO provides information technology tools to internationalize the work of extension agents everywhere