FOOD SPOILAGE

ERT 426 FOOD ENGINEERING

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What is Food Spoilage ?

- Food spoilage means the original nutritional value, texture, flavor of the food are damaged, the food become harmful to people and unsuitable to eat.

Food Fit For Consumption

- The criteria include:

1 The desired stage of development/maturity

- Fruits and vegetables should be at certain but differing of maturity/ripeness and poultry meat preferably from young birds.

2 Freedom from Contamination

- Food must be free from contamination by flies, rodent/insects which could result from the dirty handling by equipment or diseased workers.

3 Freedom from unacceptable changes in foods

- The food should be free from undesirable chemical changes that occur due to environmental factors such as prolonged exposure to air/oxygen/fluctuations in temp. and humidity.
- Microorganism and endogenous food enzymes can cause unacceptable changes in foods as in the case of putrefied meat/cheese and .

Deterioration of Food Quality

- Food may be classified broadly into three groups based on their ease of spoilage:

1 **Stable/non perishable foods** which do not spoil normally, such as sugar, salt, flour and dry beans; improper handling/ storing will, however, spoil them.

2 **Semi-perishable foods** which remain unspoiled for relatively long period under proper handling/storing conditions. These include potatoes and certain varieties of apples.

3 **Perishable foods** which spoil readily unless special preservative methods are adopted. Most of our daily foods belong to this group which includes meat, fish, milk, vegetable and fruits.

Causes of Food Spoilage

- The major causes of food spoilage include:
  1. Microorganisms, their growth and activity
  2. Action of native enzymes
  3. Insects, rodent and parasites
  4. Chemical reactions of the constituents of food
  5. Environmental factors such as temp., moisture, air and light
  6. Time

Preservation methods attempt to minimize the effect of these factors and enhance the storage stability and maintain quality of foods for prolonged periods

1. Activity of Microorganism

- Microorganisms capable of spoiling food are available commonly in soil, water and air, on the skin of cattle, fruits and vegetables, on the feathers of poultry, on the hulls of grains, and shells of nuts, on the clothing and skin of handling personnel, on processing equipment and within the intestines and body cavities of animal and human body

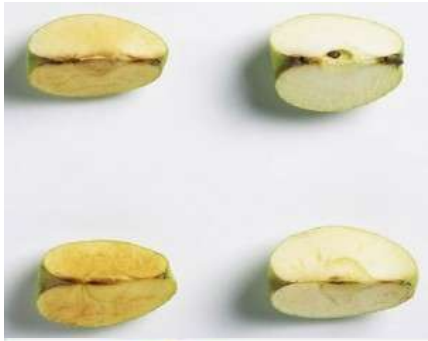
- There are three types of microorganisms that cause food spoilage -- yeasts, moulds and bacteria.
  - **Yeasts** growth causes fermentation which is the result of yeast metabolism. There are two types of yeasts *true* yeast and *false* yeast. *True yeast* metabolizes sugar producing alcohol and carbon dioxide gas. This is known as fermentation. *False yeast* grows as a dry film on a food surface, such as on pickle brine. False yeast occurs in foods that have a high sugar or high acid environment.
  - **Moulds** grow in filaments forming a tough mass which is visible as `mould growth'. Moulds form spores which, when dry, float through the air to find suitable conditions where they can start the growth cycle again.
    - Mould can cause illness, especially if the person is allergic to molds. Usually though, the main symptoms from eating mouldy food will be nausea or vomiting from the bad taste and smell of the mouldy food.
    - Both yeasts and moulds can thrive in high acid foods like fruit, tomatoes, jams, jellies and pickles. Both are easily destroyed by heat. Processing high acid foods at a temperature of 100°C (212°F) in a boiling water canner for the appropriate length of time destroys yeasts and moulds.
  - **Bacteria** are round, rod or spiral shaped microorganisms. Bacteria may grow under a wide variety of conditions. There are many types of bacteria that cause spoilage. They can be divided into: *spore-forming* and *nonspore-forming*. Bacteria generally prefer low acid foods like vegetables and meat. In order to destroy bacteria spores in a relatively short period of time, low acid foods must be processed for the appropriate length of time at 116°C (240°F) in a pressure canner. (Temperatures higher than 100°C [212°F] can be obtained *only* by pressure canning.)

2. Action of Native Enzymes

- The activity of endogenous enzymes in plant and animal foods is often intensified after harvest/slaughter due to lack of control mechanisms in the harvested plant food/ slaughtered animal
- The native enzyme may be inactivated by heat, radiation/by the use of specific chemicals.
- Examples:

Browning

Enzymes again cause browning in certain foods the moment they are exposed to air. When you cut or bruise food such as apple or yam, the exposed surface will discolour and turn brownish due to the activity of enzymes.



Ripening

Enzymes are involved in the process that causes ripening in certain foods such as fruits and vegetables. Unripe bananas for example contain starch which is gradually converted to sugars, until the banana becomes very sweet, and its skin colour changes from green to yellow. Eventually, the skin colour changes to dark brown and it is no longer fit to be consumed.

3. Insects, Parasites and Rodent

- Insects destroy→ cereal grains
  - fruits and vegetables by not only consuming the food but contaminating the food
  - Facilitate microbial attack on foods
- Parasites enter the human body mostly through poultry which have been improperly cooked
- Rodent apart from consuming considerable quantity of food also contaminate the food through their droppings, urine and filth. Rodents are also carries of pathogenic bacteria

4. Chemical Reaction

- The quality of foods deteriorate due to chemical reactions of the constituents of food.
  - Ex: the unsaturated fatty acid components undergo oxidation due to exposure to atmospheric air giving rise to oxidative rancidity in fat rich foods
  - Free fatty acids may also be released due to hydrolytic reactions causing odour as well as undesirable changes in the texture of food
- Losses of vitamins due to oxidation or light induced reactions also occur

5. Environmental Factors

- Air and oxygen can have detrimental effects on vitamin A, C, food colour, flavour and other constituents
- Oxidation reaction are facilitated due to the present of air
- Light destroy riboflavin, vitamin A, Vitamin C and also promotes light induced oxidation reactions affecting flavour and colour of food.
- Light also causes destruction of protein as in the case of milk

6. Time

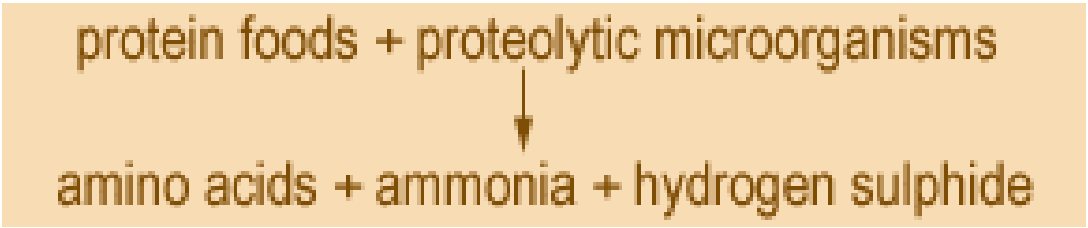
- The quality of food remains at its peak for some time soon after its harvest/slaughter and thereafter as time progress, the deterioration in the quality of the food also progress.

- Simple option for maintaining the food quality, through temporarily
  - We should keep the food alive as long as possible. This option is however, limited in its application

- The harvested / slaughtered food must be cleaned and cooled immediately. This delays the onset of deterioration of food quality but does not prevent it.

Three types of food decay

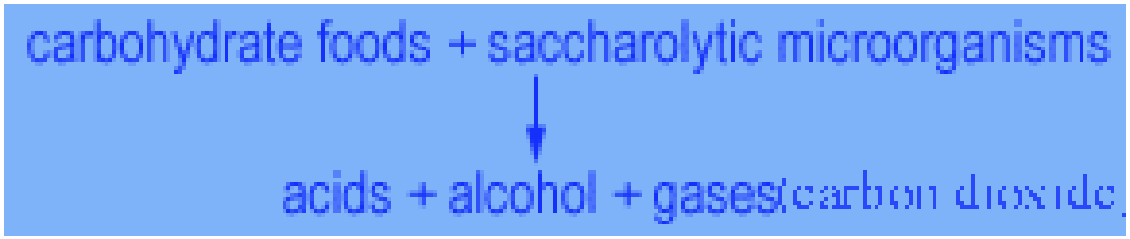
- PUTREFACTION
  - Biological decomposition of organic matter, with the production of ill-smelling and tasting products, associated with anaerobic (no oxygen present) conditions.
  - Formula of putrefaction:



FERMENTATION

- chemical changes in organic substances produced by the action of enzymes. This general definition includes virtually all chemical reactions of physiological importance, and scientists today often restrict the term to the action of specific enzymes, called ferments, produced by minute organisms such as molds, bacteria, and yeasts. For example, lactase, a ferment produced by bacteria usually found in milk, causes the milk to sour by changing lactose (milk sugar) into lactic acid.

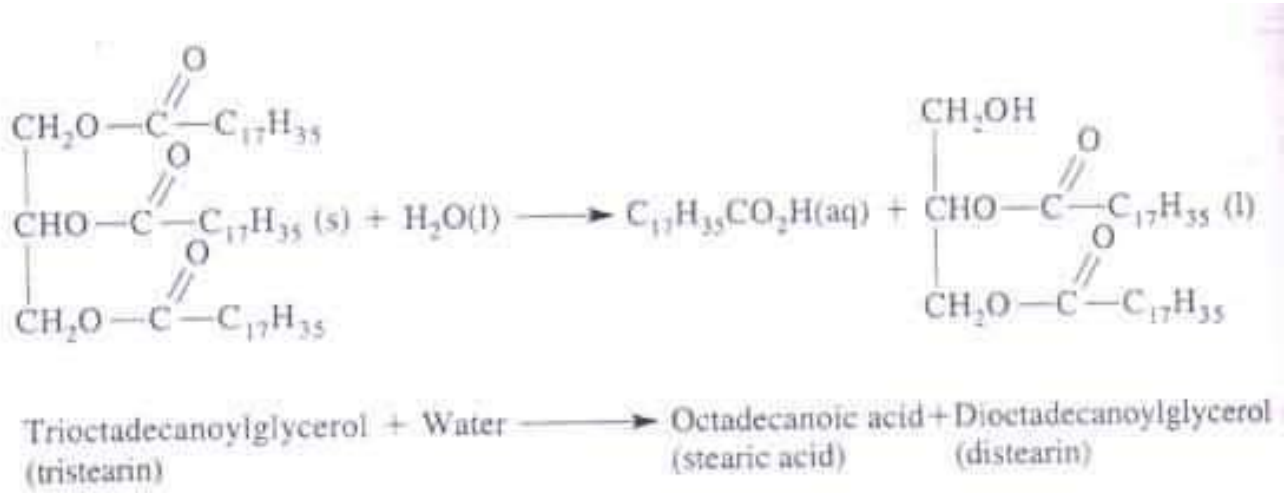
- Formula of fermentation:



- RANCIDITY
  - **(1)Microbial rancidity**
    - Like all food components, fats undergo deteriorative changes with time, which result in undesirable flavors and odors. These changes in fats are given the term "rancidity".
    - Formula of microbial rancidity:

- **(2)Hydrolytic rancidity**
  - Fatty acids formed through hydrolysis of the lipid(fat) by the water which it contains. Some of the liberated fatty acids are volatile, and some have very unpleasant odours and flavours.

  - Formula of hydrolytic rancidity



- **(3)Oxidative rancidity**
  - The oxidation of acylglycerols which occurs in air, without the presence of enzymes, is called autoxidation. Among the products of autoxidation are hydroperoxides, ROOH. These have no taste, but they decompose easily to form aldehydes, ketones and acids, which give oxidised fats and oils their rancid flavours.
  - It can be slow down by addition of antioxidants.

Examples Spoilage of Various Food and Food Products

- The various types of foodstuff ranges for
  - Cereals
  - Vegetables and fruits
  - Dairy and poultry products
  - Seafood and products made from raw food materials

1. Cereals and Cereal Products

- Low water activity of wheat, rice, rye, corn and other cereals protects them from microbial attack if stored properly
- The cereal flours are also relatively protected by the action of bleaching agents used during milling operation

2. Vegetable and Fruits

- The organisms break down pectins, giving rise to a soft, mushy consistency, sometimes a bad odour and a water soaked appearance
- Sour rot/ watery rot of vegetable is caused by *Geotrichum candidum* and other organism, and vegetable thus affected, include bean, carrot, lettuce, cabbage, onion, garlic, radish, cauliflower, tomato and turnip
- Rhizopus soft rot in carrot, potato, cabbage, cucumber, pumpkin, watermelon, radish and tomato is caused by *Rhizopus stolonifer* making the vegetables soft and mushy.

3. Bakery Products

- Moisture content of commercially made bread is insufficient for the growth of most organisms except molds
- *Rhizopus stolonifer* is the common bread mold causing the spoilage known as ropiness in bread, particularly in bread stored in high humidity or in bread wrapped while still warm
- The composition of cakes with high concentration of sugar does not allow bacterial spoilage. However, molds cause spoilage of cakes
- The baking process is sufficient to destroy many of these organisms but icings, topping, nuts and fruits added after baking can be the source of molds
- The growth of molds in bread and cakes causes hardening of these item

4. Dairy Products

- Milk , cream, butter and cheese are easily susceptible to microbial spoilage. Milk is an excellent growth medium for a variety of spoilage organisms.
- Fresh raw milk and refrigerated raw milk contain many bacteria.
- Pasteurization eliminates many of these species.
- Heat resistant streptococci cause spoilage of pasteurized milk. They produce lactic acid by fermenting lactose and decrease the pH to about 4.5 causing curdling of the milk.
- Lactobacilli, if present, can grow and continue their activity below pH 4.
- Butter is not highly perishable but still it undergoes microbial spoilage
- Two important types of spoilage of butter include surface taint/ putridity and rancidity
- Putridity→ caused bad odours
- Rancidity-→ occurs due to hydrolysis of butter fat resulting in the formation of free fatty acids.
- Cheese, particularly cottage cheese, gets spoiled to a condition called slimy curd.

5. Nutmeats

- Peanuts, walnuts, cashew nuts and almonds are safe from spoilage bacteria.
- Molds grow if sufficient moisture is available during storage.

6. Meat, Poultry and Seafood

- Fresh meat is spoiled by microflora coming from animals lymph nodes, intestinal tract, hide and from the handling equipment and personnel engaged in this business.
- Refrigerator stored the spoilage is only on the surface caused by bacteria from external sources
- Fungal spoilage as *Mucos, Rhizopus and Thamnidium* which produce whiskers on beef, *Penicillium* which produces green patches and *Cladosporium* which causes black spot
- Poutry is mostly spoiled by bacteria of the genus *Pseudomonas.* Poultry mostly spoiled by bacteria of the genus *pseudomonas*.
- Poultry spoilage occurs mostly on the surface as the inner portions of poultry tissue are generally sterile
- Fresh poultry stored in humid conditions is susceptible to aerobic bacterial growth. As spoilage occurs, off-odours and slimy appearance develop.

- Fish
  - Fish of both fresh-water and salt-water contain high levels of proteins and nitrogenous constituent with low fat content and practically no carbohydrates
  - Fresh fish and iced fish are spoiled by bacteria while salted and dried fish are spoiled by fungi
  - *Pseudomonas*, *Acinetobacter* and *Maroxella* species are involved in the bacterial spoilage.In addition intestinal bacteria of the fish and native proteolytic enzymes also contribute to the spoilage and develop off-odours and sliminess.

- Shell fish such as shrimp, lobster, crab, crayfish undergo bacterial spoilage by pseudomonas, acinetobacter, moraxella species, similar to that of fresh fish.
- Mollusks such as oyster, clam, squid, and scallops contain higher carbohydrate content compared to seafoods and undergo fermentative type of spoilage

7. Egg

- Internally the egg white is not susceptible to microbial spoilage because of its high pH of about 9.3 and because of the presence of ingredients which function as antimicrobial agents
- These include lysozyme which is effective against gram-positive bacteria, avidin which forms a complex with biotin randering the vitamin unavailable to microbes and conalbumin which forms a complex with iron preventing its use microorganism
- Egg yolk is an excellent medium for the growth of most microorganism because of its neutral pH (6.8) and nutrient content
- Bacteria grow in the yolk producing hydrogen sulphide and other foul smelling compounds and also cause the yolk to become runny and discoloured

- Storing eggs in highly humid conditions favours the growth of microorganisms on the surface and facilitates microbial penetration
- At very low humidity egg lose water and become undesirable
- Most common bacterial spoilage of egg is rotting. Green rot caused by *Pseudomonas sp*., black rot by *Aeromonas*, *Pseudomonas proteus sp*., colourless rot by *Acinetobacter* and *Pseudomonas*, red rot by *Serratia* and custard rot by *Acinetobactor* and *Pseudomonas*
- Bacteria also cause a poilage condition known as mustiness
- Molds cause pinspots due to mycelial growth which can be seen by candling
- *Penicillium* and *Cladosporium sp*. Cause the pinspots and fungal spoilage of eggs.

8. Spices

- Molds and a few bacteria grow on spices if sufficient moisture is available
- Propylene oxide treatment of spices reduces the bulk of microorganisms and those that remain, do not cause spoilage if moisture level is low

9. Mayonnaise and Salad dressing

- The yeast species saccharomyces and zygosaccharomyces cause spoilage of mayonnaise and salad dressing by producing gas and destroying the emulsion

10. Sugar and Confectionery Items

- Sugar gets spoiled only under improper storage conditions such as high humidity.
- *Torula* and osmophilic *Saccharomyces* can cause inversion of sugar.
- *Leuconostoc mesenteroides* converts sucrose to dextran, a gummy and slimy polymer of glucose.
- Chocolate creams undergo spoilage causing explosion due to the activity of *Clostridium sp*.

11. Alcoholic Beverages

- The spoilage of beer and ale is commonly referred to as beer infections caused by bacteria and yeast.
- Four different spoilage patterns are common. These are known as ropiness, sacrinase sickness, sourness and turbidity.
  - Ropiness is caused by *Acetobacter*, *Lactobacillus*, *Pediococcus cerevisiae* and *Gluconobacter oxydans*, the beer becoming viscous and oily.
  - Sarcinase sickness is caused by *P.cerevisiae* which produces diacetyl giving rise to a honey like odour to the beer.
  - Sourness is caused by Acetobacter sp. And is due to the acetic acid formed by the oxidation of ethanol by the organism
  - Turbidity and off-odours in beer is caused by *Zymononas anaerobia* and yeast such as *Sacchararomyces sp.*

What happens when you eat spoiled food?

- Eating spoiled food caused by bacteria can cause 

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- Food poisoning occurs when you swallow food or water that has been contaminated with certain types of bacteria, parasites, viruses, or toxins.
- Most cases of food poisoning are due to common bacteria such as Staphylococcus, Escherichia coli (*E. coli),* clostridium botulinum and salmonella.

Symptoms of Food Poisoning

- The most common symptoms of food poisoning include diarrhea, watery stools, abdominal cramps, nausea, vomiting, and fever. Most food poisoning symptoms are mild, however, and can safely be treated at home.
  - **Salmonella -** gives victims flu-like symptoms for as long as a week.
  - **Botulism -** The first symptoms appear abruptly, usually 18 to 48 hours after the food was eaten which include nausea, dry mouth, vomiting, abdominal pain and blurring of vision. The toxin paralyzing the nerves from conducting messages from the brain. Control of the muscles is lost, beginning with those around the face and neck. Loss of the ability to swallow makes it impossible to eat. The victim usually dies within several days.
  - **Staphylococcal - A**ssociated with abdominal cramps, fever, vomiting and diarrhea. It appears about 6 hours after eating food contaminated with an enterotoxin formed by the staph bacteria. Dairy products, pastries and fish are common foods harboring this organism.

Reasons for keeping foods from spoilage

- Deterioration may cause food to be wasted
- Contaminated food can cause illness and in severe cases, this is known as food poisoning
- Money is saved when food commodities are kept from spoilage
- When food is kept from spoilage, it maintains it nutritive value
- It also ensures food is available for use even during lean season

How to prevent food spoilage?

- **Food Preservation**
  - Temperature treatments
  - Removal of water
  - Removal of air
  - Alteration of pH

Find out HOW ?

1. Temperature treatments

- For each 10 °C rise in temperature, the activity of micro-organisms and enzymes increases by at least 2x, in the range 0-60 °C. Above this, heat quickly destroys enzymes and stops living cells from working.

- **Decreased temperatures** therefore work by slowing down these changes. The technology involved may be fairly expensive, and is needed continuously, but it does not change the flavour of food.
  - In a **refrigerator** (about 4 °C) food keeps longer because it decays more slowly. Bacteria are not killed, but merely **less active.**
  - Examples: Chilled meat, fruit, vegetables, etc. in a refrigerator.

  - In a freezer (about -15 °C) **bacteria** are completely **inactive**, but **internal enzymes** are **still active**. For this reason, frozen vegetables such as peas are **blanched** by treatment with boiling water before freezing.
  - Examples: Frozen meat, peas, vegetables, ice-cream

- The cooling process may also have the effect of removing water from food, so it is necessary to wrap it to prevent dehydration.
- Example: celery and many vegetables

- **Increased temperatures** can have a more permanent preservative effect, and only require a fairly brief treatment. They may also alter the flavour of food.

  - **Gentle heating** (about 60-70 °C, up to boiling, 100 °C) kills most bacterial cells in a few minutes, but does not affect some species which form spores. It also denatures proteins, so it deactivates enzymes. Most cooking does this, and **pasteurisation**of milk is carefully controlled (63-66 °C for 30 minutes) to prevent flavour changes, although it does not quite kill all contaminating bacteria.
  - **Pressure cooking** raises the temperature (usually to 120 °C or more), which kills bacterial cells in seconds, although spores need about 15-20 minutes. This is called **sterilisation**. Apparatus called an autoclave is used commercially, and for preparing sterile media for growth of micro-organisms in the laboratory.
  - **Ultra-high temperatures** (UHT) - 132+ °C for at least 1 second) are at the basis of treatment of liquids like milk, and fruit juices, so that these have a "**long life**".
  - After heat treatment, it is essential to ensure that foods cannot become contaminated by contact with raw food, because they are now more easily colonised by bacteria.

2. Removal of water

- Water may be added to **rehydrate** it before consumption, or if eaten dry, digestive juices moisten it and make it available to our bodies.
  - Drying removes the moisture from the food so that bacteria, yeasts and moulds cannot grow and spoil the food. It also slows down the action of enzymes, but does not inactivate them. Dried food items can be kept almost indefinitely, as long as they are not rehydrated.
  - The process of **drying foods** removes roughly 80 to 90 percent of the water content of fruits and vegetables. Drying food is a combination of continuous mild heat with air circulation that will carry the moisture off.
  - Because drying removes moisture, the food becomes smaller and lighter in weight. When the food is ready for use, the water is added back and the food returns to its original shape.
  - Examples: Various dried food products such as fruit, coffee, milk, soups, fish, meat and vegetables
- Many foods can be preserved by being simply **dried** (dehydrated, desiccated), perhaps in the sun.
  - Dried fruits are unique, tasty and nutritious. It might be argued that dried fruits are even tastier than fresh fruits. They have been called nature's candy. Dried fruit tastes sweeter because the water has been removed thus concentrating the fruit's flavor. Dried fruit can be eaten as a snack or added to cereals, muffins or ice cream.

- **Salted** foods, and foods with added **sugar** are also effectively using the same technique, since the water they contain is unavailable for microbial growth. Indeed, cells of micro-organisms become plasmolysed when they come into contact with the surfaces of these foods.
  - Food is treated with salt, strong salt solution or strong sugar solution
  - After adding salt or sugar, the water potenial outside the micro-organisms is higher than that inside the micro-organisms. As a result water essential for enzyme action and microbial growth is removed by osmosis, the microbial can't continue to live.
  - Examples: Bacon, salted fish, soy sauce, Jam, fruits in heavy sugar syrup
- Smoking foods, as well as drying, covers the outside (most exposed to microbial contamination) with a thin film of antimicrobial chemicals. Some people even like the taste!
  - The smoke is obtained by burning hickory or a similar wood under low breeze/wind at about 93^{o}C to 104^{o}C.
  - Preservative action is provided by such bactericidal chemicals in the smoke as formaldehyde(HCHO) and creosote(antiseptic obtained from wood tar) , and by the dehydration that occurs in the smokehouse.
  - Examples: Fish (Smoked salmon), ham, and sausage

3. Removal of air

- This technique is not usually used on its own - in fact some of the worst food poisoning bacteria thrive in the absence of oxygen.
- **Vacuum packing** is, however, often used in conjunction with other techniques.

4. Alteration of pH

- **Pickling**, usually in vinegar or other acids, lowers the pH so that bacterial enzymes cannot operate.
- Examples: Sauces, pickled onions and cucumbers

5. Combined treatments - provide extremely long keeping qualities.

- **Freeze drying** is a relatively recent method of preservation involving the removal of water (as vapour) from frozen food under reduced pressure.
- **Canning** is heat-treatment in an autoclave, together with sealing of the food in an air-tight container.
  - Heating destroys enzymes and micro-organisms. The sealing of cans ensures no micro-organism and oxygen can get in. Airtight containers make sure that no oxygen in the containers for bacteria to live and chemical changes.

Food additives

- Food Additives , natural and synthetic compounds added to food to supply nutrients, to enhance color, flavor, or texture, and to prevent or delay spoilage. Some additives can inactivates or kill micro-organisms, retard chemical spoilage.
  - **Preservatives -** Preservative food additives can be *antimicrobial*; which inhibit the growth of bacteria or fungi, including mold, or *antioxidant*; such as oxygen absorbers, which inhibit the oxidation of food constituents. Common antimicrobial preservatives include calcium propionate, sodium nitrate, sodium nitrite, sulfites (sulfur dioxide, sodium bisulfite, potassium hydrogen sulfite, etc.) and disodium EDTA. Antioxidants include BHA and BHT.
    (E no.s in range 200-)
  - **Colourings -** To offset color loss and to produce a consistently colored food product.
    (E no.s in range 100-)
  - **Emulsifiers**
    (E 300-)

Additives can cause allergic reactions in some people. Colourings, in particular are thought to cause hyperactivity or asthmatic symptoms especially in children and young people.

Food Act 1983

- An Act to protect the public against health hazards and fraud in the preparation, sale and use of food, and for matters incidental thereto or connected therewith.
- To prevent food poisoning we must identify the risk of contamination. It can come from 3 sources - Biological, Chemical and Physical.
- The human error is one of the most common factor contributed to the food contamination. Therefore the individual personal hygiene practice together with the team work that are discipline to maintain the hygiene standard all the time is very critical.
- Food premise means premises used for or in connection with the reparation,preservation,packaging,storage,conveyance,distribution or sale of any food, or the relabelling, reprocessing or reconditioning of any food. (Malaysian Food Act 1983(Act 281) & regulations)
- Enforcement activity: Food Premises Inspection :
    - premises are rated based on a standard format
    - unhygienic premises are closed based on provision in the Food Act 1983

THANK YOU