TOPIC 3

FOOD SPOILAGE

OBJECTIVES

At the end of topic, students be able to :

01

Explain major food compositions: water, carbohydrate, protein, fats, vitamins and minerals

02

Explain food acidity and its importance: food processing, packaging and storage

03

Explain main factors of food spoilage: Biological, Chemical & Physical

04

Explain food poisoning

05

Explain food contamination and adulteration

Food Composition

Varying amounts of nutrients are present in foods

Meats : Protein, lipids, minerals, vitamins

Milk : Protein, lipids

Plant : Carbohydrate, minerals, vitamins

WATER

- It is an essential compound of many foods.
- It can be found as an intracellular or extracellular constituent in vegetables and animal products.
- It may occur as a dispersing medium (e.g. butter) or solvent (e.g. orange juice) in a variety of foods while it may be found as a minor constituent (e.g. milk powder) in some foods.
- Source and storage of energy, Structural function.
- It is incorporated into the chemical structure of other components, such as proteins, lipids, carbohydrates, as a monolayer/multilayer bounded or capillary absorbed.
- The presence of water in food is described as moisture content/ water activity (aw) of food.

WATER ACTIVITY

- The storage quality of food does not depend on the water content, but on water activity (Aw).
- Pure water has Aw 1.0
- Water activity (Aw) = free water
- Water activity can influence the food quality on processes food.
- Decreased water activity retards the growth of microorganisms, slows enzyme catalyzed reactions and, retards non-enzymatic browning.
- One of the options for decreasing water activity and thus improving the shelf life of food is to use additives with high water binding capacities such as salt, glycerol, sorbitol and sucrose.

Water Activity (Aw) in Selected Food

Subtances	Aw
Distilled Water	1.00
Tap water	0.99
Raw meats	0.99
Juice	0.97
Dried fruit	0.60
Honey	0.5 - 0.7
Peanut Butter	< 0.35

Minimum Aw limits for Mircroorganisms

Microorganisms Inhibited	Aw
***Clostridium botulinum* E**	0.97
Escherichia coli	0.95
***Clostridium botulinum* A, B**	0.94
Salmonella	0.93
Bacillus cereus	0.93
Staphylococcus aureus	0.86
Most molds	0.80
No microbial proliferation	< 0.60

CARBOHYDRATE

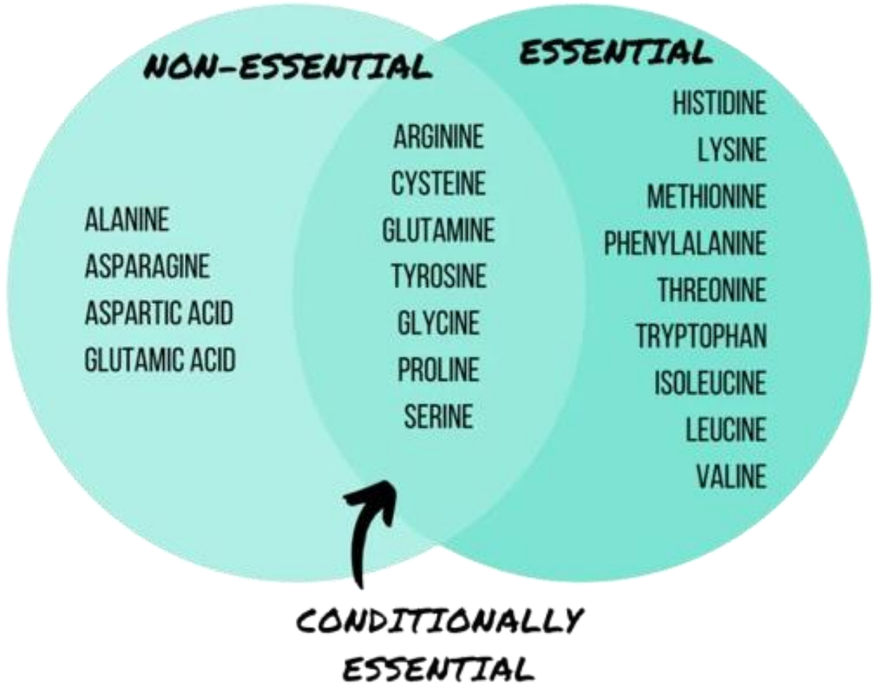
- All carbohydrates consist of carbon, hydrogen, and oxygen atoms with a chemical formula is $C_6H_{12}O_6$
- Examples of carbohydrates include starch, fiber, sugars, and cellulose.

Classification of Carbohydrate	
Monosaccharide	Cannot be hydrolyzed (will not react with water to form smaller compound) Example : Glucose, Galactose, Fructose
Disaccharide	Consists two monosaccharide unit Example : Maltose, lactose, Sucrose
Polysaccharides	Consists three or more monosaccharides unit Example : Starch, Glycogen, Cellulose

PROTEIN

- Most abundant biological macromolecules present in all cells.
- It is composed of amino acids which are commonly called building blocks of protein.
- Protein contains Carbon, Hydrogen, Oxygen and Nitrogen as the major components while Phosphorus and Sulfur are minor components.

AMINO ACIDS



LIPID

- Lipids are compounds of fatty acids with glycerol, sometimes also with other substances.
- Present in animal or plant tissues.
- A family of compounds soluble in organic solvents (ethyl eter, chloroform) but not in water.
- Natural lipids are solid fats or liquid oils, consisting mostly of triacylglycerols.
- They are the most important source of energy contain essential fatty acids, sterols, and lipophilic vitamins.
- Lipids are raw materials for many edible lipid products, such as table or frying oils, margarines, mayonnaise, and shortenings.

VITAMIN

- Vitamins are organic compounds required by the body in small amounts for metabolism, for protection, for maintenance of health and proper growth.
- Obtained by outside sources like diet because it cannot be synthesized by the body.

CLASSIFICATION OF VITAMINS	
Fats Soluble Vitamins	• **Oily and hydrophobic compounds, they are stored in the liver and not excreted out of the body.** • **Bile salts and fats are needed for their absorption.** • **Vitamins A,D,E and K are fat soluble**
Water Soluble Vitamins	• **Not stored in the body, therefore are required daily in small amounts.** • **Vitamin B & C**

MINERALS

- Minerals element that are those chemical elements other than C, H, O & N which required by the body

Classification of Minerals	
Major Minerals	• found in bulk concentrations in the body
Microminerals / Trace Element	• present in very small concentrations
Essential Elements	• Have a biological role (electrolytes, enzyme constituents and bones & teeth development) • Example : Sodium, potassium, phosphorous, iron, calcium, zinc, selenium, magnesium, copper, tin, cobalt, manganese and fluorine etc
Non essential Elements	• Example : Boron, aluminium, mercury, lead and cadmium (non-nutritive & toxic)

MINERALS

Chemical & Functional Properties of Minerals in Foods

Mierals	Food Sources	Function
Aluminium	Low and variable in foods, component of some antacids and leavening agents	• Leavening agent: As sodium aluminum sulfate (Na2SO4 . Al2(SO4)3) • Texture modifier
Calcium	Dairy products, green leafy vegetables, tofu, fish bones	Texture modifier: Forms gels with negatively charged macromolecules such as alginates, low methoxy pecitns, soy proteins, caseins, etc. Firms canned vegetables when added to canning brine.
Sodium	NaCl, MSG, other food additives, milk; low in most raw foods	Flavor modifier: NaCl elicits the classic salty taste in foods. Preservative: NaCl may be used to lower water activity in foods. Leavening agents: Many leaving agents are sodium salts, e.g ., sodium bicarbonate, sodium aluminum sulfate, sodium acid pyrophosphate

Food Acidity

- Food acids are usually organic acids, with citric, malic, lactic, tartaric, and acetic acids being the most common.

- May present either naturally, by fermentation or added as part of a specific food formulation

- Present in foods and influence the :
  a. flavor (i.e.,tartness),
  b. Color (though their impact on anthocyanin and other pH-influenced pigments)
  c. prevent/retard the growth of microorganisms or inhibit the germination of spores;
  d. Providing the proper environment for metal ion chelation, an important phenomenon in the minimization of lipid oxidation

Food Acidity

- The usual measure of acid level in a food is pH.
- pH 7 indicates neutrality (pure water)
- Lower values (<pH7) indicate acidity, and higher values (>pH 7) indicate basicity
- pH <below 4.6 consider as acid food which vegetative cells of Clostridium botulinum do not produce toxin (hazardous & high risk) and are safe from botulism.
- High-acid food is an ingredient that naturally has a pH of 3.9 or less.
- Commercially sterile foods that are properly packaged and protected from post-processing contamination have potential for extended shelf lives at ambient or room temperatures.

Food Acidity

- Foods that achieve a low pH value by the addition of edible acids or acid foods to low-acid foods are considered acidified foods.
- Acidified foods must be properly acidified to a pH below 4.6, but most foods are acidified to a pH of 4.2 or below
- Chemical preservatives are organic acids preservatives or their salts, such as sorbic, propionic, and benzoic acids are most effective in low pH foods because it is the undissociated organic acid that is capable of penetrating microbial cells.
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https://www.terrafoodtech.com/pdf/info/pH/EN_pH_food.pdf

Food Acidity

- Most microorganisms grow best at pH 7
- Microorganisms grow rapidly at different pH range
- Mould (0.4-11), Yeast (1.5-8.5), Bacteria (3.8-11)
- Most foods such as fish, meat, and vegetables are slightly acidic
- Other foods such as fruits are moderately acidic
- A few foods are alkaline such as egg white

Approximate pH Values Permitting the Growth of Selected Pathogens in Food

Microorganisms	Minimum	Optimum	Maximum
Bacillus cereus	**4.9**	**6.0-7.0**	**8.8**
Vibrio parahaemolyticus	**4.8**	**7.8-8.6**	**11**
Clostridium botulinum	**4.6**	**6.0-7.0**	**8.5**
Escherichia coli	**4.4**	**6.0-7.0**	**9.0**

Food Spoilage

Spoilage is the process in which food deteriorates to the point in which it is not edible to humans or its quality of edibility becomes reduced. It involves any change which renders food unacceptable for human consumption.

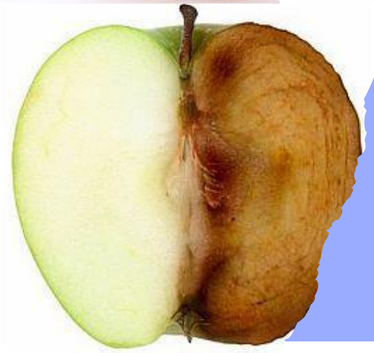
Causes of Food Spoilage

- Temperature
- Moisture
- pH
- Oxygen

Types of Food Spoilage

Microbial Spoilage

- Occurs when microorganisms, such as bacteria, yeast, and mold, grow on food surfaces.
- Lead to changes in texture, taste, and smell of the food.



Chemical Spoilage

- Occurs when chemical reactions take place in food, leading to changes in color, taste, and smell
- This type of spoilage can occur due to exposure to light, oxygen, or other chemicals.

Physical Spoilage

- Occurs when food is damaged due to external factors, such as pressure, temperature, or moisture.
- This type of spoilage can lead to changes in texture and appearance of the food.

Factor Affecting Microbial Spoilage

- The main micro-organisms responsible for the contamination of food are bacteria, moulds and yeasts.
- Moulds -They settle and multiply on suitable foods which visible as a fluffy coloured mass and the food is said to have gone mouldy.
- Yeasts -Yeasts are microscopic fungi, found in the air and soil, and on the surface of fruit.
- Some are able to tolerate fairly high acidic, salt and sugar concentrations and can grow without the presence of oxygen.
- Can cause food spoilage in syrups, fruits, fruits juices and jam especially as they can survive without air.

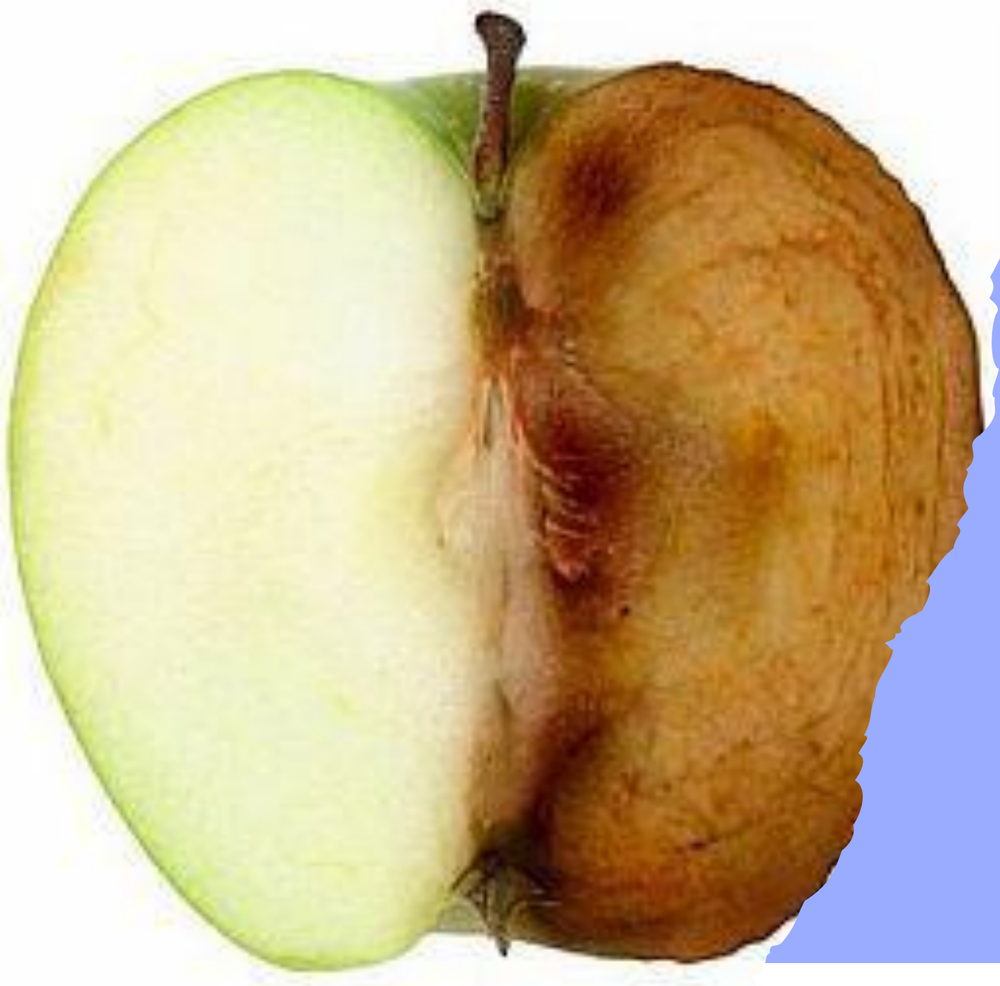
Factor Affecting Microbial Spoilage

- Bacteria most widespread of the micro-organisms found in food.
- They are minute single cells of various shapes and under ideal conditions, they divide into two every 20 minutes, consequently, millions of them may develop in contaminated food in a short time.
- They are active over a wide range of temperatures
- The removal of moisture by drying or by addition of large quantities of sugar and salt make conditions unsuitable for bacteria, and these methods are therefore use in food preservation.

Factor Affecting Microbial Spoilage

Microorganism Commonly Found in Food		
Bacteria	Yeast	Mould
Acetobactor	***Candida***	***Aspergillus***
Basillus	***Hansenula***	***Penicilium***
Clostridium	***Torulopsis***	***Mucor***

Chemical Changes

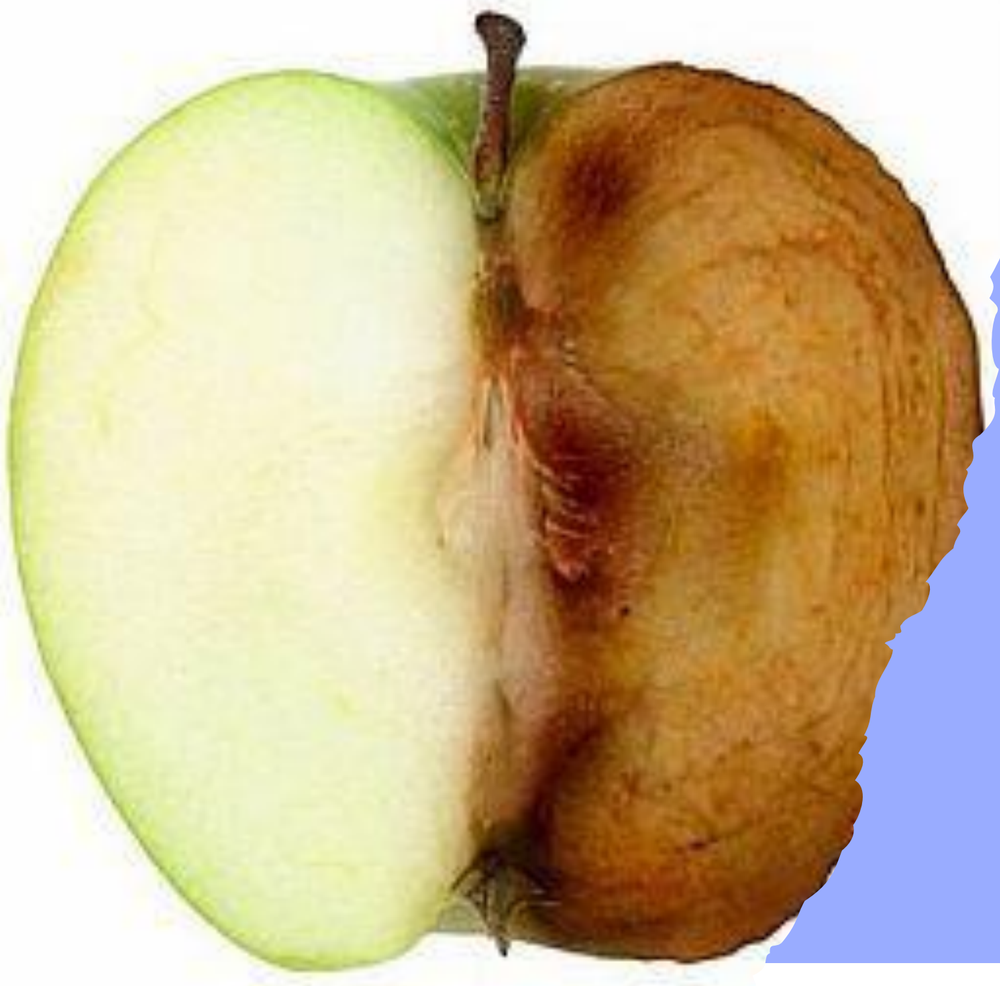


- Oxidation- Occur when food in contact with oxygen. the enzymes cause the destruction of certain nutrients e.g. vitamin C, thiamin and carotene.

- 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.

Chemical Changes



- Enzymes are present in all food and activity of indigenous enzymes is one of chemical changes that cause food spoilage
- They speed up chemical changes that result in loss of flavour, colour and texture.
- Some enzymes remain inactive until the food is harvested or slaughtered. Once activated, such enzymes speed up the process of decay by breaking down the tissues and components of the food in the various ways such as oxidation, browning and ripening.
- Enzymes are mainly composed of protein, they are sensitive to heat. The activity of these enzymes stops when they are heated above 70 oC.
- The activity of enzymes in food makes it easier for the micro-organisms responsible for food spoilage to enter the food.
- Heat treatment by blanching (i.e. pouring boiling water on the food) is recommended to deactivate enzymes in foods

Types of Food Spoilage

- Moisture loss mostly occurs in fruit and vegetables which contain large amounts of water.
- Fruits and vegetables continue to respire after harvesting and therefore lose water through their leaves and skin.
- The water retains the structures of the cells of the plants and makes them look fresh.
- Moisture loss causes the vegetable or fruit to shrink in size, becomes limp and its skin becomes wrinkled and leathery.
- Moisture loss occurs in other foods like meat, fish, cheese, due to evaporation of water from the surface.

Food Poisoning

- Food poisoning is also known as a foodborne illness caused by the consumption of contaminated food or water containing various bacteria, viruses, protozoa, non-microbial agents like vegetable origin or animal origin, and also toxins of biochemical or chemical nature.

- It can causes by microbial or non microbial contamination and can happen by:
  - Contamination of food during production: growing, harvesting, processing, storing, shipping or preparing.
  - Cross-contamination
  - Many bacterial, viral or parasitic agents cause food poisoning.

Causes of Food Poisoning

- **Microbial Contamination**

1. Bacteria - Bacillus cereus, Staphylococcus aureus, Salmonella group (except S. typhi), Shigella, Vibrio, Escherichia coli, Campylobacter, Yersinia enterocolitis, Clostridium.
2. Viruses – Rotavirus, Adenovirus, Parvovirus.
3. Protozoa - Giardia lamblia.
4. Fungi - Aspergillus flavus, Fusarium roseum

- **Non-microbial Contamination**

1. Vegetable origin - Lathyrus sativus, Mushrooms, Argemone Mexicana.
2. Animal sources - Poisonous fish like shellfish, scombroid fish etc. and Mussel.
3. Chemicals - Flavoring agents, Coloring agents, Preservatives

Symptoms of Food Poisoning

- Typical symptoms include diarrhea, vomiting, abdominal cramps, headaches, nausea, dry mouth, difficulty swallowing, and fluke-like symptoms (such as fever, chills, backache)

Sources of Food Poisoning	Symptoms
Staphylococcus aureus	• Occurs for 2-4 hours and illness lasts less than 12 hours • Vomiting and diarrhea but no fever.
Clostridium botulinum	• Incubation 12-36 hours. • Vomiting, dehydration, the mouth should be dried, hardened in feces, ocular paresis (blurred-vision), problem in speaking, also found some difficulties in breathing and may causes death within 7 days due to respiratory paralysis.
Clostridium perfringens	• Occurs for 8-24 hours. • Acute abdominal pain, diarrhea, and vomiting,
Escherichia coli (E. coli)	• Occur 72-120 hours. • Diarrhea with abdominal cramps, which may turn into grossly bloody diarrhea in a few days and no fever occurs
poisonous mushrooms	• Slight gastrointestinal discomfort to death in about 10 days

Prevention of Food Poisoning

Refrigerate or freeze perishable foods promptly

Defrost food safely

Throw it out when in doubt

Wash hands, utensils and food surfaces often

Prevent cross contamination

Ensure food are cook at right temperature

Food Contamination

Codex Alimentarius defines ‘food contamination’ as any substance not intentionally added to food, which is present in such food as a result of the production (including operations carried out in crop husbandry, animal husbandry and veterinary medicine), manufacture, processing, preparation, treatment, packing, packaging, transport or holding of such food as a result of environmental contamination

Food Contamination

Physical Contaminant

include extraneous matter such as sand, soil, hair, eyelashes finger nails, screws, nuts and bolts, bottle tops/bits of plastic, dead flies, coins, etc.

Biological contaminant

consist of microorganisms such as fungi and their metabolic products

Chemical Contaminant

agricultural residue such as fertilizers, insecticides, pesticides, antibiotics, cleaning agents, food additives, heavy metals.

Food Adultration

- Adulteration is defined as the process by which the quality or the nature of a given substance is reduced through (I) the addition of a foreign or an inferior substance and (ii) the removal of a vital element.
- Types of food adulteration are:
  - Intentional adulterant
  - Incidental adulterant
  - Metallic adulterant

Food Adultration

Intentional Adulteration

Done for financial gain

Addition of sand, marble chips, stones, mud, other filth, talc, chalk powder, water, mineral or harmful color

Incidental Adulteration

Incidental adulteration is usually due to ignorance, negligency of proper facilities.

Eg: pesticide residues, droppings of rodants, larvae in foods, insect inside grain.

Metallic Adulteration

Occurs due to arsenic from pesticides, lead from water, effluent from chemical industries, tin from cans

Causes of Food Adultration

01 Making greater profit

02 Save money

03 Cover defects or poor quality of products

04 Increase shelf life

05 Negligence and lack of awareness

Thank you!