- Ozone (O_3) is the other atmospheric gas that has antimicrobial properties and it has been tried over a number of decades as an agent to extend the shelf life of certain foods. It has been shown to be effective against a variety of microorganisms, but because it is a strong oxidizing agent, it should not be used on high lipid content foods since it would cause an increase in rancidity. Ozone was tested against E. coli O157:H7 in culture media and at 3 to 8 ppm the bacterium was destroyed in 20 to 50 minutes.

4. Presence and activities of other microorganisms: Some foodborne organisms produce substances that are either inhibitory or lethal to others. These include antibiotics, bacteriocins, hydrogen peroxide and organic acids. The inhibitory effect of some members of the food biota on others is well established.

Chemical spoilage: Concerning the chemical composition of food, it may be noted that carbohydrates, particularly sugars, are preferred by microorganisms as energy sources and only a few kinds of microorganisms can obtain energy from fats.

Chemical changes begin automatically after fruits and vegetables are harvested or animals are killed (slaughtered). O_2 in air, sunlight and high temperature can cause certain foods to undergo undesirable chemical changes. Chemical changes affect the color and flavor of foods; fats and pigments in foods are mainly affected e.g. unpleasant smell and taste of cooking oil after use at high temperature.

There are three factors in chemical change or rancidity of lipids:

1. **Lipid autolysis:** Enzymatic hydrolysis with fatty acids and glycerol as main product is called lipid autolysis.
2. **Auto oxidation:** The reaction of unsaturated lipid with O_2 called auto oxidation. Oxidative rancidity in fish can result to serious quality problems such as rancid falvours and odors as well as discoloration.
3. **Denaturation:** Denaturation of proteins during frozen storage results in tough, dry and fibrous texture. The most common chemical action which causes spoilage is the oxidative rancidity in fatty fishes. Fish is characterized by a high level of polyunsaturated fatty acids and hence undergoes oxidative changes.

Autolytic spoilage: Every living organism uses specialized proteins called enzymes to drive the chemical reactions in its cells. After death, enzymes play a role in the decomposition of once living tissue, in a process called autolysis (self-destruction) or enzymatic or autolytic spoilage. For example, some enzymes in a tomato help it to ripen, but other enzymes cause it to decay. Once enzymatic spoilage is under way, it produces damage to the tomato skin, so molds can begin to attack it as well, speeding the process of decay.

Autolytic spoilage is caused by enzymes. After the death, the normal circulatory system breaks down and chemical signals leak into the muscles causing them to stiffen. This process is known as Rigor Mortis. The blood circulation stops and the supply of O_2 is prevented. The enzymes present in muscle convert glycogen into lactic acid. The pH of the fish muscle falls. After the composition of rigor mortis, muscle stiffness gradually decreases accompanied by increases in pH, ending up in softening of muscle. This is followed by breakdown of proteins by enzymes. This process is called autolysis. Autolysis of protein starts immediately after rigor and favorable conditions for the growth of bacteria.

When fruits or vegetables are peeled or cut, the plant tissue releases some enzymes which in the presence of O_2 from the air, chemically react with plant compounds to give brown pigments e.g. apple, banana, guava etc. This reaction is known as enzymatic browning. The red pigment in meat undergoes chemical changes and turns brown when it is exposed to O_2. Enzymes cause food to ripen, then become over ripe and eventually decay. Starch changes to sugar, color changes and texture softens. Enzymes in fish cause deterioration even at low temperatures.

Food preservation

Food processing: Food processing is the set of methods and techniques used to transform raw ingredients into food or to transform food into other forms for consumption by humans or animals either in the home or by the food processing industry.

Food preservation: Food preservation is the process of treating and handling food to stop or slow down spoilage (loss of quality, edibility or nutritional value) and thus allow for longer storage.

Importance of food preservation:

Food preservation helps in –

1. Increasing the shelf-life of foods and thus increasing the supply. So any perishable food can be preserved for a long time.
2. Making the seasonal food available throughout the year.

required freezing in their unprepared state. For example, potatoes themselves require only a cool dark place to ensure many months of storage.
Cold stores provide large volume, long term storage for strategic food stocks held in case of national emergency in many countries.

4. **Boiling:** Boiling of liquid food items can kill any existing microbes. Milk and water are often boiled to kill any harmful microbes that may be present in them.
5. **Heating:** Heating to temperatures which are sufficient to kill microorganisms inside the food is a method used in perpetual stews. Milk is also boiled before storing to kill many microorganisms.
6. **Sugaring:** The earliest cultures have used sugar as a preservative and it was common place to store fruit in honey. Similar to pickled foods, sugar cane was brought to Europe through the trade routes. In northern climates without sufficient sun to dry foods, preserves are made by heating the food with sugar. Sugar tends to draw water from the microbes (plasmolysis). This process leaves the microbial cells dehydrated, thus killing them.
In this way, the food will remain safe from microbial spoilage. Sugar is used to preserve fruits, either in an antimicrobial syrup with fruit such as apples, pears, peaches, apricots and plums, or in crystallized form where the preserved material is cooked in sugar to the point of crystallization and the resultant product is then stored dry. Also, sugaring can be used in the production of jam and jelly.
7. **Pickling:** Pickling is a method of preserving food in an edible, antimicrobial liquid. Pickling can be broadly classified into two categories: chemical pickling and fermentation pickling.

- **Chemical pickling:** The food is placed in an edible liquid that inhibits or kills bacteria and other microorganisms. Typical pickling agents include brine (high in salt), vinegar, alcohol and vegetable oil. Common chemically pickled foods include cucumbers, peppers, corned beef, herring and eggs as well as mixed vegetables such as piccalilli.
- **Fermentation pickling:** Bacteria in the liquid produce organic acids as preservation agents, typically by a process that produces lactic acid through the presence of lactobacillales. Fermented pickles include sauerkraut, nakazuke, kimchi and surstromming.

8. **Lye (sodium hydroxide):** Lye (sodium hydroxide) makes food too alkaline for bacterial growth. Lye will saponify fats in the food, which will change its flavour and texture. Lutefisk uses lye in its preparation, as do some olive recipes.
9. **Canning:** Canning involves cooking food, sealing it in sterilized cans or jars and boiling the containers to kill or weaken any remaining bacteria as a form of sterilization. It was invented by French confectioner Nicolas Appert. By 1806, this process was used by the French Navy to preserve meat, fruit, vegetables and even milk.
Although Appert had discovered a new way of preservation, it wasn't understood until 1864 when Louis Pasteur found the relationship between microorganisms, food spoilage and illness.

10. **Jellying:** Food may be preserved by cooking in a material that solidifies to forma gel. Such materials include gelatin, agar, maize flour and arrowroot flour.
Jellied eels are a delicacy in the East End of London, where they are eaten with mashed potatoes.
Potted meats in aspic (a gel made from gelatin and clarified meat broth) were a common way of serving meat off-cuts in the UK until 1950s. Many jugged meats are also jellied.
11. **Jugging:** Meat can be preserved by jugging. Jugging is the process of stewing the meat of fish in a covered earthenware jug or casserole.
The animal to be jugged is usually cut into pieces, placed into a tightly sealed jug with brine or gravy and stewed. Red wine and/or the animal's own blood is sometimes added to the cooking liquid. Jugging was a popular method of preservation meat up until the middle of the 20th century.
12. **Burial:** Burial of food can preserve it due to a variety of factors:
    - lack of light
    - lack of O_2
    - Cool temperatures
    - pH level
    - desiccants in the soil

Burial may be combined with other methods such as salting or fermentation. Most foods can be preserved in soil that is very dry and salty such as sand or soil that is frozen. Cabbage was traditionally buried during Autumn in northern US farms for preservation.

3. **Bacterial invasion and putrefaction:** A fish acquires a load of bacteria in the gills and on the surface. When a fish gets died, the bacteria already present in the fish attacks the flesh and result in the formation of undesirable products. The microbial growth on fish depends on the type of water from where it caught from. The bacteria cause fish spoilage by:
    - **Reducing TMAO to TMA**: Reduction of trimethylamine oxide into trimethylamine produces an offensive odor.
    - **Degradation of amino acid to primary amines**: It can cause food poisoning.

      Example:

        - Histidine → Histamine
        - Glutamic-acid → Arginine
    - **Degradation of urea to ammonia**: It also produces an offensive odor.

Significance of bacteria in spoilage:

1. Raw and processed foods normally contain many types of microorganisms capable of multiplying and causing spoilage.
2. Bacteria, because of their shorter generation time, are in a favourable position over moulds to cause rapid spoilage of foods.
3. Among the three microbial groups, the highest incidence of spoilage, especially rapid spoilage of processed foods is caused by bacteria, followed by yeasts and molds.
4. The initial microbial load and the percentage of spoilage bacteria in it decide the shelf life of any product.

Fish processing: Fish processing refers to the processes associated with fish and fish products between the time fish are caught or harvested and the time when the final product is delivered to the customer.

Fish is a highly perishable food which need proper handling and preservation if it is to have a long shelf life and retain a desirable quality and nutritional value. The central concern of fish processing is to prevent fish from deterioration.

Fish preservation techniques: Preservation techniques are needed to prevent fish spoilage and lengthen shelf life. They are designed to inhibit the activity of spoilage bacteria and the metabolic changes that result in the loss of fish quality.

Preservation techniques can be classified as follows:

1. **Control of temperature**
2. **Control of water activity**
3. **Physical control of microbial loads**
4. **Chemical control of microbial loads**
5. **Control of O_2 reduction potential**
6. **Combined techniques**

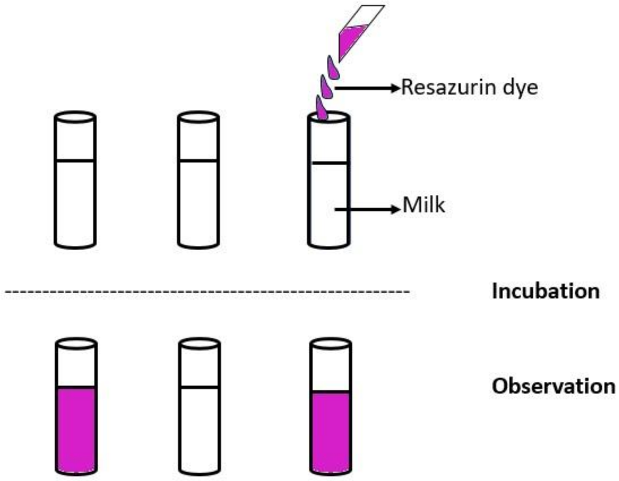
They are discussed below:

1. **Control of temperature:** If the temperature is decreased, the metabolic activity in the fish from microbial or autolytic processes can be reduced or stopped. This is achieved by refrigeration where the temperature is dropped to about 0^0 C, freezing where the temperature is dropped to below – 18^0 C.
   On fishing vessels, the fish are refrigerated mechanically by circulating cold air or by packing the fish in boxes with ice.
   An effective method of preserving the freshness of fish is to chill with ice by distributing ice uniformly around the fish. It is a safe cooling method that keeps the fish moist and in an easily stored form suitable for transport.
2. **Control of water activity (a_w):** The water activity (a_w) in a fish is distributed as the ratio of the water vapour pressure of pure water at the same temperature and pressure. It ranges between 0 and 1 and is a parameter that measures how available the water is in the flesh of the fish. Available water is necessary for the microbial and enzymatic reactions involved in spoilage.

   There are a number of techniques that have been or are used to tie up the available water or remove it by reducing the a_w. Traditionally, techniques such as drying, salting and smoking have been used, and have been used for thousands of years. These techniques can be very simple, for example, by using solar drying.

   In more recent times, freeze-drying, water-binding humectants and fully automated equipment with temperature and humidity control have been added. Often a combination of these techniques is used.

D. **Resazurin test:** It is very similar to the methylene blue reductase test.
Procedure: First, resazurin is added to milk sample and then incubated for 10 minute and observed the shades of color.

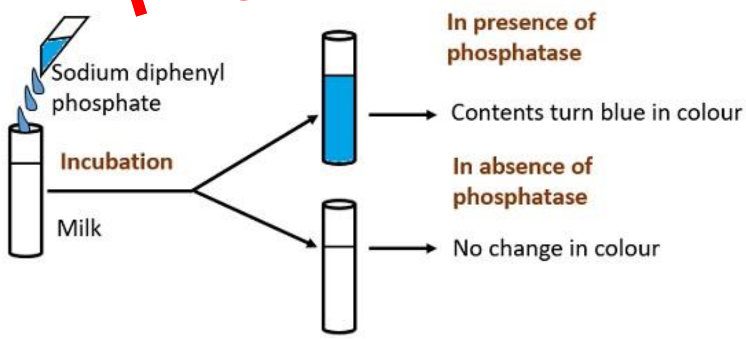


Interpretation of the result:

Positive: Formation of pink color indicates the presence of bacteria that reduce resazurin.
Negative: Color remains unchanged, i.e. bacteria are not present in the milk indicates that milk is of good quality.

E. **Phosphatase test:** It is used to check the pasteurization process. It verifies whether milk is pasteurized or not. Phosphatase is an enzyme that is usually present in the milk. This enzyme gets inactivated if pasteurization is performed properly.
Procedure:

First, 50 mL of milk is taken.
↓
A few drops of sodium diphenyl phosphate is added.
↓
Incubated for 10 – 15 minutes.



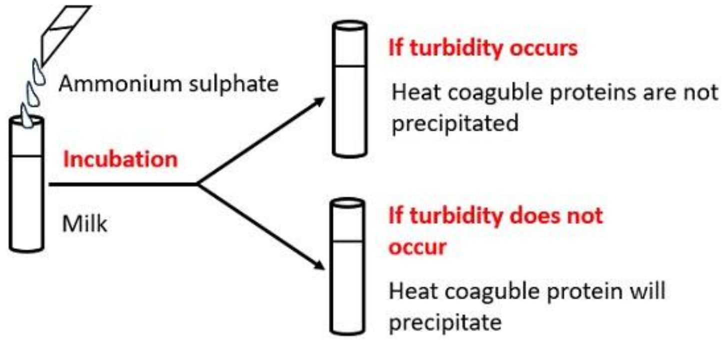
Interpretation of the result:

Positive: Blue color appears, indicating the presence of phosphatase (milk is pasteurized appropriately).
Negative: No changes in color, indicating the absence of phosphatase (milk is not pasteurized appropriately).

F. **Turbidity test:** This test checks the sterilization process of milk, whether the milk is boiled correctly or not, to the temperature prescribed for sterilization. It milk is sterilized properly, then all coagulable heat proteins get precipitated.
Procedure:

At first, 5 mL of sterilized milk is taken.

↓
Then a few drops of ammonium sulfate is added.
↓
The mixture is boiled in a water bath for 5 minutes.

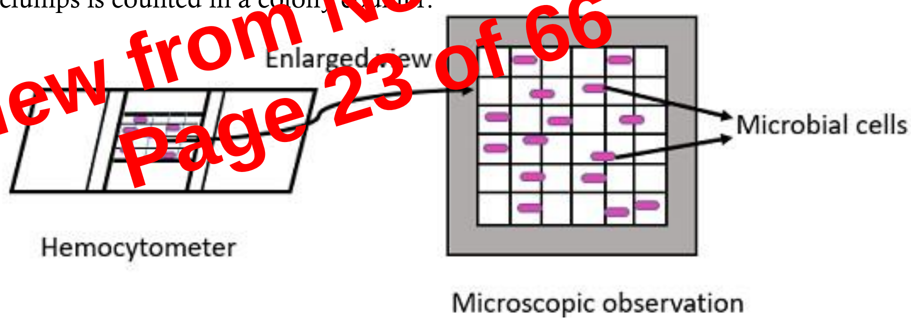


Interpretation of the result:

Positive: If turbidity appears, milk is not sterilized properly.
Negative: If there is no turbidity, milk is sterilized properly.

G. **Direct microscopic count:** It is a rapid method for microbial examination, which determines cell morphology. It counts both viable and non-viable cells.
Procedure:

0.01 mL of raw milk is taken in glass slide (hemocytometer) and then air dried.
↓
One drop of methylene blue is added.
↓
Bacterial clumps is counted in a colony counter.



Deleterious color and flavor changes in milk:

Flavour changes:

- **Sour or acid flavour:** Lactic streptococci and aroma forming Leuconostoc cause this.
- **Bitter flavour:** This results from proteolysis, fermentation of lactose, lipolysis. It is caused by some cocci.
- **Burnt or caramel flavour:** This is caused by *Streptococcus lactis*.
- **Miscellaneous flavour:**
  - Turnip like flavour is caused by *E. coli*
  - Fruit flavour is caused by *Pseudomonas fragi*
  - Potato like flavour is caused by *Pseudomonas mucidolens*.

Colour change:

- **Blue milk:** It is caused by acid fermenter *Streptococcus lactis*.
- **Yellow milk:** It is caused by *Flavibacterium*.

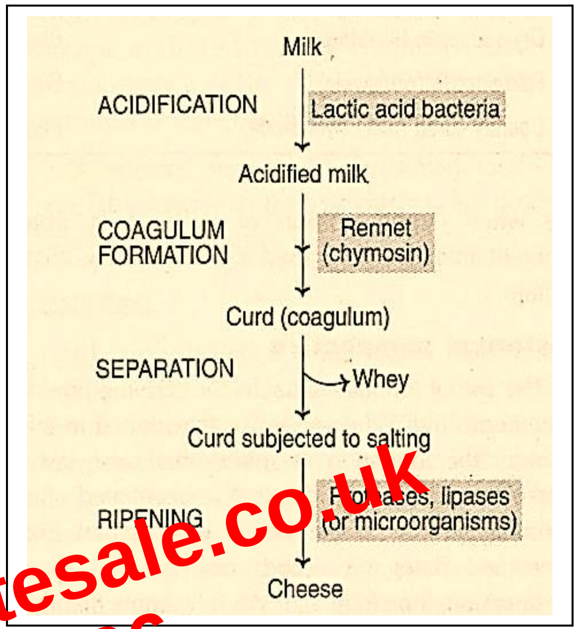
- **Red milk:** It is caused by *Micrococcus roseus*. Yeast may produce red or pink colonies on the surface of sour milk.
- **Brown milk:** It is caused by *Pseudomonas putrefaciens*.

Cheese production:

Cheese production is the largest dairy industry in the world. There are around 1,000 types of different cheeses.

Types: Broadly two types:

1. **Unripened cheese:** Cottage cheese with low fat, cream cheese with high fat.
2. **Ripened cheese:**
    - Hard cheese e.g. cheddar, blue cheese
    - Soft cheese e.g. limburger, camembert.



Production process

All cheese are irreversibly made from casein of milk that is produced after separating the whey (liquid protein of milk). Milk from different animals can be used e.g. sheep, cow, goat, buffalo.

The production process of cheese is discussed hereunder:

1. **Acidification of milk:** By employing lactic acid bacteria (*Streptococcus lactis, Lactobacillus lactis*) the sugar of milk (lactose) can be converted to lactic acid. This lowers the pH to around 4.6 and thus acidifies milk.
2. **Coagulum formation:** When the acidified milk is treated with rennet (i.e. the enzyme chymosin of animal or fungal origin), casein gets coagulated. Casein mainly consists of three components – insoluble α and β-caseins and a κ casein that keeps them in soluble state. By the action of chymosin, κ casein is degraded. Consequently, α and β-caseins and the degraded products of κ casein combine to form a coagulum (curd). This process of coagulation is dependent on Ca^{2+}.
3. **Separation of curd from whey:** When the temperature of the coagulum is raised to around 40°C, the coagulum (curd) and whey (fluid portion) are separated. The separated curd is cut into blocks, drained and pressed into different shapes.
4. **Ripening of cheese:** The flavour of raw cheese (with rubber texture) such as cheddar is bland. Ripening imparts flavour, besides making changes in the texture. The procedures adopted for ripening (or maturation) are highly variable depending on the type of cheese to be prepared. The blocks of curd separated are subjected to the action of proteases and/or lipases. Alternatively, they may be inoculated with certain fungi (e.g. *Penicillium roquefortii*). The hydrolysis of proteins and fats (either by enzymes or by microorganisms) results in certain compounds which imparts flavour to the cheese. Mild hydrolysis of fats (or cheese), usually carried out by lipases or *Aspergillus niger or Mucor maihai* results in butyric acid formation with characteristic flavour.

Yogurt

Yogurt is produced by fermenting whole milk by employing a mixed culture of *Lactobacillus bulgaricus* and *Streptococcus thermophilus*. While *L. bulgaricus* produced acetaldehyde that imparts a characteristic taste, *S. thermophilus* results in the formation of lactic acid to give acid flavour. In addition, both these bacteria produce extracellular polymers that increase the viscosity of the fermented milk. Yogurt is very delicious and in fact, frozen yoghurt is becoming popular as an alternative to ice cream.

Production process:

1. **Adjustment of milk composition and blending ingredients:** Milk composition may be adjusted to achieve desired fat and solids content. Ingredients such as stabilizers are added at this time.
2. **Pasteurization of milk:** Milk is pasteurized at 85^0 C for 30 minutes or at 95^0 C for 10 minutes. A high heat treatment is used to determine the whey proteins.
3. **Homogenization:** The blend is homogenized (2,000 – 2,500 psi) to mix all ingredients thoroughly and improve yogurt consistency.

4. **Cooling milk:** The milk is cooled to 42^0 C to bring the yogurt to the ideal growth temperature for the starter culture.
5. **Inoculate with starter cultures:** The starter cultures are mixed into the cooled milk.
6. **Holding:** The milk is held at 42^0 C until a pH of 4.5 is reached.
7. **Cooling:** The yogurt is then cooled to 7^0 C to stop the fermentation.
8. **Packaging:** The yogurt is pumped from the fermentation vat and packaged as desired.

to mucosal necrosis. The toxin also forms multimeric transmembrane pores and facilitates the release of cellular arachidonic acid and inositol. Additionally, the α toxin with the phospholipase and sphingomyelinase activity is also responsible for necrotizing effects.

Clinical findings:

- Watery diarrhea
- Abdominal cramps
- No vomiting
- No fever

The illness lasts only 1 – 2 days.

Conditions necessary for an outbreak: The following conditions are necessary for an outbreak:

1. The food contains or becomes contaminated with *C. perfringens*.
2. Usually the food is cooked and reduced conditions develop.
3. The food is inadequately cooled and favourable temperature and enough time is allowed for appreciable growth.
4. The food is consumed without reheating so that large numbers of viable cells are ingested.
5. The cells sporulate in vivo and elaborate the enterotoxin.

Prevention:

1. Adequate and rapid cooling of cooked meats and other foods.
2. Holding hot foods above 60^0 C.
3. Reheating the leftover foods and
4. Good personal hygiene.

Food related diseases caused by *E. coli*

Important properties:

1. **Gram staining property:** *E. coli* is a straight Gram-negative rod.
2. **Morphology:**
   - Motile with peritrichous flagella.
   - Most strains are fimbricated or piliated.
   - It has 3 antigens: O (cell wall antigen), H (flagellar antigen), K (capsular antigen).
3. Facultative anaerobe
4. *E. coli* ferments lactose (a property that distinguishes it from the two major intestinal pathogens, Salmonella and Shigella).
5. Catalase positive
6. Oxidase negative
7. Because there are more than 150 O, 50 H and 90 K antigens, the various combinations result in more than 1000 antigenic types of *E. coli*.
8. Specific serotypes are associated with certain diseases e.g. O55 and O111 cause outbreaks of neonatal diarrhea.

Virulence factors of *E. coli* (in short)

1. **Exotoxins (enterotoxins):** 3 exotoxins.
   - Heat labile toxin (LT)
   - Heat stable toxin (ST)
   - Verotoxin
2. **Pili:** They help the bacteria to adhere to the site of infection.
3. **Capsules:** Capsule interferes with phagocytosis.
4. Endotoxin
5. **Verotoxn:** Shigella-like toxin (SLT).

1. Ingestion of undercooked hamburger, often at fast-food restaurants, unpasteurized juices and fresh vegetables.
2. Direct contact with animals e.g. visits to farms and petting zoos, have resulted in bloody diarrhea caused by O157:H7 strains.

Incubation period: 1 to 7 days.

Pathogenesis: Shiga toxin acts by removing an adenine from the large (28S) rRNA, thereby stopping protein synthesis.

Verotoxin released by EHEC, most commonly O157:H7
↓
Toxin binds with the receptor on the intestinal cell wall
↓
Removes an adenine from the large 28S rRNA
↓
Stop protein synthesis in the intestinal epithelial cells
↓
Tissue necrosis
↓
Bloody diarrhea

Prevention: Many cases of hemorrhagic colitis and its associated complications can be prevented by thoroughly cooking ground beef.

E. **Enteroaggregative *E. coli* (EAEC):** EAEC strains are so called because they show a typical 'stacked brick' arrangement on Hep-2 cells or glass due to their autoagglutination. Bundle forming fimbriae of the bacteria (such as AAF/I and AAF/II), which are carried on a plasmid, medicate this process. These EAEC strains secrete a low molecular weight, heat stable enterotoxin called enteroaggregative heat stable enterotoxin-1 (EAST-1). EAEC increases mucus secretion, which forms a layer overlying the epithelium of the small intestine. This layer of biofilm traps the bacteria in epithelium of the small intestine. In animal experiments, they cause shortening of the microvilli, mononuclear infiltration and hemorrhage. These strains are associated with persistent, watery diarrhea with dehydration in infants, especially in developing countries.

F. **Diffusely adherent *E. coli* (DAEC):** DAEC strains cause watery diarrhea found primarily in children between 1 and 5 years of age. These strains are identified by their ability to adhere to cultured cells. They cause elongation of the microvilli with the bacteria trapped in the cell membrane.

Pathogenesis of UTI caused by *E. coli*: *E. coli* is the most common cause of UTI and accounts for approximately 90% of first UTI in young women.

Pathogenesis of UTI:

Relatively minor trauma or mechanical disruptions can allow bacteria colonizing the periurethral area. *E. coli* from the fecal flora may enter the bladder of women after sexual intercourse. Urinary catheters or obstruction to urine outflow (enlarged prostate) allow the bacteria more time to multiply and cause injury.
↓
Certain O serotypes of *E. coli* preferentially cause UTI. These uropathic strains are characterized by pili with adhesion proteins that bind to specific receptors on the urinary tract of epithelium.
↓
The motility of *E. coli* helps to ascend the urethra into the bladder and ascend the ureter into the kidney.
↓
Once established, LPS, α-hemolysin and cytotoxic necrotizing factor (CNF) cause injury. Spread to the bloodstream leads to LPS-induced septic shock.

Laboratory diagnosis of UTI or diarrhea caused by *E. coli*:

Principle: The diagnosis is based on demonstration of the causative organism by microscopic examination and isolation and identification by culture. Immunological tests and some others tests are also helpful.

Steps:

A. Specimen collection:

- Freshly passed stool
- Rectal swab
- Urine

B. **Microscopic examination:** Gram staining.

Finding: Gram-negative rods are found.

C. Isolation and identification from culture:

1. **MacConkey agar media:**
    - Incubated at 37^0 C
    - Finding: Form pink colonies (due to fermentation of lactose)
2. **EMB agar media:** *E. coli* colonies have a characteristic green sheen.

D. **Immunological test:** Sometimes helpful.

E. Special test:

- *E. coli* O157:H7 does not ferment sorbitol, which serves as an important criterion that distinguishes it from other strains of *E. coli*.
- For ETEC, EPEC, VTEC done in reference lab.

F. **Demonstration of toxins of diarrheagenic *E. coli*:** Laboratory diagnosis of diarrhea caused by diarrheagenic *E. coli* can be made by demonstration of the bacilli in feces by culture.

Method:

The feces are collected from the patient in a sterile container and sent immediately to the laboratory.

↓

The fecal samples are inoculated directly on MacConkey and blood agar media.

↓

The plates are incubated at 37^0 C overnight and looked for the characteristic lactose fermenting colonies on MacConkey and beta hemolytic colonies on blood agar

↓

Since *E. coli* is present as commensals in the intestine, hence it is detected even in normal stool; it is essential to perform various diagnostic tests in order to consider it as diarrheagenic pathogenic *E. coli* strain. These strains are identified by:

- Serotyping
- Animal inoculation
- Cytopathic effects in cell cultures
- Molecular methods

Food related diseases caused by Salmonella species

Characteristics

1. They are Gram negative and motile rod-shaped organisms.
2. Ferment glucose usually without producing gas, but do not ferment lactose and sucrose.
3. The primary habitat of Salmonella species is the intestinal tract of animals such as birds, reptiles, farm animals, humans and occasionally insects. Although their primary habitat is the intestinal tract, they may be found in other parts of the body from time to time.
4. As intestinal forms, the organisms are excreted in feces from which they may be transmitted by insects and other living creatures to a large number of places.
5. Optimum temperature is 37^0 C, range 6.7 — 45.6^0 C .
6. **pH:** 4.1 – 9
7. **a_w:** 0.93 – 0.95
8. **D_{60} C:** 0.06-11.3 minute

Source of infection: The sources of infection are food and drink that have been contaminated with Salmonellae. The following sources are important:

- **Water:** Contamination with feces often results in explosive epidemics.
- **Milk and other dairy products (ice cream, cheese, custard):** Contamination with feces and inadequate pasteurization of improper handling. Some outbreaks are traceable to the source of supply.

Transmission:

- There is a low level of transmission between flocks. A common source was suggested via vertical transmission rather than hatchery or transportation sources. The consensus seems to be that this organism is not transmitted through the hatchery, but instead to broiler chicks by vermin. One study revealed that the organism appeared in all chicken inhabitants within a week once it was found among any of the inhabitants.
- In addition to poultry, the other primary source of this organism is raw milk. Because the organism exists in cow feces, it is not surprising that it may be found in raw milk and the degree of contamination would be expected to vary depending on milking procedures.
- Human to human transmission also occurs, but is very rare.

Virulence properties:

At least some strains of *C. jejuni* produce a heat labile enterotoxin that shares some common properties with the enterotoxins of V. cholerae (CT) and *E. coli* (LT). Also *C. jejuni* enteritis appear to be caused in part by the invasive abilities of the organism.

Disease produced: Food borne illness which is characterized by enteritis.

Infective dose: 500 – 10,000 organisms (dose often correlates with the intensity of the attack).

Pathogenesis of disease caused by *C. jejuni*: Following three mechanisms have been postulated in the pathogenesis of intestinal disease caused by *C. jejuni*:

1. **Adherence and production of heat labile enterotoxins:** *C. jejuni* adheres to the jejunum, ileum and colon. Adherence to epithelial cells and/or mucus at these sites is possibly facilitated by flagella. LPS or other outer membrane components are also believed to contribute to adhesion. PEB1 is a superficial antigen that has been found to be a major adhesion protein, which is found among *C. jejuni* strains. Furthermore, *C. jejuni* enterotoxin is a heat labile cholera-like enterotoxin, which is responsible for diarrhea observed during infections.
2. **Invasion and proliferation of bacteria within the intestinal epithelium:** *C. jejuni* causes characteristic histologic damage, in the mucosal surface of the jejunum, ileum and colon. The organism produces diffuse, bloody, edematous and exudative enteritis. Infiltration of lamia propria occurs with neutrophils. It is also associated with crypt abscesses in the epithelial glands and ulceration of the mucosal epithelium. Precise role of enterotoxins and cytopathic toxins in causation of intestinal pathology is not known.
3. **Invasion of intestinal mucosa and proliferation:** *C. jejuni* invades intestinal mucosa and multiplies in the lamina propria and mesenteric lymph nodes. This results in extraintestinal infections, such as cholecystitis, mesentery adenitis, urinary tract infection and meningitis.

Campylobacter jejuni infection in a small number of cases is associated with Guillain-Barre syndrome, hemolytic uremic syndrome and thrombotic thrombocytopenic purpura.

Characteristics:

1. Abdominal pain or crams
2. Diarrhea
3. Malaise
4. Headache
5. Fever

In the more severe cases, bloody stools may occur and the diarrhea may resemble ulcerative colitis, where the abdominal pain may mimic acute appendicitis. Campylobacter enteritis is considered to be the leading foodborne illness in the United States and its prevalence is compared to that of Salmonella and *E. coli* O157:H7.

Prevention:

1. *V. parahaemolyticus, Y. enterocolitica* and *C. jejuni* are all heat sensitive bacteria that are destroyed by milk pasteurization temperatures.
2. Campylobacteriosis can be avoided by not eating undercooked or unpasteurized foods of animal origin, especially milk.