FE 305FOOD MICROBIOLOGY
Microbial Spoilage in Meat and Meat Products

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Food Spoilage

- Food for humans is obtained from plants and animals.
- The nutrients in these foods are not only for human needs
  - but are also vital to the growth and survival of microorganisms.
- Thus, if foods **are not** immediately utilized or preserved from harvest to consumption, it spoils.
- Spoilage of food can be described as a loss of qualitative properties in foods with regard to color, texture, flavor, odor and structure.
  - Spoiled food may have a foul odor, off-flavor, slime, discolored and visible microbial growth.
- Types of food spoilage fall into two major groups:
  - **Microbial**: results from growth of microorganisms or action of microbial enzymes.
  - **Nonmicrobial**: result from foreign material, enzymes in the foods naturally present, chemical reactions, physical damage and infection with insects and rodents.

Food Spoilage

- When decomposition of food is not accepted by consumer,
  - it is called spoilage.
- About one-fourth of the world's food supply is **lost** through the action of microorganisms alone.
- Criteria for acceptability of food of fitness to eat:
  1. has desired stage of development or maturity of food.
  2. are freedom from pollution from harvesting to consumption.
  3. are freedom from biological, chemical and physical changes results from food enzymes, microorganisms, insects, rodents, invasion of parasites, pressure, heating, drying and the like.
  4. freedom from agents causing foodborne illnesses.
- Enzymes and microbial activities are undesirable,
  - when they are unwanted or uncontrolled.
    - Examples: souring of milk; if unwanted, it is spoilage,
      - but same process is used in the production of cheeses and other fermented milk products.

Food Spoilage

- Bacteria, yeast and molds all play a role in the deterioration of nutrients. These microorganisms, which are factors of spoilage, use food as a source of nutrients and energy. While growing in foods, microorganisms fermentatively break down carbohydrates, fats and proteins. These decomposition products, on the other hand, cause food spoilage.
- Microbial food spoilage is caused by both the growth of microorganisms and the action of enzymes produced by microorganisms. With the development of microorganisms, food spoils faster.
- Spoilage of a food; It is an indication that microorganisms develop and reach high numbers during the procurement of raw materials, transportation to the factory, processing and storage of the desired product. As a result of microbiological deterioration, taste, odor and texture changes, gas formation and liquid accumulation may occur in foods.

Classification of Foods Depending on Stability

- Foods can be classified into four groups according to spoilage potential categories and type of preservation process applied.

1. ***Highly perishable foods***

- The majority of our daily foods classified as perishable.
- If no preservation process is applied, the quality retention time is about 1-3 days.
- This group includes meat, poultry, fish, raw milk, eggs, many fruits, vegetables, and all cooked foods except the dry and very acid ones.

2. ***Semiperishable foods***

- Lightly processing is given to foods
  - The quality retention time of these foods is about 1-3 weeks.
  - Such as pasteurization of milk and egg products, and than refrigerated.
- Other examples are frozen foods, baked goods, hard cheeses and fruits.

Classification of Foods Depending on Stability

3. ***Shelf-stable foods***

- Two or more preservation process can be used (the hurdle concept) such as vacuum packaging the cooked meat products, with a quality retention time from 1 to 4 months.

4. ***Nonperishable foods***

- Highly processed (such as heat processed, sterilized and hermatically sealed) foods are usually listed in this group.
- Such as vegetables, dried milk products with a quality retention up to 1 year or more.
- Other examples are sugar, flour, dry foods, etc.
- Few foods are truly nonperishable.
- Most foods fall into one of these four groups,
  - but some are near enough to the borderline to be difficult to place.

Potentially Hazard Foods

The following is the definition used in the definition of potentially hazard foods:

a) "**Potentially hazardous food**" means a food requires temperature control because it supports:
- the rapid and progressive growth of spoilage, pathogenic or toxigenic microorganisms;
- the growth of microorganisms: results with
  - changes nutrient components,
  - production of toxin, such as by *C. botulinum*,
  - increasing number of pathogen in foods, such as *Salmonella enteritidis* in raw shell eggs.

b) "**Potentially hazardous food**" includes
- an animal food that is raw or heat-treated;
- a plant food that is heat-treated or consists of raw seed sprouts, cut melons and garlic-in-oil mixtures.

Types of Agents Causing Food Spoilage

- Food spoilage may be caused by one or more of the followings:
  1. Growth and activity of microorganisms.
  2. Insects, rodents or animals.
  3. Action of the enzymes naturally present in the plant or animal food
     - such as degradation of vegetables by pectinases and fishes by proteinases.
  4. Purely chemical reactions in the food,
     - such as browning and oxidation.
  5. Physical changes,
     - such as those caused by freezing, burning, drying, pressure, etc.
  6. Presence of foreign material,
     - such as heavy metals, toxins, nonfood materials.
  7. Presence of parasites or their eggs.

Factors Effecting Food Spoilage

- Microbial spoilage occurs as a result of microbial contamination with foods and the activities of microorganisms under suitable conditions.
- Factors:
  - Microorganisms,
  - Food residues,
  - Moisture,
  - Time,
  - Temperature,
  - Physical state and structure of food,
  - Significance of microbial types.

Practices to Prevent Food Spoilage

- Spoilage can be slowed by following practice:
  - Package the fresh product.
  - Use good sanitation and personal hygiene habits during processing and packaging of food.
  - Use sanitation habits for equipments used in the food production.
  - Cool processed foods as quickly as possible to below 4°C.
  - Keep leftover foods covered to prevent contamination and put them under refrigeration as soon as possible.
  - Keep hot food on a steam table, above 60°C.
  - Keep cold food cold.
  - Cool the foods in large containers containing ice.
  - Cook food up to an internal temperature of 75°C
    - to destroy both enzymes and vegetative bacterial cells.
  - Stir the cooked foods during cooling until the temperature reaches 4°C.

Meat Microbiology

- Red meat can be defined as the muscle tissue of mammals.
- **Meat**; It is the edible part of the carcass after the internal organs of animals such as cattle, sheep and goats are separated.
- Meats, meat products and seafood are the most suitable environments for microorganisms to grow and multiply. Because these products;
  - Humidity is high (75-78%),
  - Water activity is 0.99,
  - It can be fermented.
- In addition, these products; The fact that it contains glycogen, is rich in nitrogenous nutrients and minerals also facilitates the formation of microorganisms.
- Fresh meat is one of the foods most susceptible to microbiological spoilage due to its physical and chemical properties.

Meat Microbiology-Introduction

- If red meat is cooled without completing the rigor mortis,
  - it will be unacceptable.
- After slaughter of the animal, the carcass requires aging until rigor has disappeared and the meat is more tender.
- Different events take place during rigor mortis after animal's slaughter:
  1. The ability to synthesize A TP is lost,
     - lack of ATP causes combination of actin and myosin to form actomyosin,
     - this leads to a stiffening of muscle;
  2. 0_2 supply fails,
     - resulting in a reduction of the oxidation-reduction potential;
  3. Loss of vitamins and antioxidants slows rancidity;
  4. Temperature of the animal fail and fat solidify:
  5. Respiration stops;

Meat Microbiology-Introduction

6. Glycolysis begins: convert most glycogen to lactic acid,
   - reduces pH from about 7.4 to 5.7,
   - this pH initiates protein denaturation and completes rigor mortis;
7. Stopping immune system leads to susceptibility of meat to microorganisms; and
8. Accumulation of metabolite leads to protein denaturation.

- These events require 5 days at 13°C, 2 days at 18°C and 24 to 36 h at 29°C.
- The greater the temperature for rigor mortis, the greater the chance of undesirable microbial growth and spoilage.

Meat Microbiology

- Factors affecting the growth of microorganisms in meat are as follows:
  - Moisture content
  - Nutrient content
  - pH
  - Storage temperature
  - Storage time,
  - Storage conditions
  - Oxidation and reduction potential
  - Infected microorganisms and the level of contamination

Contamination to Meat

- Animal meat is sterile before slaughter. From the slaughter of animals, meat meets with microorganisms both in the intestinal flora and on the outer surface. In other words, after slaughter, the protection mechanism against microorganisms weakens and eventually stops. Thus, microorganisms begin to spread to all tissues.
- However, during slaughter, skinning, removal of internal organs, splitting of carcass and deboning, many unwanted microorganisms contaminate the meat from the skin of the animal, intestines, slaughter tools, hands and clothes of workers, transport cars, air, tools and equipment.
- Since the meat comes into contact with oxygen after slaughter, anaerobic microorganisms do not develop. In contact with air, aerobic microorganisms develop.

Contamination to Meat

Factors Effecting Microbial Contamination :

- The following factors affect contamination of microorganisms with meat:

1. Bacterial flora of animal. Higher the microbial number in the intestine of the animal, the greater the contamination of meats.
2. Physiological condition of the animal before slaughter.
   - If the animal is stressed or fatigued,
     - bacteria enter into the tissues and
     - spread through tissue.
3. Method of slaughter and bleeding. The better sanitary bleeding increases keeping quality of the meat.
4. Injury during hide removal or evisceration. Bacteria can enter into the tissue through injury.
5. Rate of carcass cooling. Rapid cooling will prevent microbial growth.
6. Exposed surface of meat. Grinding increases the surface area and encourages microbial growth.

Contamination to Meat

7. Chemical properties of meat. A little moisture allows growth of molds and yeasts. High moisture favors bacterial growth.
   - The low content or absence of fermentable carbohydrate and the high protein content favor the nonfermenting microorganisms.
   - High pH value favors microbial growth.
8. Availability of oxygen. Aerobic conditions at the surface of meat are favorable to molds, yeasts and aerobic bacteria.
9. Temperature. Molds, yeasts and psychrotrophic bacteria grow slowly in meal stored above freezing.
10. Contamination. Personal hygiene, degree of sanitation, contact of meat with fecal matter, hide, hair and skinning operations effect level of contamination and spoilage.

Contamination to Meat

- Fresh meat may contain many kinds of microorganisms: species of *Acinetobacter, Aeromonas, Alcaligenes, Alteromonas, Brochothrix, Carnobacıerium, Escherichia, Enterobacter, Enterococcus, Flavobacterium, Hafnia, Lactobacillus, Leuconostoc, Micrococcus, Moraxella, Proteus, Pseudomonas, Sarcinia, Serratia, Shewanella, Streptococcus,* yeasts and molds.
- Pathogenic microorganisms from intestinal tract are *Salmonella, S. aureus, Y. enterocolitica, C botulinum, C jejuni, C. perfringens, A. hydrophila, L. monocytogenes and E. coli.*
- Normal flora of meats coming from the animal's lymph nodes is *Staphylococcus, Streptococcus, Clostridium and Salmonella*.
- Bacteria (such as *Staphylococcus, Micrococcus and Pseudomonas*), yeasts and molds on hide, skin microflora, and from fecal material and soil.
- Refrigerated meat mainly contains *Acinetobacter, Moraxella, Pseudomonas, Aeromonas, Alcaligenes and Micrococcus*.
- Processed and cured meats:
  - LAB, *Acinetobacter, Bacillus, Micrococcus, Serratia and Staphylococcus*;
  - mold genera *Aspergillus, Penicillium, Rhizopus and Thamnidium*; and
  - yeast genera *Candida, Debaryomyces, Torula, Torulapsis and Trichosporon.*
- Vacuum Package gas impermeable bags will usually lead to the growth of *Brochothrix thermosphacta* and LAB (mostly L*actobaci*llus).

Meat and meat products	Alteration (spoilage)	Microorganism
Fresh beef (at 4°)	Surface slime and/or off odor	*Pseudomonas. Shewanella, Acinetobacter. Brochothrix, Leuconostoc, Moraxella*
	White growth	*Sporotrichum carnis, Mucor mucedo, Rhizopus*
	Red spot	*Serratia mercescens*
	Blue discoloration	*Pseudomonas syncyanea*
	Green patch	*Penicillium expansum, P. asperulum*
	Brown color	*Chromobacterium lividum*
	Black spot	*Cladosporidium herbarium*
	Slime, greening	*Lactobacillus, Leuconostoc*
Sausages	Souring at 0-1 1 °C	*Lactobacillus, Leuconostoc*
	Off odor	LAB
	Souring at 22°C	*Microbacterium*
	Surface slime	*Lactobacillus, Leuconostoc Bacillus*
	Greening	*Lactobacillus, Leuconostoc, Pediococcus, Enterococcus*
Dried meats	Surface slime	*Micrococcus*
	Off odor	*Flavobacterium*
	Blue color	*Pseudomonas syncyanea, P. spinulosum; Rhodotorula*
	Red color	*Bacillus*
Vacuum Packed	Putrefication and gas souring, off odor	*Clostridium, Alcaligenes, Lb. carnosus, Lb. gelidium, Leu. mesenteroides, Alcaligenes, Pediococcus*

Contamination to Meat

- Most important genera of molds spoiling fresh meats are;
  - Flamentous growth: *Thamnidium, Mucor and Rhizopus*.
  - White growth: *Mucor mucedo, Thamnidium elegans, Rhizopus* and others;
  - Black spot: C*ladosporium herbarum; and*
  - *Green spot: Penicillium expansum*.
- Molds do not grow on meats if the storage temperature is below -5°C.
- Genera of yeasts spoiling refrigerated meats are *Candida (C. lipolytica, C. zeylanoides), Torulapsis and Rhodotorula.*

Microbial Spoilage in Meat and Meat Products

- One of the most important factors affecting the type of spoilage in meat is the presence of oxygen. In the presence of oxygen, aerobic degradation occurs, and in the absence of oxygen, anaerobic degradation occurs.

a) Aerobic Spoilage

- Under aerobic conditions, bacteria, yeast and molds develop in meat and cause spoilage.
- **Stickiness**: This deterioration is caused by *Pseudomonas, Acinetobacter, Streptococcoccus, Leuconostoc, Bacillus and Micrococcus* species. Appropriate temperature and humidity cause these bacteria to thrive on the meat surface. The meat surface is covered with a sticky, mucous layer.
- **Color Changes**: Red color of meat due to peroxides formed by bacteria due to oxidation and oxidizing compounds such as hydrogen sulfide (H_2S); turns green, brown, and gray. *Lactobacillus and Leuconostoc* species produce a green color in sausages and sausages.

Microbial Spoilage in Meat and Meat Products

- Fresh meats stored at refrigerated temperature (5°C) are spoiled by psychrotrophic bacteria.
  - Psychrotrophic aerobes and facultative anaerobes grow in meats stored under aerobic condition.
  - *Pseudomonas* spp. will grow rapidly due to short generation time.

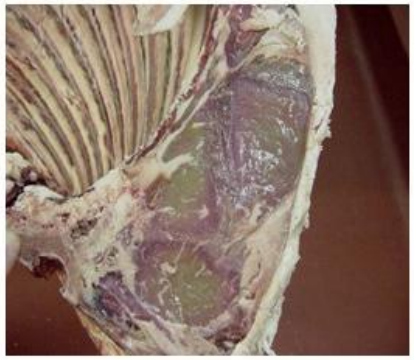
- Once simple carbohydrates have been used,
  - Psychrotrophs, such as *Aeromonas*, *Acinetobacter, Alcaligenes, Moraxella*,
  - *Pseudomonas*, utilize free amino acids and simple nitrogenous compounds.
  - They produce methyl sulfides, esters and acids from amino acids.

Microbial Spoilage in Meat and Meat Products

- Surface slime of meat is caused by *Acinetobacter, Alcaligenes, Leuconostoc, Moraxella, Pseudomonas;*
  - red spot by *Serratia mercescens*;
  - blue color by *P. syncyanea*,
  - yellow discoloration by *Flavobacterium*.
- Cooking of meat will destroy large population of the microflora of the raw meat.
  - Thermoduric organisms, such as spores of *C. perfringens* and *B. Cereus*, will usually be reduced to low numbers.
  - Improper storage after cooking can allow growth of such survivors.

Microbial Spoilage in Meat and Meat Products

- *Serratia marcescens* or some other red-pigmented bacteria cause a "red stain" in meat.
- Blue color on the meat surface of *Pseudomonas sycyane*; Bacteria such as *Flavobacterium* cause green discoloration.
- *Chomabacterium lividium* causes brownish black spots on stored meat.



Microbial Spoilage in Meat and Meat Products

- **Oxidation of Fats (Bitter):** Lipolytic species of *Pseudomonas* and *Acinetobacter* create oxidative effects in oils and cause rancidity by hydrolyzing oils.

- **Mold Growth**: Most of the bacteria that cause spoilage in meat cannot operate below a water activity value of 0.96. In this case, molds begin to develop. Bearding, black spot formation, white spot formation are seen in the meat. All other mold growth is carried out by *Penicillium* species.

- **Formation of Bad Smell and Taste**: Bad-smelling compounds such as skatole (3-methylindole), amine and ammonia occur with the formation of pitrite (FeS_2) on the bacteria on the meat surface. The sour taste may occur due to the formation of volatile acids formed as a result of the development of yeasts. Therefore, molds cause undesirable color, odor and taste changes. Molds impart a characteristic moldy taste to areas where they thrive**.**

Microbial Spoilage in Meat and Meat Products

b) Anaerobic Spoilage

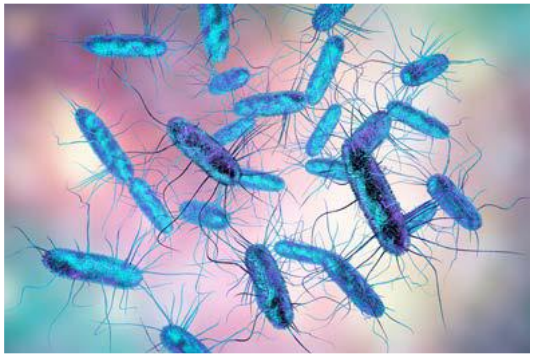
- It occurs as a result of the growth of facultative anaerobic and anaerobic bacteria.
- **Sourness**: As a result of bacterial activity, organic acids such as formic, acetic, propionic, and lactic acid are formed. This formation creates a sour taste and odor in meat and meat products.
- **Putrefaction**: Generally, Clostridium species break down proteins under anaerobic conditions. As a result, malodorous compounds such as hydrogen sulfide (H_2S), ammonia (NH_3), and amines are formed.

Microbial Spoilage in Fermented Meat Products

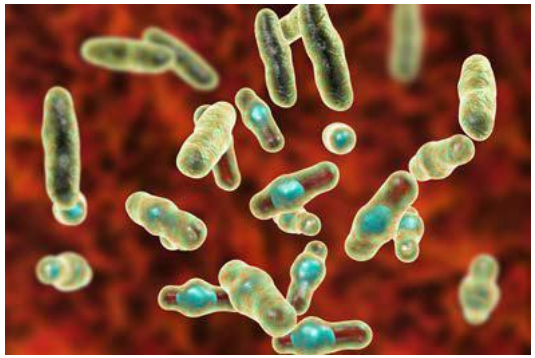
- Meat products such as sausage, bacon, ham, and seafood such as salted fish and pickled fish undergo a microbial maturation period. While the low pH value of fermented meat products is 4.5-5.3, the water activity is 0.73-0.93. When acid production of lactic acid bacteria is slow during fermentation, unwanted bacteria develop and undesirable formations such as slipperiness, rancidity and green color occur.
- Sausage in general terms; It is a food product consisting of meat, oil, additives and spices. After the meat is stuffed into the casings and ripening begins, the microflora also begins to change. At the beginning of fermentation in sucuk, gram (+) and gram (-) bacteria are formed. Microorganisms that cause spoilage in sausage can grow on the inner and outer surfaces of the sausage casing and in the inner parts of the sausage.
- Meat initially contains *Pseudomonas, Enterobacteriacea* microorganisms. Later, with the addition of salt, oxygen and nitrite-nitrate salts, lactic acid bacteria begin to develop in the environment.

Microbial Spoilage in Fermented Meat Products

- Lactic acid bacteria lower the pH of the environment. This inhibits the growth of pathogenic microorganisms and inhibits the growth of *Clostridium* and *Bacillus* species.
- Putting the sausages in the casings and decreasing the pH value prevent the growth of *Micrococcus* and *Staphylococcus*. Because these microorganisms cannot multiply in an anaerobic environment.



Salmonella



Clostridium perfringens

Detection of Meat Spoilage

- Physical methods will indicate meat spoilage due to changes on organoleptic characteristics (odor, touch, appearance and taste).
  - Extract-release value (ERV) is able to indicate spoilage and shelf life of meats.
  - ERV is based on volume of extract released by meat
    - allowed to pass liquid through filter paper for a given period of time.
  - Meat with good organoleptic and microbial quality releases large volumes of extract
    - while meat of poor microbiological quality releases smaller volumes.

Microbial Spoilage in Poultry

- Poultry meats have very favorable chemical properties for microbial growth. Microorganisms to poultry; It is transmitted from feed, dust, soil and air in the poultry house, various animals coming to the poultry house, shoes and equipment of employees.
- Pathogenic microorganisms found in poultry meat and their locations are as follows:
  - *Salmonella* (feather, feet and gut)
  - *Clostridium perfringens* (feather, feet and gut)
  - *Staphylococcus aureus* (feather, skin)
  - *Escherichia coli* (feet, intestine).

- Poultry meat can play a common mediator role in the spread of food poisoning and infections.
- The putrefaction, which usually occurs on the surface of chicken meat, can be determined by the total number of bacteria reaching 10^6cfu/cm^2. Poultry meat stored at 10 °C and below is usually caused by *Pseudomonas*.

Microbial Spoilage in Poultry

- Poultry meat is a suitable medium for microorganisms.
  - it is rich in nitrogenous substances, carbohydrates and other growth factors.
  - it is high in moisture and pH is favorable to bacteria.
- Poultry are major source of food poisoning bacteria; *Salmonella, Camplobacter, C. perfringens, S. aureus, enteropathogenic E. coli and Yercinia enterocolitica*.
- Certain *Salmonella* spp. are host adapted, such as
  - *S. hador* in turkeys,
  - *S. agona* in chickens and
  - *S. enteritidis* in poultry.

Microbial Spoilage in Poultry

- Psychrotrophic bacteria associating with refrigerated raw poultry are *Pseudomonas, Acinetobacter, Alcaligenes, Moraxella, Proteus*.
- Cross-contamination can occur from one poultry to others.
  - Cross-contamination occurs from knives, equipment and worker's hands.
- Defathering process may spread microorganisms among carcasses.
- Additional cross-contamination may occur with flapping of wings to generate dust and aerosols transferred onto carcasses.
- Intestinal tract of healthy poultry contains species of *Enterococcus, Salmonella, Staphylococcus and C. perfringens*.
- Contaminants of bacteria during processing *are Alcaligenes, Klebsiella, Proteus, Vibrio and coliforms. C. jejuni* can also contaminate with chicken meats.
- Spray washing removes organic material
  - but bacteria firmly attached to carcass surface will remain.

Poultry spoilage

- Major bacteria involved in the spoilage of refrigerated poultry raw carcasses are *Pseudomonas fluorescens, Pseudomonas putida, Corynebacterium, Acinetobacter, Flavobacterium and Moraxella.*
- The surface of fresh poultry is susceptible to growth of aerobic bacteria, such as *Pseudomonas*.
- The sliminess is caused by *Pseudomonas*.
- The fluorescence on the poultry is due to the presence of large numbers of *Pseudomonas*.
- Poultry held at 10°C or below is spoiled mostly by *Pseudomonas; Proteus, coliforms, Torulapsis and Rhodotorula*.
  - Above 10°C, *Alcaligenes, Flavobacterium and Micrococcus*.
  - *Alcaligenes putrefaciens* grows well at 5°C and produces off-odors.
- Iced, cut-up poultry often develops **a slime that is accompanied by an odor** by *Alcaligenes and Pseudomonas.*

Poultry spoilage

- *Acinetobacter, Moraxella and Alteromonas putrefaciens* can produce H_2S, methyl mercaptan and dimethyl sulfide.
- Fungi are less important in poultry spoilage except when antibiotics are employed to suppress bacterial growth.
- The genera *Candida, Rhodotorula and Torula* spp. are the most important yeasts on poultry.
  - The spoilage associating with yeasts is sliminess on the surface of carcasses.
- Enzymes of poultry may cause deterioration, but chief spoilage is caused by bacteria.

Microbial Spoilage in Seafoods

- The meat of most fish species is more susceptible to microbial spoilage than red meat. Because in fish meat, much faster degradation reactions occur by enzymes.
- In general, the meat of a freshly caught healthy fish is sterile. Microorganisms are found in fish, on the outer protective layer covering the body surface, in the gills and intestines. The most susceptible part of the fish to spoilage is the gill area.
- Bacteria develop on the surface first; then spread on fish meat. In general, fish; Bacteria and some yeasts belonging to *Micrococcus, Bacillus, Pseudomonas, Escherichia, Vibrio, Serratia, Alcaligenez, Flavobacterium, Chromobacter, Orynebacterium* genera cause spoilage.
- Factors affecting the deterioration of fish; the type of fish, microbial contamination level, temperature and condition of the fish when caught.

Microbial Spoilage in Seafoods

- The first sensory deterioration in fish is seen with the formation of a foul odor in the gills. In the deterioration of the fish, compounds such as **ammonia, histamine, sulfur appear and odor** occurs.
- The growth of pathogenic bacteria such as *Clostridium and Listeria monocytogenes* as a result of contamination in fish is also affected by environmental conditions. Measurement of T.M.A and histamine in fish and pH give information about deterioration in fish.
- The deterioration of shellfish meat is similar to the deterioration seen in fish meat. As a spoilage factor in sea creatures such as shrimp, crab and lobster; There are species included in the genera *Moraxella, Acinetobacter, Vibrio, Alcaligenez, Bacillus, Micrococcus, Pseudomonas, Proteus*.

Microbial Spoilage in Seafoods

- Bacterial growth causes
  - slime layer,
  - discoloration of gills and eyes (in whole fish), and
  - loss of muscle texture (soften due to proteolysis).
- H_2S and other sulfur compounds, such as mercaptans and dimethyl sulfide, are produced by *Shewanella putrefaciens*.
- Major spoilage bacterial flora are:
  - Gram-negative aerobic rods (e.g., *Pseudomonas, Acinetobacter, Moraxella, Flavobacterium*), and
  - Facultative anaerobic rods (e.g. *Shewanella, Alcaligenes, Vibrio*), and coliforms.
- Spoilage due to psychrotrophic *Pseudomonas* predominates under aerobic storage at refrigerater.
- LAB can predominate in fish stored under vacuum or CO_2.
- Many fish spoilage bacteria grow well at 0°C.

Microbial Spoilage in Seafoods

- At room temperature, *Bacillus*, *Clostridium*, *Escherichia*, *Micrococcus*, *Proteus*, *Sarcina* and *Serratia* may predominate.
- The spoilage microflora of fresh ice-stored fish consists largely *Pseudomonas* spp.
  - Greenish yellow color is caused by *P. fluorescens.*
  - *Y*ellow color by *Micrococcus*.
  - Red color by *Bacillus*, *Sarcina*, molds and yeasts.
  - Chocolate-brown color by yeasts and molds.
  - Musty odor by *Streptomyces*.
- Halophilic bacteria can spoil salted fish: *Alcaligenes*, *Bacillus*, *Micrococcus*, *Pseudomonas*, *Serratia* and others.
- Molds are the chief spoilage organisms on smoked fish.

Prevention of spoilage in Red Meat, Poultry and Seafoods

a) Prevention of spoilage in Red Meat

- Every animal taken to the slaughterhouse should be cleaned without delay after veterinary control. In addition, disinfection operations should be carried out effectively in slaughterhouses, there should be no meat in the environment during spraying, tools and equipment should be turned off, and these tools should be washed before re-use.
- After slaughter, the animal should be completely bled and skinned in the hide removal room. Tools and equipment in the slaughterhouse, knives should be cleaned and disinfected at the end of the cut.
- The skinned animal carcass should be washed with running water without removing the internal organs, the internal organs should be removed and cleaned in a separate room, and the edible offal should be washed with running water.
- It should be ensured that personnel wear appropriate protective clothing, boots and headgear; hands should be washed regularly with running hot water, soap or detergent; Compliance with the working rules of all employees should be checked and the personnel should be subjected to frequent health checks (taking into account infected wounds, infections and respiratory diseases).

Prevention of spoilage in Red Meat

- Meats submitted to human consumption after being checked; Contamination and putrefaction should also be prevented during processing, storage and transportation.
- Meat to be used during processing must comply with hygienic rules and be fresh.
- Other additives used in the preparation of products must be uncontaminated and intact, and must undergo laboratory control.
- Deboning, stripping, processing and packaging of the product should be done as quickly as possible to prevent contamination, reproduction of pathogens and spoilage.
- Appropriate and hygienic conditions should be provided in storage.

b) Prevention of spoilage in Poultry

- Before slaughter, feeds, personnel and farm should be cleaned of any contamination.
- Hygiene rules should be applied during and after slaughter.
- Animals should be given drinking water quality water, slaughterhouses should be thoroughly cleaned at least once a week.
- The equipment used in the slaughterhouse should be made of non-corrosive and easy-to-clean metal.
- After slaughter, the meat temperature should be reduced to +4 °C (cooling).
- Meats that are desired to be stored for a long time; It can be stored up to 6 months at -18 °C, 9 months at -21 °C, and 12 months at -28 °C (freezing).

c) Prevention of spoilage in Seafoods

- The caught fish are put in wooden crates. The shelves where the fish are placed should be slightly inclined to allow the dirty water to drain and the fish pile on the shelves should not be too high.
- When fish are caught, they should be carefully washed and cooled in ice to 0 ˚C as soon as possible, and the ice used should be made of clean drinking quality water.
- Prevention of microbial contamination naturally depends on hygienic conditions during processing.
- Microbial load increases when fish are washed by immersing them in water.
- In order to control microorganisms in the washing water, disinfectants containing chlorine, calcium and sodium hypochlorite should be added to the water.
- Personnel must comply with hygiene rules; The porter and those with open wounds should not be in the working areas.
- Fish should be stored at -30 °C.