Script

Title: Food spoilage by microorganisms

Introduction:

Microorganisms are microscopic, living, single-celled organisms such as bacteria. Ubiquitous throughout the world, **microorganisms** play a vital role in supporting and maintaining nature and life. Although some bacteria are harmful and some are beneficial bacteria ,eg,lactic acid bacteria ect.

This episode deals with different types **of** spoilage microorganisms, special reference to food, eg, meat ,milk, vegetables, canned products ,ect. The following topics are highlighted.

- 1. Food spoilage
- 2. Different types of spoilage bacteria
- 3. Wide variety of fungi spoil foods
- 4. Spoilage of Meat and dairy
- 5. Common food borne pathogens

1:Food spoilage

Spoilage caused by microorganisms like fungi (moulds, yeasts) and bacteria. They spoil food by growing in it and producing substances that change the colour, texture and odour of the food. Eventually the food will be unfit for human consumption. Food spoilage directly affects the colour, taste, odour and consistency or texture of food, and it may become dangerous to eat. The presence of a bad odour or smell coming from food is an indication that it may be unsafe. Spoilage bacteria can cause fruits and vegetables to get mushy or slimy, or meat to develop a bad odor. Spoilage bacteria:

Spoilage bacteria are microorganisms too small to be seen without a microscope that cause food to deteriorate and develop unpleasant odors, tastes, and textures. Microorganisms can cause fruits and vegetables to get mushy or slimy, or meat to develop a bad odor.

2:Different types of spoilage bacteria

Mesophiles ,prefer moderate temperatures ranging from 41 °F (5 °C) to 50 °F (10 °C). In a favorable medium, these bacteria double their numbers in as little as 30 minutes.

Psychrotrophs : can grow at about 32 °F (0 °C) (the freezing temperature of water), but grow best at moderate temperatures.

Thermophiles prefer a warmer temperature. The optimum temperature for growth is usually between 131 °F (55 °C) and 149 °F (65 °F). Some can grow in temperatures as low at 95 °F (35 °F) or as high as 167 °F (75 °C) to 194 °F (90 °C).

These grow at temperatures above 45°C. Often their optimum growth temperatures is between 50°C and 70°C.Growth of some bacteria occur at 80°C.Bacteria in this group are mainly spore formers and are of importance in the food industry especially in processed foods.

- Anaerobic or facultatively anaerobic sporeformers are most likely to grow in canned foods .
- Microaerophilic bacteria are most likely to grow in vacuum packed foods since they have low oxygen tension
- Aerobic bacteria are likely to grow on the surface of raw meat.
- Aerobic molds will grow in insufficiently dried or salted products

Psychrophiles: Prefer low temperatures. They can grow at temperatures of 32 °F (0 °C) or lower, but they can also thrive at moderate temperatures of 59 °F (15 °C) to 68

°F (20 °C). They are quite common in environments where the temperature remains consistently low. They are mainly of marine origin.

Yeasts

Yeast can be responsible for the decomposition of food with a high sugar content. The same effect is useful in the production of various types of food and beverages, such as bread, yougurt cider and alcoholic beverages.

Effect of spoilage on various food products:

Protein food : They go putrified when they are contaminated. This is the situation where protein foods rot, and produce very bad smell.

Carbohydrates: Cooked cereals become marshy and slimy when affected by microorganisms. This condition is known as serenasis. Flour products smell and taste unpleasant when they are spoilt. They are described as being stale.

Fruits and vegetables: They rot, ferment and decay.

Microorganisms that spoil and contaminate poultry .

Microorganisms that contaminate poultry Immediately after obtaining, surface of carcasses is mainly contaminated with bacteria of the genera *Acinetobacter*, *Flavobacterium*, but superficial rotting is produced primarily by *Pseudomonas* (fluorescens, putide, fragi, etc.) and to a lesser extent by *Aeromonas*, *Acinetobacter and Moraxella*.

Ganerally, bacteria exist in higher numbers at the time of processing on the skin of chickens and in their intestinal tracts are primarily mesophiles. These bacteria do not multiply to an appreciable degree at refrigerator temperatures. Salmonella, *E. coli* and other bacteria found on chickens are mesophiles.

Unlike marine animals, on the freshwater fish are often found bacteria family Enterobacteriaceae and the genus *Aeromonas*. Molluscs meat is contaminated with a large number of microorganisms (104 -106 /g), especially Gram negative bacteria (*Vibrio, Pseudomonas, Acinetobacter, Moraxella, Flavobacterium*).

3:Wide variety of fungi spoil foods

Some of the most common fungi include

- Rhizopus
- Alternaria
- Penicillium
- Aspergillus
- Botrytis

Fungi grow readily in acidic low-moisture environments: Meat are more perishable than other food commodities, it contain all nutritents required for growth of bacteria, yeasts and molds.

Whiskers (*Mucor, Rhizopus*), black or green spots (*Cladosporium, Penicillium*): Ground meats and steaks are almost exclusively spoiled by bacteria

Storage temperature selects for psychrotropic spoilage organisms: *Pseudomonas, Moraxella, Acinetobacter, Psychrobacter ,Steaks tend to undergo surface spoilage.*

4: Canned goods spoilage:

Canning is a method of preserving food in which the food contents are processed and sealed in an airtight container. Canning is a way of processing food to extend its shelf life.

<u>Canned Foods:Thermophilic sporeformers :</u> Can cause some types of spoilage of low acid (high pH) foods (such as corn, beans, peas) when the cans are temperature abused at 43°C and above, even for short duration

Spoilage due to insufficients heating: *Clostridium* and some *Bacillus* spp.

Spoilage due to container leakage: Spoilage in canned foods caused by leakage can be caused by a variety of microorganisms that do not normally survive the heat treatment. These MO usually enter at the start of cooling through a faulty seam and produce a swelled can.

Canned foods are classified as (a) **low acid**, (b) **acid** or (c) **high acid** products and each group has characteristic spoilage microorganisms, whose growth is most often due to inadequate processing:

<u>Low Acid canned foods</u> (most prod.): pH >4.6 e.g. meat, milk, many vegetables, etc. Because of the concern over *C. botulinum* growth, these foods must receive the highest heat treatment.

1.Flat-sour spoilage by thermophilic sporeformers such

as Bacillus stearothermophilus (strick aerobe!) and B. coagulans (fac. anaerobe).

Can does not bulge (flat) but pH falls and food tastes sour, off odors may be apparent.

- 2.**Sulfide spoilage**_by anaerobic thermophilic sporeformers that produce H₂S like *Clostridium nigrificans* and *C. bifermentans*.
- The gas is often absorbed by the food so can may not swell but the odor is unmistakable. Blackening of the food may also be observed.
- 3.**Gaseous spoilage** by putrefactive anaerobes like *C. butyricum*. The can swells and the food may have a fermented, cheesy or putrid odor.
- <u>High acid foods</u> (pH <4.0) e.g. fruits, a few vegetables and fermented products like sauerkraut. Spoilage is usually due to non spore forming mesophiles like yeasts, molds and lactic acid bacteria.

Specific Food Groups

Bacterial genera commonly infecting meat while it is being processed, cut, packaged, transported, sold and handled include *salmonella spp.,Shigella spp.,E.coli*, , and *Staph.aureua,B.cereus*, and faecal *streptococci*. These bacteria are all commonly carried by humans; infectious bacteria from the soil include *Cl.botulinum*.

Among the moulds commonly infecting meat are *Penicillium, Mucor, Cladosporium, Alternaria,ect.*

<u>1.Whole Meats</u>:

Fresh meats are among the most perishable foods. The microflora of fresh meat is composed primarily of, Gram negative aerobic rods such as *Pseudomonas*, *Acinetobacter* and *Moraxella*, *Bacillus* and clostridia (e.g. *C. perfringens*) are also common on all types of meat. Storage temperature is the single most important control factor for meat spoilage.

<u>Sources of Contamination</u>: Several genera of molds grow on the surface of meat and can cause spoilage, but cannot grow on meat stored below 5°C. Usually, fresh cut meats in the refrigerator at high humidity undergo bacterial spoilage by: Gram negative aerobes like *Pseudomonas, Acinetobacter* and *Moraxella* spp.

Meat spoilage is characterized by the appearance of off odors and slime, which are manifest when surface loads exceed 10⁷ CFU/cm².

Vacuum packaged meats

- 80% of beef leaves packing plant in vacuum package.
- Not all O₂ is removed during packaging but residual is consumed by respiration of aerobic MO and the tissue itself.
- Results in increased CO₂ levels and thus get a longer shelf life.
- If nitrites have been added to the vacuum packaged meat (e.g. to inhibit *C. botulinum* in hams, bacon), LAB domination is even more pronounced.

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

1: Raw or cooked meat product

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

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

Nitrite concentration in meat.

<u>High</u> nitrite conc. favors lactic acid bacteria.

<u>Low</u> nitrite levels may allow growth of *Brochothrix thermosphacta* (G+ rod, growth @ 0-30°C from pH 5.0-9.0).

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

<u>Slimy spoilage</u>: Like other meat products, this occurs on the surface and is caused by the buildup of cells of yeasts, lactobacilli, enterococci or *Brochothrix thermosphacta*. Washing the slime off with hot water can restore the product quality.

Sour spoilage: Results from growth of lactic acid bacteria (which originate from contaminated ingredients like milk solids) under the casing. These organisms ferment lactose and other CHOs in the product and produce organic acids. Taste is adversely affected but the product is not harmful if eaten.

<u>**Greening**</u> due to H_2O_2 or H_2S production.

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

Spoilage of Milk

In milk, the microorganisms that are principally involved in spoilage are psychrotrophic organisms. Most psychrotrophs are destroyed by pasteurization temperatures, however, some like *Pseudomonas fluorescens*, *Pseudomonas fragi* can produce proteolytic and lipolytic extracellular enzymes which are heat stable and capable of causing spoilage.

Some species and strains of *Bacillus, Clostridium, Cornebacterium, Arthrobacter, Lactobacillus, Microbacterium, Micrococcus,* and *Streptococcus* can survive pasteurization and grow at refrigeration temperatures which can cause spoilage problems.

Vegetables

Composition:

-88% water

-8.6 % CHO.

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

Microflora of vegetables is primarily composed of:

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

Soft rot

One of the most common types of bacterial spoilage.caused by *Erwinia carotovora* and sometimes by *Pseudomonas* spp., which grow at 4°C

Sources of Contamination

1. Surface contamination – Soil, water, air, human pathogens from manure (night soil)

2. Harvesting - hand picking vs. machines.

3.High damage if crop is ripe...harvest before ripe *Geotrichium candidum* – mold on harvest or storage

4. Packaging: containers reused-sanitized

5.Processing plant

6.Markets - handling, cross-contamination

The microflora of vegetables will generally reflect on the sanitation of processing steps as well as the condition of the original raw product. Soil-borne MO such as clostridia are common on raw vegetables, and some species, like

C. botulinum, are of such great concern that they are the focus of processing steps designed to destroy MO.

<u>Fruits</u>

Average composition -85% water -13% CHO -low pH (1.8-5.6)

Specific Spoilage Organisms:

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

Dairy Products - Milk is a very rich medium for spoilage organisms

Raw milk flora may include:

a. All MO found on the cow hide (which incl. soil and fecal bacteria), udder, and milking utensils b. Can include G-, G+, yeasts and molds.

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

<u>c.Psycrotropic *pseudomonads*</u> are common in bulk stored raw milk. d.Psychrotropic *Bacillus* spp. are also common in raw milk.

<u>Pasteurized fluid milk</u> – spoiled by a variety of bacteria, yeasts and molds.

- a. Milk was usually soured by LAB such as *enterococci, lactococci,* or lactobacilli, which dropped the pH to 4.5 where milk proteins coagulate (curdling).
- b. Milk is more frequently spoiled by aerobic spore formers such as *Bacillus*, whose proteolytic enzymes cause curdling.
- c. Molds may grow on the surface of spoiled milk, but the product is usually discarded before this occur.

Butter; high lipid content and low a_w make it more susceptible to surface mold growth than to bacterial spoilage.Some *pseudomonads* can be a problem; "surface taint" -putrid smell, caused by the production of organic acids (esp. isovaleric) from *P. putrefaciens*. Rancidity due to butterfat lypolysis caused by *P. fragi* are common.

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

The most common bacterial spoilage is "**slimy curd**" caused by *Alcaligenes* spp. (Gaerobic rod bound in soil, water, and intestinal tract of vertebrates). Like *Campylobacter*, these species do not oxidize CHOs but instead use amino acids and TCA intermediates. *Penicillum*, *Mucor* and other fungi also grow well on cottage cheese and impart stale or yeasty flavors.

Ripened Cheeses – (1) low a_{w} , (2) low pH and (3) high salt inhibit most spoilage microorganisms except surface mould growth. Spores of *C. butyricum*, *C. sporogenes* and others can germinate in cheeses (e.g. Swiss) with intrinsic properties that are less inhibitory (e.g. lower salt, higher pH). These organisms may metabolize

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

<u>Eggs</u>

Eggs have several intrinsic parameters which help to protect the nutrient-rich yolk from microbial attack. These include the shell and associated membranes, as well as lysozyme, conalbumin, and a high pH (>9.0) in the white. Freshly laid eggs are generally sterile, but soon become contaminated with numerous genera of bacteria. Eventually, these MO will penetrate the eggshell and spoilage will occur. Pseudomonads are common spoilage agents, but molds like *Penicillium* and *Cladosporium* sometimes grow in the air sac and spoil the egg.

Cereal and Bakery foods

- These products are characterized by a low a_w which, when stored properly under low humidity, restricts all MO except molds. *Rhizopus stolonifer* is the common bread mold, and other species from this genus spoil cereals and other baked goods.
- Refrigerated frozen dough products have more water and can be spoiled by lactic acid bacteria.

Fermented Foods and Beverages

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

Beer and wine (pH 4-5) can be spoiled by yeasts and bacteria. Bacteria involved are primarily lactic acid bacteria like lactobacilli and *Pediococcus* spp., and (under aerobic conditions) acetic acid bacteria

like *Acetobacter* and *Gluconobacter* spp. Acetic acid bacteria convert ethanol to acetic acid in the presence of oxygen.

- Spoilage in packaged beer is often due to growth of the yeast *Saccharomyces diastaticus*, which grows on dextrin's that brewer's yeast cannot utilize. *Candida valida* is the most important spoilage yeast in wine. In either case, spoilage by yeasts results in the development of turbidity, off flavors and odors.
- Wines can also be spoiled by lactic acid bacteria which are able to convert malic acid to lactic acid (malo-lactic fermentation). Yeasts, molds and lactic acid bacteria can also spoil fermented vegetables such as sauerkraut and pickles, as well as other acid foods like salad dressings and mayonnaise. Spoilage in fermented vegetables is often manifest by off odors or changes in the color or texture (softening) of the product.

COMMON FOODBORNE BACTERIA

1.Gram positive genera:

*Bacillus:*Aerobic sporeforming rods, meso-, psychro- and thermophilic species exist. This genus includes important spoilage species as well as pathogenic species which cause anthrax (*B. anthracis*) and *B. cereus* which can cause foodborne gastroenteritis. Due to the resistance of endospores to drying and most other stresses, aerobic sporeformers are widely distributed in nature but it is generally accepted that the primary habitat of most *Bacillus* species is soil from which they contaminate everything by distribution in dust.

Clostridium; anaerobic sporeforming rods. Like *Bacillus*, meso-, psychroand thermophilic species exist. The most notorious species are *C. botulinum* which causes botulism, and *C. perfringens*, a common cause of gastroenteritis. Clostridia are ubiquitous, they are found in soil, sewage, decaying vegetation, animal and plant products, and in the intestinal tract of man and animals.

Lactobacillus; very diverse genus of fastidious acid tolerant (some can grow at pH<3.0), microaerophilic, non spore forming rods. Lactobacilli are found in low

numbers on all plant surfaces and are also an important part of the natural intestinal micro biota. Lactobacilli are included among the lactic acid bacteria and this genera includes species used to ferment dairy, vegetable and meat products as well as other species that are responsible for spoilage of acid foods and meats.

Listeria; nonsporing rods, aerobic or facultatively aerobic. Mesophilic but some species and strains can grow at temperatures as low as 1°C or as high as 45°C. *Listeria* spp. are widely distributed in nature and can be isolated from water, mud, vegetation and from human and animal waste. This genus includes the important pathogen *L. monocytogenes* that causes listeriosis in humans.

Staphylococcus; Mesophilic, facultatively anaerobic cocci. Staphylococci are primarily associated with skin glands, and mucus membranes of warm-blooded animals. *S. aureus* and some other species produces a heat stable enterotoxin (some toxins survive 16 h @ 60°C) that is a major cause of food poisoning, usually as a result of poor sanitation or hygiene.

2Gram-negative genera:

Campylobacter, Microaerophilic to anaerobic spirally curved rods. Found in the intestinal and reproductive tracts of man and animals. This genus contains several pathogenic species such as *C. jejuni*.

Escherichia; Most thoroughly studied genus of bacteria. Facultative anaerobic rods that are found in the lower intestine of warm-blooded animals. Because *E coli* are associated with fecal contamination, this species is used as an indicator of food safety and sanitation. Some strains of *E. coli* cause food poisoning and are the leading cause of traveler's diarrhea.

Pseudomonas; Without question the single most important food spoilage group of bacteria Aerobic rods, meso- and psychrophilic species, found in soils and

water. Most it not all cannot grow at pH<4.5. Few Nutritional requirements – some can even use H_2 or CO as energy sources! Several species produce pigmented compounds that fluoresce.

Salmonella; Mesophilic, facultatively anaerobic rods. All members of this genus are considered pathogenic, causing fever, gastroenteritis and septicemia. *Salmonella* have not been separated into different species but instead are grouped into subgenera which contain related serovars defined by antigenic properties. *Salmonella* are intestinal organisms transmitted to humans by fecal contamination of food and water.

Shigella; Like Salmonella, members of this genus

are mesophilic, facultatively anaerobic rods and all are considered pathogenic. These bacteria are intracellular parasites of the epithelium of humans and higher primates.

Vibrio; Facultatively anaerobic, mesophilic (although some can grow at 4°C) rods found in fresh and salt water. *V. cholera* is the causative agent for epidemic cholera and several other species are serious pathogens. Consumption of raw shellfish and fish are often linked to vibrio outbreaks.

<u>Conclusion</u>: Spoilage caused by microorganisms like fungi (moulds, yeasts) and bacteria they are *Mesophiles*, *Psychrotrophs* and *Thermophiles* They spoil food by growing in it and producing substances that change the colour, texture and odour of the food. Eventually the food will be unfit for human consumption. Food spoilage directly affects the colour, taste, odour and consistency or texture of food, and it may become dangerous to eat. Spoilage bacteria can cause fruits and vegetables to get mushy or slimy, or meat to develop a bad odor.

Anaerobic or facultatively anaerobic sporeformers are most likely to grow in canned foods. Fungi grow readily in acidic low-moisture environments: