Food microbiology (FST 606)

**CONTAMINATION AND SPOILAGE OF PERISHABLE, SEMI PERISHABLE AND STABLE FOODS**

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Food spoilage

INTRODUCTION Food spoilage can be defined as: • any changes in the visual, smell and texture of food that makes it unacceptable for consumption. Or • is the process in which food deteriorates to the points it is not edible to humans or its quality of edibility becomes reduced.

Food spoilage can be the result of: – insect damage – physical injury – enzymatic degradation – microbial activity

TYPES OF FOOD SPOILAGE a. Physical spoilage • moisture loss or gain

[.](https://image.slidesharecdn.com/foodspoilage-160331203037/95/food-spoilage-6-638.jpg?cb=1459456277)b. Chemical spoilage • Oxidation of fat • Browning of fruits and vegetables

c. Microbial spoilage • Growth of microorganisms • Enzyme production

Microbial Spoilage BACTERIA YEAST MOLDS

[.](https://image.slidesharecdn.com/foodspoilage-160331203037/95/food-spoilage-9-638.jpg?cb=1459456277)• Various bacteria can be responsible for the spoilage of food. • When bacteria breaks down the food, acids and other waste products are created in the process. • • While the bacteria itself may or may not be harmful, the waste products may be unpleasant to taste or may even be harmful to one's health.

[.](https://image.slidesharecdn.com/foodspoilage-160331203037/95/food-spoilage-10-638.jpg?cb=1459456277)• Yeasts 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, yogurt and alcoholic beverages.

[.](https://image.slidesharecdn.com/foodspoilage-160331203037/95/food-spoilage-11-638.jpg?cb=1459456277)• Some spoiled foods are harmless to eat, and may simply be diminished in quality. • But foods exhibiting certain types of spoilage may be harmful to consume. Uncooked or under-cooked animal flesh that spoils is typically quite toxic, and consumption can result in serious illness or death. • The toxic effects from consuming spoiled food are known as "food poisoning", and more properly as"foodborne illness”.

Off-flavours Microbial spoilage – how does it manifest itself?¬ Slime ¬ Gas production ¬ Visible growth

[.](https://image.slidesharecdn.com/foodspoilage-160331203037/95/food-spoilage-13-638.jpg?cb=1459456277)**Sequence of events in food spoilage**

Microorganisms have to get into the food from a source or more

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Food environment should favour the growth of microbes

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Food need to be stored under the growth condition for a sufficient length of time

• To allow sufficient number necessary to cause spoilage or changes in food.

• To allow the produced enzyme to spoil the food.

Pectin hydrolysis¬ Degradation of lipids ¬ Degradation of N- compounds ¬ Degradation of carbohydrates ¬Chemical changes caused by micro organisms

• Inadequate storage temperatures • Prolonged storage times • Improper ventilation • Cross contamination • Excessive delays between receiving and storing

**Common Causes of Food Spoilage**

Spoilage Signs • Odor: – Breakdown of proteins (putrefaction) e.g. “rotten egg” smell • Sliminess -due primarily to surface accumulation of microbial cells -also be a manifestation of tissue degradation • Discoloration – Mold on bread, blue and green mold on citrus fruit and cheese

Spoilage Signs… • Souring – Production of acid e.g. sour milk from production of lactic acid • Gas formation – Meat becomes spongy – Swollen or bubbling packages and cans

**Classification of food by ease of spoilage**

Foods can be classified into three groups based on ease of spoilage: I. Stable or non perishable foods. Foods which do not spoil unless handle carelessly. Example: Sugar, flour and dry beans.

II. Semi perishable foods. If these foods are properly handled and stored, they will remain unspoiled for a fairly long period. Examples: potatoes, apples and nuts.

III. Perishable foods. This group includes most of our important daily foods that spoil readily unless special preservative methods are used. Examples: meats, fish, milk, vegetables, eggs and etc.

**Spoilage of different types of food**

**Meat Spoilage**

Meat spoilage… Sources of contamination • Cutting board contamination • Conveyor belts • Temperature • Delay between storage and distribution • Fecal contamination from intestines

Meat spoilage… • Storage temperature is the single most important control factor for meat spoilage. • Several genera of molds grow on the surface of meat and can cause spoilage like Penicillium, Mucor, Cladosporium, Alternaria, but cannot grow on meat stored below 5oC.

Meat spoilage… • Meat spoilage is characterized by the appearance of off odors and slime, which are manifest when surface loads exceed 107 CFU/cm2. • The slime is due to the accumulation of bacterial cells.

Meat spoilage… • Interestingly, meat spoilage (including poultry and fish) occurs without any significant breakdown of the primary protein structure. • Instead, spoilage bacteria utilize glucose, free amino acids or other simple nitrogenous compounds to attain population of about 108 CFU/cm2, at which point the organoleptic quality of the meat will clearly reveal it is spoiled.

Meat spoilage… Fresh Meats: Chemical composition: -75% water -18% protein -3% fat, 1% ash, traces of CHO, vitamins, etc.

Meat Spoilage • Whole Meats: The microflora of fresh meat is composed primarily of: 1- Gram negative aerobic rods such as: – Pseudomonas spp. – P. fragi, P. lundensis and P. fluorescens – Acinetobacter – Psychrobacter immobilis

Meat spoilage… 2- Bacillus and clostridia (e.g. C. perfringens) are also common on all types of meat. • Although subsurface portions of meat are generally sterile, some parts such as lymph nodes may be heavily contaminated. • Mechanical disruption of the tissue during processing can distribute microorganisms from the meat surface throughout the product.

Meat spoilage… • Ground Meats: Same MO as whole meats, but always have higher microbial loads. Why? • greater surface area which gives microbes better access to the food and also traps air to favor the growth of gram-negative, aerobic bacteria like Pseudomonas spp. • every handling or processing (storage utensils, cutting knives, grinders) step can contribute additional contamination to the final product. • one heavily contaminated piece (e.g. a lymph node) can contaminate an entire lot when they are ground together.

Meat Spoilage • Vacuum – packed meats -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. The microflora shifts from predominantly G- aerobes to G+ anaerobes and microaerophilic lactic acid bacteria (LAB) (like Lactobacillus,Carnobacterium and Leuconostoc).

Meat Spoilage • 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 • • In general, vacuum packaged meats are considered very safe foods and free from most pathogenic species of bacteria.

Spoilage in vacuum packaged meats is manifest by: 1. Slime development due to overgrowth of microbe. 2. Greening caused by microbial production of H2O2 or H2S. • H2O2 production in meat has been associated with several types of lactic acid bacteria (primarily Lactobacillus)

Meat Spoilage 3. Off odors which result from: 1. the release of short chain fatty acids 2. the production of volatile compounds like acetoin, diacetyl and H2S (and many other compounds, depending on the dominant spoilage bacterium).

Meat Spoilage The type of spoilage bacteria that will dominate is influenced by several factors that include: 1. Is the meat product is raw or cooked? -Cooked products have a higher pH (>6.0) which may allow growth of G- facultative anaerobic pathogens like Yersinia enterocolitica. -Raw products have a pH of about 5.6 which favors lactic acid bacteria, esp. Lactobacillus, Carnobacterium, and Leuconostoc. 2. Nitrite concentration in meat. -High nitrite conc. favors lactic acid bacteria. -Low nitrite levels may allow growth of Brochothrix thermosphacta (G+ rod, fac anaer, growth @ 0-30oC from pH 5.0-9.0 catalase+).

Meat Spoilage

• Processed meats (hot dogs, sausage and luncheon meats)

• These products are composed of a variety of blended ingredients, any of which can contribute microorganisms to the food. • Yeasts and bacteria are the most common causes of spoilage, which is usually manifest in 3 ways:

A. Slimy spoilage 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. B. Sour spoilage. Results from growth of lactic acid bacteria (which originate from contaminated ingredients like milk solids. 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.

C. Greening due to H2O2 or H2S production. Because greening indicates more extensive product breakdown, it is not recommend eating green wieners.

**Poultry and egg spoilage**

Poultry a. general trends are the same as other fresh meats b. whole birds have lower counts than cut-up parts c. additional processing steps add to the microbial load -When poultry is in the advanced stages of spoilage, the skin will often fluoresce under UV because so many fluorescent pseudomonads are present.

• Off odors generally appear before sliminess develops. The same bacteria can produce visceral taint, a condition manifest by off odors in the abdominal cavity of poultry. Point to remember: During the initial stages of spoilage, the skin supports bacterial growth better than does the tissue (which remains essentially free of bacteria for some time). Thus, the skin can sometimes be removed to salvage the food.

Eggs • 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 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.

**Fish Spoilage**

a. Fish have high nitrogen content but no carbohydrate. b. The microbial quality of fish and especially shellfish is heavily influenced by the quality of the water from which they were harvested. • Unsanitized processing steps are principal culprits in fish products with high microbial loads. • In general, frozen fish products have lower counts than fresh products. • Bacteria on fresh fish are concentrated on the outer slime, gills and intestine.

• Spoilage of salt- and freshwater fish occurs in similar ways; the most susceptible part of the fish to spoilage is the gill region. • and the best way to detect spoilage in fresh fish is to sniff this area for off odors produced by Pseudomonas and Acinetobacter-Moraxella bacteria. • The odors include ammonia, triethylamine, H2S and other compounds. • If fish are not eviscerated quickly, bacteria will move through the intestinal walls and invade the meat that lies next to the abdominal cavity.

• **Spoilage of crustaceans (shrimp, lobsters, crabs and crayfish)** is similar, but these products have some CHO (0.5%) and more free amino acids so spoilage can occur more rapidly. • Mollusks (oysters, clams, mussels, squid and scallops) • have more CHO (3-5%) and less nitrogen than either fish or shellfish. Microflora of mollusks can vary a great deal depending on the quality of the water from which they were harvested. • Shellfish are filter feeders and can be expected to contain almost any microorganism or virus that occurs in the water where they were obtained. • If these products were taken from clean waters, then the usual Pseudomonas and Acinetobacter-Moraxella types of spoilage bacteria dominate.

**Spoilage of Milk and Dairy Products**

Milk Milk is a very rich medium • 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. • Psychrotropic pseudomonads are common in bulk stored raw milk • produce heat stable enzymes that can reduce milk quality and shelf life.

• Pasteurization kills most G- (incl. Pseudo.), yeasts and molds. • some G- enzymes, thermotolerant G+ bacteria and spores survive • Psychrotropic Bacillus spp. are also common in raw milk.

• Pasteurized fluid milk spoiled by a variety of bacteria, yeasts and molds. a. milk is more frequently spoiled by aerobic sporeformers 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 occurs.

• Butter high lipid content and low aw 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. 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. (G- aerobic rod bound in soil, water, and intestinal tract of vertebrates). • Penicillum, Mucor and other fungi also grow well on cottage cheese and impart stale or yeasty flavors.

• Ripened Cheeses (1) low aw (2) low pH (3) high salt inhibit most spoilage microorganisms except surface mold 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 CO2 or H2 gas which “blows” the cheese.

**Spoilage of Fruits and Vegetables**

Vegetables Typical composition: -88% water -8.6 % CHO. Includes readily available mono- and disaccharides like glucose and maltose, as well as more complex oligosaccharides, which are available to fewer types of microorganisms. -1.9% protein -0.3 % fat -0.84 % minerals -also contain fat and water soluble vitamins and nucleic acids (<1%). -pH of most veggies is around 6.0; within the growth range of many bacteria.

Vegetables • Vegetables are a good substrate for yeasts, molds or bacteria • It is estimated that 20% of all harvested fruits and vegetables for humans are lost to spoilage by these microorganisms. • Because bacteria grow more rapidly, they usually out- compete fungi for readily available substrates in vegetables. • As a result, bacteria are of greater consequence in the spoilage of vegetables with intrinsic properties that support bacterial growth (favorable pH, Eh).

Vegetables • Microflora of vegetables is primarily composed of: – G+ bacteria like lactic acid bacteria (e.g. leuconostocs, lactobacilli, streptococci. – Coryneforms and staphylococci (the latter coming from the hands of employees during processing.

• Staphylococci are usually unable to proliferate but cross- contamination can introduce them into other foods where growth conditions are more favorable.

Vegetables • Soft rot a. One of the most common types of bacterial spoilage. b. caused by Erwinia carotovora and sometimes by Pseudomonas spp., which grow at 4oC • Softening can also be caused by endogenous enzymes.

Vegetables Mold spoilage a. In vegetables where bacterial growth is not favored (e.g. low pH), molds are the principal spoilage agents. b. Most molds must invade plant tissue through a surface wound such as a bruise or crack. c. Spores are frequently deposited at these sites by insects like Drosophila melanogaster, the common fruit fly. d. Other molds like Botrytis cinerea, which causes grey mole rot on a variety of vegetables, are able to penetrate fruit or vegetable skin on their own.

Vegetables The microflora of vegetables will reflect: a. the sanitation of processing steps. b. 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.

Vegetables Sources of Contamination 1. Surface contamination – Soil, water, air, human pathogens from manure (night soil) 2. Harvesting - hand picking vs. machines 3. Packaging: containers reused 4. Markets – handling, cross-contamination

Fruits Average composition -85% water -13% CHO -0.9% protein (a bit low on nitrogen sources) -0.5% fat -0.5% ash -trace amounts of vitamins, nucleotides, etc. -less water and more CHO than veggies -low pH (1.8-5.6)

Fruits • Like vegetables, fruits are nutrient rich substrates but the pH of fruits does not favor bacterial growth. As a result, yeasts and molds are more important than bacteria in the spoilage of fruits. a. Several genera of yeasts can be found on fruit. b. Because these organisms grow faster than molds, yeast often initiate fruit spoilage. c. then molds finish the job by degrading complex polysaccharides in cell walls and rinds.

Fruits 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

**Cereal and Bakery Goods**

• These products are characterized by a low aw 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.

**Fermented Foods and Beverages**

• 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. • The anaerobic bacterium Megasphaera cerevisiae can also spoil beer by producing acid and H2S.

beer • Spoilage in packaged beer is often due to growth of the yeast Saccharomyces diastaticus, which grows on dextrins that brewers yeast cannot utilize. • In either case, spoilage by yeasts results in the development of turbidity, off flavors and odors.

Wines • Candida valida is the most important spoilage yeast in wine. • can also be spoiled by lactic acid bacteria which are able to convert malic acid to lactic acid (malo-lactic fermentation). This reduces the acidity of the wine and adversely affect wine flavor. • In some areas (e.g. Northwest), wine grapes have too much malic acid so this fermentation is deliberately used to reduce the acidity of grape juice that will be used for wine.

• 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. • In mayonnaise or salad dressing, the first signs of spoilage are usually off odors and emulsion separation.