FE 305 FOOD MICROBIOLOGY
Microbial spoilage in cereals, vegetables and fruits

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Grain and Cereal Products Microbiology

- Grain refers to all grains such as wheat, rye, corn, rice, oats, millet, barley, which are the seeds of the *Graminiae* family.
- Cereal products are flour, cake, pastry, bread, pasta, noodles, etc. obtained by various processes from grain groups.
- Since cereals and cereal products have very low water content, microbial growth on these products is limited. However, when the water content of these products increases, microorganisms cause deterioration.
- The transmission routes of bacteria causing microbial spoilage in cereals and cereal products are as follows:
  - Soil
  - dirt layer
  - Spraying
  - Disease
  - Harvest
  - Processing
  - Storage
  - Packaging

Grain and Cereal Products Microbiology

- Depending on the amount of water in the product, molds are effective in spoiling first.
- With the increase in the amount of water, yeast and bacteria are also factors in spoilage.
- Cereal products with high water content (bread, chilled dough, pasta, etc.) are susceptible to microbiological spoilage.
- Cereal grains are dried to a moisture content of 10-12%. In this case, aw ≤ 0.60. Microbial deterioration does not occur in cereal grains containing moisture at these values. However, some molds may develop when the aw value of the grain rises above 0.6 during harvest, processing and storage.

Grain and Cereal Products Microbiology

- Cereals can be contaminated by different pathogenic and spoilage microorganisms during growth, harvesting, processing and storage.
  - The most commonly associating bacterial family with cereals are *Bacillaceae, Micrococceae, Lactobacillaceae and Pseudomonadaceae*.
  - With the increase in humidity, some molds such as *Aspergillus, Penicillium, Rhizopus, Fusarium* species may develop. As a result of mold growth, deterioration in the appearance and sensory quality of the grain occurs.
  - In addition, lactic acid and coliform bacteria perform acid fermentation depending on the increase in humidity. Bacteria commonly found in cereals are species belonging to *Pseudomonados and Micrococcaceae, Lactobacillaceae and Bacillaceae* families.
- Cereals may show undesirable changes under unsuitable conditions and as a result of the activity of existing microorganisms.
  - Reddening, mold, germination, rot, burning, mycotoxin formation, rancidity and alcohol odor, discoloration are some of these undesirable negative features.

Contamination of Grains

- Bacteria in flour include *Bacillus* spores, coliform, *Achromobacter*, *Flavobacterium*, *Sarcina*, *Micrococcus*, *Alcaligenes* and *Serratia*.
  - *Bacillus* spp. in flours can cause problems during bread-making.
  - *Salmonella* spp. can cause problems in infant formula containing cereal flours
    - that create risk for babies.
- The molds associating with cereal grains can be divided into two groups:
  - the field molds (plant pathogens which invade the grains before hervest) and
  - the storage molds, which invade the grains during drying and storage.
- Mold spores in cereal grains and flour are chiefly *Aspergillus*, *Penicillium*, *Alternaria*, *Mucor*, *Cladosporium*, *Fusarium* and *Rhizopus*.
- Harvested grain (wheat, rye, corn, etc.) be contaminated with microorganisms from soil, insects and other sources.
- Molds are the predominant natural microflora on grains.
  - Molds such as *Alternaria, Fusarium, Helmintbosporium* and *Cladosporium* are primarily responsible for invading wheat.

Contamination of Grains

Spoilage before harvest

- Field molds invade the kernels of the grain.
  - They may cause blights, discolorations and diseases of the kernels.
  - These molds include members of the genera *Alternaria*, *Fusarium*, *Drechslera*, *Cladosporium*, *Botrytis* and *Phoma*. *Alternaria* spp. can cause blights and blemishes.
  - Preharvested rice carries a wide variety of
    - molds genera *Acremonium*, *Alternaria*, *Aspergillus*, *Bipolaris*, *Chaetomium*, *Curvularia*, *Fusarium*, *Nigrospora*, *Penicillium*, *Rhizopus* and *Trichoconiella*, and
    - bacterial genera *Pseudomonas*, *Enterobacter* and *Micrococcus*.
- Loose and covered smuts of wheat, barley and oats may result in heavy crop losses during harvesting due to molds;
  - by *Ustilago tritici*, *U. nuda*, *U. avenae*, *U. lordei*, *Tilletia caries* and *T. foetida*.
- The main genera producing mycotoxins in preharvest are *Aspergillus, Alternaria and Fusarium*.
- Field molds die slowly during storage as the RH falls.

Contamination of Grains

Spoilage during storage

- During storage, the field molds on grain are replaced by molds capable of growing at a lower aw (storage molds).
- Spoilage will occur during storage
  - If the moisture content of the grain is sufficiently high to support mold growth.
- The main genera of molds causing spoilage during storage are *Aspergillus* and *Penicillium*.
- The first mold predominating in grain at a_w of 0.68-0.75 is *Asp. penicillioides*, followed by *Asp. restrictus* and *Eurotium* spp.
  - These can raise the temperature of the grain to 35-40^{o}C.
- Mold growth follows with *Asp. candidus*, *Asp. ochraceus* and *Asp. flavus*.
  - These can raise the temperature of the grain to 50-55^{o}C.
- Then;
  - *Penicillium* spp, and thermophilic fungi (e.g. *Humicola lanuginosa*, *Thermoascus crustaceus*, *T. aurantiacus*) start to grow at this stage.
    - Rise temperature to 60-65^{o}C.
  - Thermophilic bacteria then start to grow;
    - These can raise the temperature of the grain to 75 ^{o}C.

Microbial Spoilage in Flours

- During the cleaning, washing, grinding and sieving of the cereal grain, the microorganism content is reduced.
- As in cereal grains, microbial growth is not observed in flours as long as the moisture content does not increase (12%).
- When the moisture content of flour reaches 15%, *Aspergillus and Penicillium* mold types are effective in spoilage. Bacteria and yeasts also grow if the moisture content of flour is 17% or more.
- Acid fermentation starts if there are acid-producing bacteria in the environment, such as in cereal grains. Then, if there are yeasts in the environment, alcoholic fermentation occurs by them. As a result, the flour becomes bitter.
- Microorganisms containing risk factors for microbial development in cereal flours; aerobic mesophiles are *E. coli, Bacilus cereus, C. perfiringens, Salmonela* spp., Rope spores and molds.
- Some strains of bacteria of the genus *Bacillus*, which cause Rope disease, produce toxins and cause food poisoning.

Microbial Spoilage in Bread

- Desired changes occur in bread dough as a result of fermentation by microorganisms.
- As a result of fermentation, bread is produced that has the desired textural properties, can be easily chewed in the mouth, remain soft without clumping, easily digested, and has a good taste and aroma.
- As a result of acid fermentation created by lactic and coliform bacteria in the dough, a sour taste is formed in the bread.
- The water activity value of bread is normally low (0.75-0.90) to prevent bacterial growth.
- For this reason, two types of microbial spoilage are seen in bread.
  - These are mold and rop formation.
- Main molds involved in the spoilage of bread are *Rhizopus stolonifer* (bread mold).
  - It produces white cottony mycelium and black dots of sporangia.
- Other spoilage molds are;
  - *P. expansum* or *P. stoloniferun* green-spored;
  - *A. niger* greenish-brown to black with conidial spores (pigment diffusing into bread);
  - *Monilia sitophila* a pink or reddish color.
  - Species of *Mucor* and *Geotrichum* may grow.
- Mold growth starts from the surface of the bread and progresses into the bread.

Microbial Spoilage in Bread

- Events that increase mold growth in bread are as follows:
  - Leaving the breads to cool for a long time in an environment containing a lot of mold spores after baking and contacting with contaminated (contaminated) slicing machines
  - Bread contact with more air during slicing
  - Packing the bread while it is hot during packaging
  - Storing bread in a warm and humid environment

Microbial Spoilage in Bread

- **Rope Formation:** It is the formation seen in the form of creep or threading in bread. The reason for this deterioration is *Bacillus subtilis (B. mesentericus)* and secondarily *B. licheniformis* bacteria.
  - The temperature given during the baking of the bread is insufficient to kill *B. subtilis* spores.
  - During this deterioration in breads, bread cells break down and a sticky structure emerges.
  - Apart from these two deteriorations, which are common and of great importance in breads, red stain (bleeding bread) caused by *Serratia marcescens* and chalk disease caused by *Trichosporan* variable are also seen.
  - Proper cleaning and disinfection is sufficient to prevent these deteriorations.

Fruit and Vegetable Microbiology

- About 20% of the fruits and vegetables that people use for consumption are thrown away without being consumed due to microbiological deterioration.
- Fruits and vegetables have their own natural microflora.
- In general, microorganisms are not found in the internal tissues of healthy fruits and vegetables.
- Their outer surfaces are susceptible to contamination by various means. The sources of infection can be listed as follows:
  - environment where it grew up,
  - tools-equipment used in harvesting and sorting,
  - packaging material and
  - the environment in which it is stored.

Fruit and Vegetable Microbiology

Microbial Contamination

- Fresh vegetables contain microorganisms
  - contaminate from soil, water, air and other sources.
- Heat-resistant spores of spoilage bacteria can contaminate from these sources,
  - Such as, spores of flat sour bacteria, putrefactive anaerobes (*C. thermosaccharolyticum*).
- Microorganisms grow more rapidly in damaged or cut vegetables.
- Air, high humidity and higher temperature increase the chances of spoilage.
- Bacterial numbers on fresh vegetables can range from 10^3 to 10^7 per g.
- Cutting, slicing, chopping and mixing can increase populations of microorganisms on fresh vegetables.

Fruit and Vegetable Microbiology

- The cuticle layer on the outer surface of fresh fruits and vegetables and the waxy layer that can be found naturally prevent microorganisms from passing into the inner parts.
- The antimicrobial substances contained in these structures have an effect on the development activity of microorganisms.
- The cuticle layer of the fruit is damaged due to various physical reasons (such as ripening, impact, insects).
- Resistance to microorganisms decreases in these damaged areas, and the passage of microorganisms to the inner tissues of fruits and vegetables becomes easier.
- Ultimately, microorganisms develop in these products, which have high water content, protein, carbohydrate, vitamin and mineral content, and cause deterioration in the product.
- While the flora of fruits is generally formed by yeast and mold fungi, bacteria are also involved in vegetables.

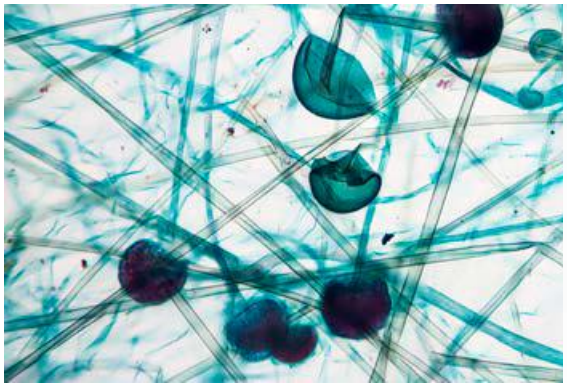
Microbiology of Fresh and Cold Stored Fruits and Vegetables

- The spoilage caused by microorganisms differs according to the type of fruit and vegetables they are found in.
- Plant pathogens and saprophytic (rotten) microorganisms, which are usually on the surface of fruits and vegetables, are effective in spoilage. Some disease-causing microorganisms and sources of contamination that can be transmitted by fruits and vegetables;

Microorganisms	Disease	Source
Salmonella	Salmonellosis	Tomato, beans, watermelon, unpasteurized orange and apple juice
Shigella	Shigellosis (bacillary dysentery)	Green lettuce, vegetable salads, melon, orange juice
Yersinia enterocolitica	Yersinosis	Salad vegetables
Listeria monocytogenes	Listeriosis	Green salad, lettuce, tomato, asparagus, broccoli, cauliflower and cabbage
Clostridium botulinum	Botulism	Prepackaged coleslaw, vacuum-packed mushrooms
Giardia lamblia	Giardiasis	Raw sliced vegetables
Hepatit A	Hepatitis A infection	Lettuce, diced tomatoes, raspberries, strawberries

Spoilage in Fruits

- **Soft Rot:** In this deterioration, the pectin in the fruit tissue is broken down. As a result of disintegration, cell water comes out. The fruit looks almost crushed. *Rhizopus* species are the most common cause of this kind of deterioration.



Rhizopus nigricans

Core House Rot: This type of deterioration is seen especially in apples and pears. The outer surface of the fruit looks normal, but after the fruit is cut, browning from the core of the fruit to the stem and white micelles are noticed in the cavities of the seed house. The spoilage factors are *Botrytis, Alterneria, Fusarium, Penicillium, Cladosporium* and some other molds.

Spoilage in Fruits

- ***Monilia* Spoilage:** In this deterioration, fruit tissues soften and turn brown. As the deterioration progresses, the whole fruit molds and turns black. The causative agent is members of the genus *Monilia*. It is seen in fruits with soft and hard seeds.

- **Green Mold Spoilage:** The tissues of the spoiled fruits are softened. While the surface of the fruit is covered with a mold layer that turns white, gray and green over time, a typical musty odor occurs in the same process. It is caused by *Penicillium digitatum or P. italicum*. It is effective in citrus fruits.

Spoilage in Fruits

- **Gray Mold Spoilage:** In this decay, the fruit surface is covered with gray mold micelles. As the process progresses, the fruit acquires a brownish color. Deterioration is encouraged in humid and warm weather. The factor of deterioration is *Botrytis* species. It is seen in fruits such as oranges, peaches, lemons, apples, apricots, especially grapes and strawberries.

- **Phytophthora-Fruit Spoilage:** In this deterioration, the fruit is brown if yellow; If it is green in color, dark green spots are formed. In damp places, white micelles can be seen on these spots. The decay factor is *Phytophthora cactorum*.

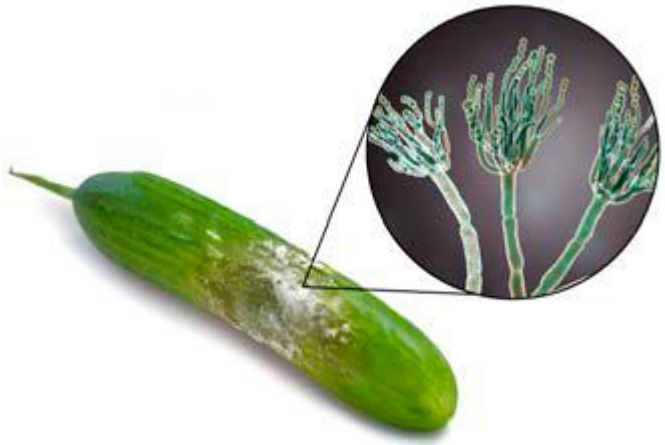
- **Changes Caused by Yeast:** Yeasts can be effective before harvest, that is, while they are on the fruit branch. It breaks down fruit sugar to form alcohol, CO_2 and water.

Spoilage in Vegetables

- Different microorganims can cause spoilage on vegetables.
- Initial spoilage starts with bacteria,
  - this is due to faster growth rate of bacteria,
  - than yeasts or molds.
- Soil contaminated by poor quality water may expose spoilage microorganims or human pathogens to vegetables.
- Processing steps (e.g. washing, disinfection) on vegetables before consumption increase possibility of spoilage. But:
  - Washing with chlorinated water and other disinfectants has limited antimicrobial effect on vegetables.
  - Vegetables are sold as fresh with adding 5 to 250 μg chlorine per liter to wash water.
  - Dipping tomatoes in a 200 to 250 μg per liter chlorine solution can reduce and inactivate microorganims from surface area.

Spoilage in Vegetables

- **Bacterial Soft Spoilage:** Bacteria with pectolytic enzymes break down the structures of vegetables and cause soft rot. The most important factors are *Erwinia caratovora and Pseudomonas marginalis*. As a result of rotting, the texture of the vegetable takes on a mushy consistency and bad odors occur in the vegetable.
- As a result of the enzyme activity of the bacteria, the tissue turns into a jelly, then other bacteria develop and the vegetables become unusable.
- These bacteria can also cause spoilage in products stored in the refrigerator. Soft rot is most common in vegetables such as onions, cucumbers, garlic, potatoes, asparagus, carrots, celery, spinach, cabbage, artichokes, cauliflower, tomatoes, peppers, and eggplant.



Spoilage in Vegetables

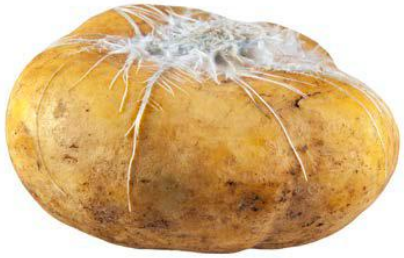
- **Gray Mold Spoilage:** *Botrytis cineria* is the cause of this decay. It can cause spoilage in almost all vegetables. This microorganism enters the vegetable through the wounds and cracks on it and then spreads to the whole tissue.

- **Sour Spoilage:** The spoilage factor is *Geotrichum candidum*. With deterioration (rot), acid formation, sour taste and unpleasant odor occur. It is common in tomatoes, carrots, onions, lettuce, artichokes, cabbage and beans. For the first development, there must be injuries such as wounds and cracks in the shell.

Spoilage in Vegetables

- ***Rhizopus Soft Spoilage:*** The decomposition agent is *Rhizopus stolonifer*. White-gray micelles develop on the vegetables in the form of cotton piles. It usually occurs in all vegetables. High humidity promotes spoilage.

- ***Anthracnos (Anthracnose):*** It is usually seen as brown and brick-colored spots on the fruits and leaves of vegetables. It occurs frequently in beans, cucumbers, zucchini, tomatoes and peppers, especially when the weather is rainy, humid and warm. The causative agents are *Fusarium, Alterneria, Penicillum, Trichothecium and Sclerotinia molds.*



Microbiology of Frozen Fruits and Vegetables

- There is no active microorganism development in frozen fruits and vegetables.
- The water in fruits and vegetables turns into inactive ice by freezing. In this case, the water activity drops to 0.7. Thus, the growth of microorganisms is prevented. Therefore, there is no deterioration in the products.
- During freezing, some of the microorganisms present in fruits and vegetables die. However, a significant decrease is observed when compared to the initial number of microorganisms.
- Defrosting frozen products for a very long time provides a suitable environment for the development of psychrophilic microorganisms, yeasts and *Lactobacillus* species.
- This causes fermentation and taste disorders in frozen fruits and vegetables.

Microbiology of Dried Fruits and Vegetables

- The water rate of dried fruits is 14-15%; The water rate of dried vegetables decreases to 3-5%. Thus, as the water content decreases, the growth of microorganisms in these products is greatly limited.
- As the water content decreases with the drying process, the risk of microbial spoilage in foods decreases.
- Dried fruits and vegetables are not susceptible to microbiological spoilage. However, as the water content of these products increases, their susceptibility to microbial spoilage increases.
- Microbial deterioration begins when the water content of dried fruits reaches 22% or more. Deterioration is caused by yeasts such *as Candida and Saccaromyces*, and molds of *Aspergillus and Penicillium* species.
- When the water rate in dry vegetables reaches 10-12%, microbial deterioration begins. Generally, spoilage is caused by *Lactobacillus, Leuconastoc, Bacillus, Clostridium, Pseudomonas* species.

Microbiology of Fermented Fruits and Vegetables

- Most vegetables can be fermented. Cucumber and sauerkraut, olive brine are the fermented products with the most production and consumption.
- When fruits and vegetables are put in brine, lactic acid fermentation occurs with the effect of natural microflora. Thus, fruits and vegetables gain properties that are pleasing in terms of flavor and texture.
- There is about 15% salt in the brine. Only yeast and halophilic bacteria can grow in this high salt environment.
- At lower salt concentrations (≤ 5%), lactic acid bacteria, yeasts (*Saccahoromyces, Torulopsis, Candida*) and coliforms produce carbon dioxide (CO_2), causing swelling in the product.
- In brines prepared using sugar or vinegar, lactic acid bacteria and yeasts play a role in spoilage.

Microbiology of Fermented Fruits and Vegetables

- The resulting microbiological deteriorations are generally classified as follows:
  - **Softening**: It is produced by microorganisms with pectolytic properties. Microorganisms that cause softening in pickles are *Bacillus, Fusarium, Penicillium, Cladosporium, Alternaria, Mucor and Aspergillus*.
    - One or more of these microorganisms can cause spoilage.
  - **Swelling**: It is caused by gas produced by *Enterobacter, Lactobacillus and Pediococcus* species.
  - **Blackening**: *Bacillus nigrificans*, which produces a water-soluble dark pigment, causes this type of deterioration

Microbial Spoilage in Fruit Juice

- These products are products with low pH values (pH 2.5-4.0). At the same time, their sugar content is quite high (5-15% in fruit juices, 40-60% in jams). High sugar content in concentrated products reduces the water activity value to 0.9. The redox potential (O-R potential) is low in carbonated beverages. For these reasons, the growth of microorganisms is limited.
- If proper storage conditions are not met, only asyric molds, yeasts and bacteria (*Lactobacillus, Acetobacter and Leuconostoc*) cause deterioration in these products.
- Bacteria that cause deterioration in freshly squeezed fruit juices if no preservation method is applied are generally *Saccharomyces, Candida, Hanseniaspora, Crytococcus, Rhodotorula, Penicillium, Mucor, Aspergillus, Geotrichum, Byssochlamys, Lactobacillus, Acetobacter, Bacillus* species.
- Acidity decreases as a result of the development of oxidative yeasts and molds (such as *Penicillium, Mucor*) in fruit juices; sour taste occurs. The discoloration, which is a negative feature in fruit juices, is due to the decrease in acidity. Yeast growth in clear juices causes turbidity.

Microbial Spoilage in Fruit Juice

- Most microorganisms cannot grow in concentrated fruit juices and jams due to the decrease in water activity (0.82-0.94) and heat treatment (60-82 °C). *Zygosaccharomyces* species are effective in the deterioration of these products.
- *Torulopsis, Candida, Hansenula and Saccharomyces* species cause turbidity in carbonated beverages. In still beverages, yeasts, *Lactobacillus and Leuconostoc* species cause turbidity in the products.
- The pH value of vegetable juices is higher than the pH value of fruit juices (5.0-5.8) (with the exception of tomato juice, pH 4.3).
- This causes the development of lactic acid bacteria and the occurrence of spoilage.
- Various preservation methods such as heat treatment, cooling, freezing and the use of chemical preservatives are used to prevent the proliferation of microorganisms that cause potential spoilage.

Test microorganisms are selected depending on the pH of foods

(1) Foods with pH over 4.6 (low acid foods) are heated over 100^{o}C

- to destroy heat-resistant spores of pathogenic bacterium, *Clostridium botulinum*, and
- to ensure a product free from any pathogen.

– But spores of some spoilage bacteria have greater heat resistance than the spores of *C. botulinum* and
  - can survive.

– The spores of bacteria surviving at the heat treatment used to destroy *C. botulinum* spores; that
  - can germinate at 43°C and above,
  - some can outgrow and multiply at temperature as low as 30°C.

Test microorganisms are selected depending on the pH of foods

- Low-acid canned foods are required to be heat treated at a specific temperature and time to cause a reduction of C. *botulinum* spores by a **factor of 10^{12}** (12D process).
- The test bacteria used for this aim are *B. stearothermophilus* and *C. thermosaccharolyticum*.
  - They are high heat resistant microorganisms in these foods than C. *botulinum* spores.
    - They can also be used as test bacteria to produce commercially sterile food.

Test microorganisms are selected depending on the pH of foods

(2) Foods with pH between 4.0 and 4.6 (medium acidic foods) are heat treated at 100^{o}C to kill all vegetative cells and some spores.

- *C. botulinum* cells and spores are inactivated by heat treatment at this acidic pH with 100 ^{o}C.
- Acidic pH inhibits germination of spores.
- Spores of some acidic thermophilic spoilage bacteria can survive at this temperature;
  - germinate and grow in heated canned foods.
- These bacteria are *B. coagulans* and *B. stearothermophilus*.
- They can be used as test bacteria for these foods.

(3) Canned foods with pH lower than 4.0 (high acid foods)

- Higher acids inhibit most bacteria while aciduric molds can survive.
- *Byssochlamys fulva* can be used as a test microorganism for these foods to produce commercially sterile foods.

Microbiology of Canned Foods

- Canned food is obtained as a result of the processes of filling the appropriate raw material into tin cans or glass jars after some pre-treatment, sealing the containers in an airtight manner (hermetic) and killing microorganisms that cause spoilage by heat treatments (pasteurization and sterilization). There may be microbiological, chemical and physical deterioration in canned food.
- Deterioration in canned foods; It is caused by the activities of microorganisms, the interaction between the contents of the box and the box, or the mistakes made during processing.

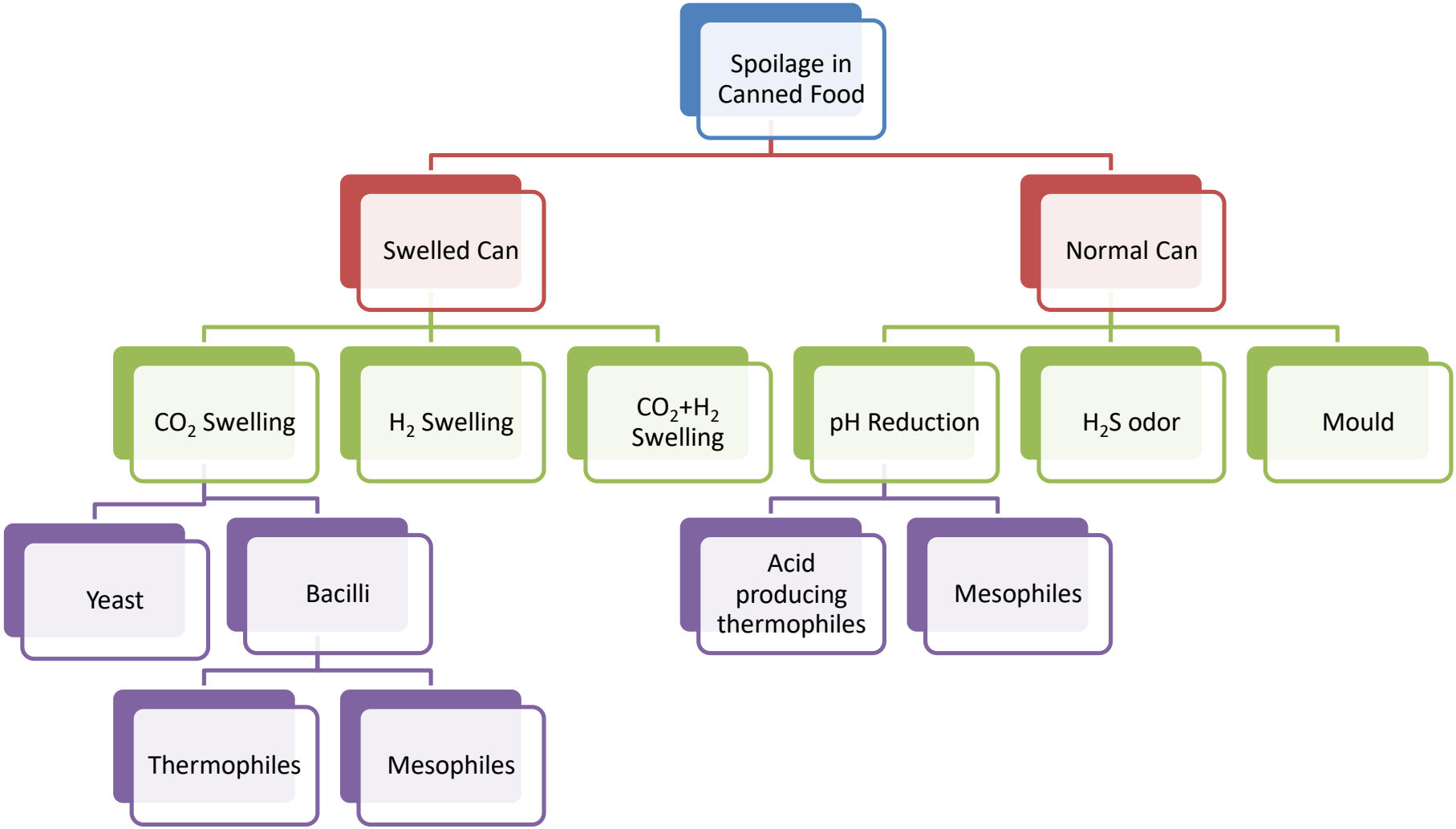
Microbiological Spoilage in Canned Foods

- The microbiological quality of canned food depends on the quality characteristics of the raw materials and additives used, as well as on storage and transportation conditions. There are two important microbiological steps in the processing of fruits and vegetables into canned food. These are applications before and after heat treatment.
- If the chopped and boiled products are kept waiting before the heat treatment, that is, if the heat treatment is delayed, the microorganism load in the products increases. In addition, the tools and equipment used in the enterprise and the spices and additives used are important sources of contamination for the product being processed.

Microbiological Spoilage in Canned Foods

- Microorganisms that grow inside the can can decompose with or without gas formation. If gas is formed, the gas formed can be easily observed from the outside of the box. Inflating the box in this way is called a "swelling".
- In the bombing event caused by microorganisms, the food product in the box deteriorated and became unconsumable. The sale of bombed boxes is prohibited.
- Sometimes the gas formed dissolves in the filling liquid inside the box, so that no swelling can be seen in the box from the outside. This type of deterioration is called “flat souring”.

Microbial Spoilage in Canned Foods and Their Causes



Canned Food Spoilage

- Canned food spoilage can result from nonmicrobial (chemical and enzymatic reactions) and microbial spoilage.
  - Chemical reactions lead to the formation of H_2 gas (hydrogen swell), CO_2 gas, browning and corrosion of cans.
  - Different microorganisms (spore forming bacteria, molds and yeasts) can cause spoilage in canned foods.
- Spoilage of canned products results from three main reasons:
  1. inadequate heating, allowing in survival and growth of mesophilic microorganisms (vegetative cells and spores),
  2. inadequate cooling after heating or high-temperature storage, allowing germination and growth of thermophilic sporeformers, and
  3. leakage in the cans, allowing microbial contamination from outside after heat treatment.

Canned Food Spoilage

- The major sporeformers causing spoilage are
  - thermophilic flat-sour organisms,
  - thermophilic anaerobes not producing H_2S,
  - thermophilic anaerobes producing H_2S,
  - putrefactive anaerobes,
  - mesophilic *Bacillus*,
  - butyric *Clostridium*,
  - lactobacilli and
  - heat resistant molds and yeasts.

Microbial Spoilage in Cans Before Heat Treatment

- The product to be canned may have deteriorated before heat treatment. Causes of deterioration of canned food before heat treatment;
- Transportation and storage of the harvested product in unsuitable conditions
- Waiting for products longer than necessary
- Malfunctions in tools and equipment (insufficient heat treatment, leakage, etc.)

Spoilage in Canned Foods Due to Leakage

- If an error has been made in closing the box or even though the box has been properly closed; If the hermetic closure is broken, the clamps are opened and thus leakage occurs due to mistakes made in using the autoclave, infection may occur with the cooling water or air sucked in depending on the vacuum in the box.
- When a microbiological analysis is made of the boxes that are damaged due to leakage, it is understood that the microorganisms causing the deterioration are mostly of cooling water origin.
- In addition, these microorganisms are generally non-heat resistant species. Since the gas formed in this type of deterioration will come out from the leak site, bombing may not be seen in the boxes.

Microbial Deterioration Caused by Insufficient Heat Treatment in Canned Foods

Deterioration Caused by Spore Thermophilic Bacteria

It is the most common type of spoilage in canned food. In this type of deterioration, the pH value of the product is very important. Because the pH value shows the effectiveness of the heat treatment. It also affects the growth of microorganisms during the storage period. The deteriorations caused by thermophilic bacteria are listed as follows:

Deterioration Caused by Flat Sour Microorganisms

Some bacteria cause spoilage without bombarding. Since there is no change in the outer appearance of the can (bombing, etc.), the deterioration is not apparent until the can is opened. This deterioration is caused mainly by *Bacillus* species. These bacteria produce acid by fermenting carbohydrates without producing gas; It causes bad odor and cloudy appearance. Acids that occur with flat souring deterioration reduce the pH value of the environment. Thus, the self-development of the organism stops. Therefore, the pH value does not fall below 4.7. Because bacteria cannot multiply below pH 4.7. In addition, acid formation in the can causes the can to rust.

Microbial Deterioration Caused by Insufficient Heat Treatment in Canned Foods

Thermophilic Anaerobe (TA) Deterioration

It is the type of spoilage caused by the thermophilic anaerobic *Clostridium thermosaccbarolyticum* bacteria in low and medium acid foods. Bombing is seen inside the box, as the spoilage factor bacteria creates acid, hydrogen gas and carbon dioxide from carbohydrates.

Sulfur Decomposition

Clostridium nigrificans bacterium develops when the heat treatment is insufficient and breaks down the nitrogenous substances containing sulfur to form sulfur (H_2S) gas. Since H_2S gas is a water-soluble gas, it does not bombard the box. A foul odor occurs in cans with sulfur degradation.

Microbial Deterioration Caused by Insufficient Heat Treatment in Canned Foods

Deterioration Caused by Spore Mesophilic Bacteria

It is a type of deterioration caused by some bacteria of the genus *Bacillus and Clostridium*. Botulin toxin with neurotoxin properties, formed by *Clostridium botulinum* bacteria, is especially important because it causes fatal cases. While Bacillus, an aerobic bacterium, poses a danger in canned food that has not been exaust, it cannot deteriorate in hermetically sealed cans.

Deterioration Caused by Nonspore Mesophilic Bacteria

Some heat-resistant, non-sporeless bacteria can remain viable at pasteurization temperature and cause spoilage in cans. These include *Streptococcus thermophilus, some Micrococcus, Lactobacillus and Micobacterium* species.

Decays Caused by Yeast

The growth and deterioration of these microorganisms in canned foods can only occur as a result of leakage or inadequate pasteurization. Since carbon dioxide is formed as a result of fermentation, bombing is always seen in this type of canned food, which is spoiled by yeast.

Microbial Deterioration Caused by Insufficient Heat Treatment in Canned Foods

Deterioration Caused by Molds

Since molds are generally aerobic microorganisms, they cannot grow in hermetically sealed containers. Molds can only be a significant spoilage factor in home canned food that is not well-sealed and inadequately heat-treated.

Autosterilization

Microorganisms, especially bacteria, die as a result of the toxic effects of their metabolites (acids). Although the outer appearance of the box may be with or without bombardment, the contents of the box have always been corrupted and become unconsumable. Autosterilization is mostly seen in acidic foods and fruit preserves.