Microbial spoilage of various foods

Sahana Ghosh

What Is Spoilage?

- To spoil means to ‘deprive of good or effective qualities’.
- When a food is spoiled its characteristics are changed so that it is no longer acceptable.
- Such changes may not always be microbiological in origin; a product may become unacceptable as a result of insect damage, drying out, discolouration, staling or rancidity for instance, but by and large most food spoilage is a result of microbial activity
- Visible microbial growth may be apparent in the form of surface slime or colonies, degradation of structural components of the food can cause a loss of texture, but the most common manifestation will be chemical products of microbial metabolism, gas, pigments, polysaccharides, off odours and flavour.
- Spoilage is also a subjective quality; what is spoiled for one person may be perfectly acceptable to another.
- A general feature of microbial spoilage is its relatively sudden onset – it does not appear to develop gradually, day by day a little worse, but more often as an unexpected and unpleasant revelation.

Microbial Spoilage Of Meat

Salle & Adams & Moss

- Earlier studies, newer results indicate that meat obtained from healthy, freshly slaughtered animals is seldom sterile.
- The organisms that have been isolated grow very slowly, visible signs appearing in from 7 to 14 days.
- Frozen or cold-storage meats can be kept for long periods of time without showing any signs of spoilage. On the other hand, meats kept at higher temperatures (chilled) show spoilage in much shorter periods.
- The changes that take place are the result of the action of autolytic enzymes normally present in the meat and those elaborated by the contaminating organisms.
- The bacteria and molds usually found on meat are, with rare exceptions, not dangerous to health.
- **Weinzirl and Newton** examined samples of meats purchased in the open market and found that the numbers of aerobic organisms present varied from 270,000 to 88,000,000 per gram.
- Both aerobic and anaerobic organisms are concerned in the spoilage of meats, fish, and other high-protein-containing foods.

Microbial Spoilage Of Meat

Salle & Adams & Moss

- Many types of organisms are concerned in putrefaction. These may be grouped as follows:

(1) Gram-positive, aerobic, spore-bearing rods,
(2) Gram-negative, aerobic, nonspore-forming rods,
(3) cocci,
(4) anaerobes, and
(5) molds and yeasts.

- The Gram-positive, aerobic, spore bearing group includes ***Bacillus subtilis, B. albolactis, B. mesentericus,*** etc.

- The Gram-negative, aerobic, nonspore-forming group includes ***Escherichia coli, E. coli var., communior, Proteus vulgaris, P. mirabilis, Aerobacter cloacae, and Pseudomonas fluorescens.***

- Several species of yeasts have been isolated from meat kept under refrigeration.
- Most molds produce pigments that impart discolorations to meat.
- If molds are permitted to grow without being checked, they may impart unpleasant odors and flavors to meat.

Microbial Spoilage Of Meat

Salle & Adams & Moss

- Some of the cocci that have been isolated include *Staphylococcus aureus, Micrococcus candidus, M. aurantiacus, M. candicans, M. saccatus, M. flavescens, M. roseus, and Sarcina aurantfaca.*
- Some of the anaerobes that have been isolated from fresh and spoiled meat are *Clostridium perfringens, C. tertium, C. bifermentans, and C. sporogenes.*
- The molds that have been found growing on meat belong to the following genera: *Aspergillus, Penicillium, Mucor, Cladosporium, Sporotrichium, Alternaria, and Monilia.*
- Bacterial metabolism produces a complex mixture of volatile esters, alcohols, ketones and sulfur-containing compounds which collectively comprise the off odours detected
- These have confirmed the predominant role of pseudomonads in spoilage of aerobically stored chilled meat
- The first indication of spoilage is generally the buttery or cheesy odour associated with production of diacetyl (2,3- butanedione), acetoin (3-hydroxy-2-butanone), 3-methyl-butanol and 2-methylpropanol.

Microbial Spoilage Of Meat

Salle & Adams & Moss

- Vacuum and modified-atmosphere packing of meat changes the meat microflora and consequently the time-course and character of spoilage. In vacuum packs the accumulation of CO2 and the absence of oxygen restrict the growth of pseudomonads giving rise to a microflora dominated by Gram-positives, particularly lactic acid bacteria of the genera *Lactobacillus*, *Carnobacterium and Leuconostoc*.

- Spoilage of vacuum packed meat is characterized by the development of sour acid odours which are far less objectionable than the odour associated with aerobically stored meat.

- Some work has suggested that methane thiol and dimethyl sulfide may contribute to the sour odour.

Microbial Spoilage Of Meat

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IMPORTANT ISOLATED MICRO-ORGANISMS FROM MEAT	
PRODUCT	**MICRO-ORGANISMS ISOLATED**
Fresh & Refrigerated Meat	Bacteria : *Pseudomonas, Aeromonas, Micrococcus & Alcaligenes*
	Molds: *Cladosporium, Geotrichum & Mucor*
	Yeasts: *Candida, Torulopsis & Rhodotorula*
Processed & Cured Meats	Bacteria: *Lactobacillus & other lactic acid bacteria, Bacillus, Micrococcus & Staphylococcus*
	Molds: *Penicillium, Aspergillus*
	Yeasts: *Candid, Torula, Torulopsis*

Microbial Spoilage Of Butter

1. INTRODUCTION

Microbiology of Butter reflects the micro flora present in pasteurization cream from which it is made, water added at the time of salting of butter, Sanitary Condition of process of equipment, manufacturing environment and conditions under which the product is stored. Intrinsic properties of butter for e.g., pH salt content, uniformity of moisture distribution and droplet size, all impact microbiological stability.

2. MICRO-ENVIRONMENT OF BUTTER

Micro-environment of Butter is unfavorable for growth of Microorganisms compared because of the following compositional and structural differences.

2.1. COMPOSITIONAL DIFFERENCES

a) Fat content in butter is relatively resistant to microbial decomposition is present in greater butter in butter (about 80%) compared to cream (except for high fat plastic cream)

b) Lactose which is readily utilizable by many of the microorganisms is present in lower quantities.

c) Moisture content which is essential for microbial growth is present lower quantities (<16%) in butter.

d) Salt in butter make its micro environment unfavorable for microbial growth.

Microbial Spoilage Of Butter

2.2. STRUCTURAL DIFFERENCES

The nature of distribution of water and fat in cream and butter makes their microenvironment different. In cream water is in continuous phase and fat is in discontinuous phase, where are the reverse in case of butter where water is discontinuous phase present as drops dispersed in fat. A large number of water droplets are more than the number of Microorganisms in butter. Moreover, unlike that in cream, Microorganisms cannot proliferate easily and spread in butter.

3. MICROFLORA OF BUTTER

In spite of unfavorable conditions in butter for microbiological growth; since cream utilized for butter making is pasteurized, the bulk of Microbial population in the final packet is contributed by post pasteurization contamination during butter making. Microorganisms of the post pasteurization contamination from utensils, H2O, air etc and belong to different groups of bacteria such as psychrophilic/psychrotropic (proteolytic/Lipolytic), Mesophilic (Lactic and non lactic acid) and spore forming bacteria. In case of yeast and molds, they may enter through aerial route.

3.1 SOURCES OF MICROORGANISMS IN BUTTER

3.1.1 Raw Material (Milk or Cream)

3.1.2 Equipments

3.1.3 Water supplies

3.1.4 Air

Microbial Spoilage Of Butter

3.2 MICROBIAL DETERIORATION/SPOILAGE OF BUTTER

Growth of micro organisms in butter causes a variety of color and flavor defects. Most of the microorgansims in cream gets killed during pasteurization, the spoilage organisms mainly come through post pasteurization steps and butter making. The defects in butter mainly attributed to the presence of psychotropic bacteria (lipolytic & proteolytic), yeast and molds. The psychotropic bacteria which are entering the product through unhygienic equipment grow during low temperature storage. However, molds create problems and relatively high temperature as prevalent India.

A. COLOUR DEFECTS (DISCOLORATION)

Discoloration of butter may be caused by bacteria, yeasts and molds. However major color defect in butter are caused by yeast and molds.

Bacterial Discoloration

a) Black discoloration (like grease smudge) causative organisms: *Pseudomonas nigrificans*. Due to butter stored at low temperature (optimum for pigmentation is 4ºC i.e. 15-20% salt concentration in the moisture droplets.

b) Fungal Discoloration: Butter gets discolored due to surface growth of molds and the defect is also described as “moldy butter”. This is a major defect commonly occurred in India since the ambient temperature storage condition encourages the growth of Fungi in butter. Fungi growth also favored by higher moisture content and acidity. Some psychotropic molds like *Alternaria, Harmodendrum, phoma and stamphylium* have been appear to grow in butter (unsalted) at low temperature (5ºC) slightly growth at -4 to -6ºC but not at -7 to -9ºC. Some common fungal discoloration frequently occurred in butter areas follows

Microbial Spoilage Of Butter

Discolouration	Causative agent
a. Mold discoloration	
Black	*Cladosporium Eg. C. harbarum, Aspergillus, Hasmodendrum,Alternaria, Mucor, Rhizopus, and Stamphylium*
Brown	*Aspergillus spp, and Phoma spp (muddy brown)*
Green & blue green	*Penicillium spp and Aspergillus app*
Orange & yellow	*Geotrichum candidum*
Reddish pink	*Fusarium*
b. Yeast	
Black	*Torula spp*
Pink	*Rhodotorula spp*

Microbial Spoilage Of Butter

B. FLAVOR DEFECTS

Rancid & putrid or cheesy odor is the most common flavor defects in butter. The other defects like malty, Shunk-like flavor yeasty may also occur in butter.

a. Rancid flavor

b. Putrefactive taint

c. Cheese taints

d. Other flavor taints

Microbial Spoilage Of Butter

Many of the defects of butter originate in the cream from which it is made

Flavor Defects

Flavor Effect	Causing Organisms
Chessiness	*Lactobacilli*
Barny	*Enterobactor*
Malty	*Streptococcus lactis*
Musty	*Molds & Actinomycetes*
Fishiness	*Aeromonas hydrophila*
Shunk-like flavor	*Pseudomonas mephitica*

- **The formation of 3-methyl butanol in butter mainly responsible for malty flavor.**
- **Fishy taint is due to decomposition of lecithin to Trimethyl amine by microbes.**

Microbial Spoilage Of Vegetables

Introduction

Vegetables have been associated with outbreaks of food borne disease in many countries. Organisms involved include bacteria, viruses and parasites. Contamination of vegetables may take place at all stages during pre and post-harvest procedures. Cultivation and operation or preparation of vegetables is responsible for this contamination. Unsafe water used for rinsing the vegetables and sprinkling to keep them fresh is also a source of contamination. Other possible sources of microorganisms include soil, faeces (human and animal origin), water (irrigation, cleaning), ice, animals (including insects and birds), handling of the product, harvesting and processing equipment and transport.

Microorganisms capable of causing human illness and others whose food borne disease potential is uncertain, includes *Aeromonas hydrophila*, *Citrobacter freundii*, *Enterobacter cloacae* and *Klebsiella* sp. and they have been isolated in lettuce and salad vegetables.

Microbial Spoilage Of Vegetables

Microbial spoilage of vegetables

It is also estimated that about 20% vegetables produced is lost each year due to spoilage.

According to a USDA-Economic Research Service study in 2010, 18.9 billion pounds of fresh fruits and vegetables were lost annually due to spoilage. The portion of loss specifically due to microbiological spoilage.

Most microorganisms that are initially observed on whole fruit or vegetable surfaces are soil inhabitants, members of a very large and diverse community of microbes that collectively are responsible for maintaining a dynamic ecological balance within most agricultural systems.

Vectors for disseminating these microbes include soil particles, airborne spores, and irrigation water.

Most bacteria and fungi that arrive on the developing crop plant either are completely benign to the crops health or, in many instances, provide a natural biological barrier to infestation by the subset of microorganisms responsible for crop damage.

Processing techniques, including peeling, cutting, washing, and dewatering, also influence the vulnerability of fresh-cut fruits and vegetables to microbiological spoilage.

Microbial Spoilage Of Vegetables

Impact of microbial spoilage in vegetables

Microbiological spoilage or microbiological shelf life has become a major reason for sensory quality shelf life failure for most packaged fresh-cut vegetables, followed by surface discoloration (e.g., pinking of cut lettuce, browning of cut potato, graying and gray discoloration with cabbage), water-soaked appearance or translucency (e.g., cut watermelon, papaya, honeydew, and tomatoes), moisture loss (e.g., “baby” carrots and celery sticks), offaroma (e.g., broccoli florets and diced cabbage in low % O_2 and high CO_2 packages), flavour changes (e.g., cut kiwifruit), and texture changes.

Microbial spoilage is a limiting factor for shelf life of fruit pieces stored under controlled atmosphere conditions.

Shelf life, including microbial spoilage, results in 30–50% shrinkage of fresh-cut fruits.

Microbial spoilage has been used by quality assurance departments in the fresh-cut industry as the objective indicator for quality failure for more than 50% of fresh-cut vegetable commodities and almost 100% of fresh-cut fruit products that have been treated with preservatives and packaged properly using MAP technologies.

Microbial Spoilage Of Vegetables

Sources of microbial contamination in vegetables

Contamination sources of fresh-cut fruits and vegetables include raw materials and contact with processing equipment.

Significantly higher bacterial counts were observed during processing on automated cutters and package fillers of a lettuce processing line, indicating that clean product can become recontaminated after passing through operations where vegetable and fruit debris can accumulate, such as cutters and package-filling equipment.

Shredding and slicing steps in fresh-cut processing resulted in increased microbial populations by 1–3 logs on cut cabbage, lettuce, and onions and at least increase for lettuce and chicory salads.

Microbial population significantly increased on broccoli florets after the washing step.

Shredding, rinsing, and centrifugation of red lettuce Lollo Rosso increase coliform, lactic acid bacteria, and psychrotrophic bacterial counts.

Yeast populations on cut cantaloupes were found to be increased after packaging.

Several researchers have suggested that the large numbers of lactic acid bacteria and fungi present on fresh-cut products indicate likely contamination from processing, such as cutting machines.

Microbial Spoilage Of Vegetables

Vegetables form an integral part of diet due to their role in providing various types of vital nutrients such as carbohydrates, minerals, vitamins, roughage etc. Vegetables being a part of fresh produce, contain high moisture which makes them highly perishable foods and hence more prone to spoilage. Microorganisms gain entry into vegetables from various sources. These sources include:

- Soil
- Water
- Diseased plant
- Harvesting and processing equipments
- Handlers
- Packaging and packing material
- Contact with spoiled vegetables

The conditions in which vegetables are stored and transported after harvesting also contribute to rate of spoilage. Other than microbial, sources, the spoilage of vegetables can also occur due to the activity of native enzymes.

Microbial Spoilage Of Vegetables

Characteristics of vegetable spoilage microorganisms

Food borne bacterial pathogens, commonly detected in fresh vegetables, were coliform bacteria, *Escherichia coli*, *Staphylococcus aureus* and *Salmonella* sp.

The internal tissues of vegetables are nutrient rich and many, especially vegetables, have a near neutral pH. Their structure is comprised mainly of the polysaccharides cellulose, hemicellulose, and pectin. The principal storage polymer is starch. Spoilage microorganisms exploit the host using extracellular lytic enzymes that degrade these polymers to release water and the plants other intracellular constituents for use as nutrients for their growth.

Fungi in particular produce an abundance of extracellular pectinases and hemicellulases that are important factors for fungal spoilage.

Some spoilage microbes are capable of colonizing and creating lesions on healthy, undamaged plant tissue. Spoilage microorganisms can also enter plant tissues during fruit development, either through the calyx (flower end) or along the stem, or through various specialized water and gas exchange structures of leafy matter.

Colonization and lesion development more typically and more rapidly occurs within damaged or otherwise compromised plant tissue. External damage such as bruising, cracks, and punctures creates sites for establishment and outgrowth of the spoilage microbes.

Microbial Spoilage Of Vegetables

Staphylococcus aureus is the third most common cause of confirmed food poisoning in the world and the illness is due to the ingestion of preformed enterotoxins produced in foods.

Several Gram-positive bacteria, most notably the lactic acid bacteria, have been associated with spoilage of fresh-cut fruits and vegetables that are packaged under modified atmosphere with <2% O_2 and >10% CO_2 and stored at 7$_o$C or above.

The genera of lactic acid bacteria include *Lactobacillus*, *Leuconostoc*, *Pediococcus*, *Lactococcus*, and *Enterococcus*.

The most common and important spoilage microorganisms of refrigerated fresh-cut vegetables are the fluorescent Pseudomonas species of which *Pseudomonas marginalis* is an example.

Pseudomonas is widely distributed in nature and is found on both animal and plant products. They are able to utilize a wide variety of organic compounds and produce acids oxidatively from glucose and maltose. Some Pseudomonas species produce pyoverdine or fluorescein that are water soluble, fluorescent pigments and can be observed in spoiled foods under ultraviolet light.

Pseudomonas produce catalase, oxidase, and enzymes that catalyze proteolytic and lipolytic reactions that contributes to spoilage of refrigerated fresh animal products, and pectinolytic enzymes that can cause soft rot of fleshy vegetables.

Microbial Spoilage Of Vegetables

Erwinia sp. is another common Gram-negative spoilage microbe associated with fresh-cut vegetables.

Erwinia cause rapid necrosis, progressive tissue maceration called “soft-rot” occlusion of vessel elements called “vascular wilt,” and hypertrophy leading to gall or tumor formation in plant tissues.

E. carotovora subsp. *carotovora* is one of several species of *Erwinia* that infect and destroy plant tissues both pre- and postharvest and causes the greatest damage to harvested vegetables.

“Soft-rot Erwinia” tend to initiate infection and decay at wound sites and, once established, can quickly advance to total destruction of the product. Soft-rot *Erwinia* express four pectin-degrading extracellular enzymes: pectin lyase, polygalacturonase, pectin methylesterase, and pectate lyase. Of these enzymes, pectate lyase is primarily responsible for extensive decay. *E. carotovora* has builtin redundancy for this apparently critical pathogenicity factor, expressing four distinct extracellular pectate lyase isozymes.

Two wound pathogens, *Penicillium expansum* and *Botrytis cinerea*, if not scrupulously cleaned from fruits prior to storage or if fruits with infected wounds have not thoroughly been culled from the lot, can cause significant crop loss as these spoilage fungi eventually degrade the wound sites, create lesions, and cross-contaminate adjacent fruits.

Microbial Spoilage Of Vegetables

Like yeasts, mold populations have been reported in various types of fresh-cut fruits and vegetables and visible molds have resulted in inedible fresh-cut fruits, such as strawberry, honeydew, pineapple, and cantaloupe.

Penicillium expansum and *Botrytis cinerea* are pathogens of apples, pears, and a number of other pectin-rich fruits

Botrytis cinerea is an especially sophisticated and selective plant pathogen that possesses multiple cutinases and lipases that are capable of degrading plants rich in pectin.

Microbial Spoilage Of Vegetables

SOME MICROBIAL DEFECTS OF VEGETABLES

Food	Defect	Organism
Beans 	• Anthracnose • Blight	• Colletotrichum • Xanthomonas
Carrots 	• Soft rot • Fungal rot • Decay, Wet rot	• Rhizopus stolonifer • Fusarium • Rhizoctonia carotae
Onions 	• Neck rot • Rot • Black mold	• Botrytis allii • Pseudomonas cepacia • Aspergillus niger
Potatoes 	• Ring rot • Dry rot	• Corynebacterium • Fusarium
Tomatoes 	• Ferment • Fungal rot • Bacterial spot • Soft rot	• Candida, Pichia • Aspergillus • Xanthomonas • Byssochlamys fulva

Microbial Spoilage Of Fruits

INTRODUCTION

- Fruits and vegetables are rich source of energy, body-building nutrients, vitamins and minerals.
- Protected mechanically by the pectins which constitute a protective gum between the cells and gives firmness.
- Spoilage in fruits starts with the hydrolysis of the pectin. Once the pectinases have damage the structure of the fruit/vegetable, other organisms start to contribute to the soft rot.
- Majority of the microorganisms in fruits and vegetables are saprophytes, such as lactic acid bacteria, *coryniforms*, *coliforms*, *micrococci*, spore-formers, and pseudomonas, which may be from the air, soil, and water.

  The fungus namely *Aureobasidium*, *Fusarium*, and *Alternaria*, are also commonly present but lower in number as compare to bacteria.

Microbial Spoilage Of Fruits

Fruits are natural sources of minerals, vitamins besides carbohydrates and other essential substances. Naturally fresh fruits and juices made out of them contain high amount of water thereby making them highly prone to attack by microorganisms. While most of the fruits are naturally provided with coatings and coverings in the form of skins, but these are fragile enough to be easily disturbed by various biological and mechanical factors. Like vegetables, fruits being produce of plants get contaminated through different sources by a variety of microorganisms which may play significant role in their spoilage. These are soil, water, diseased plant, harvesting and processing equipments, handlers, packaging and packing material and contact with spoiled fruits.

Microbial Spoilage Of Fruits

BASIC TYPES OF SPOILAGE

On the basis of appearance:

- Microbial growth
- Change in food colour

Textural change

- Slime formation
- Tissue softening

Changes in taste and odor

- Development of nitrogenous compounds
- Organic acids
- Sulfides

Microbial Spoilage Of Fruits

CAUSATIVE MICROBES

Saprophytic microorganisms :-

- *P. fluorescens*
- *E. agglomerans*
- *E. herbicola*

Pectinolytic microorganisms :-

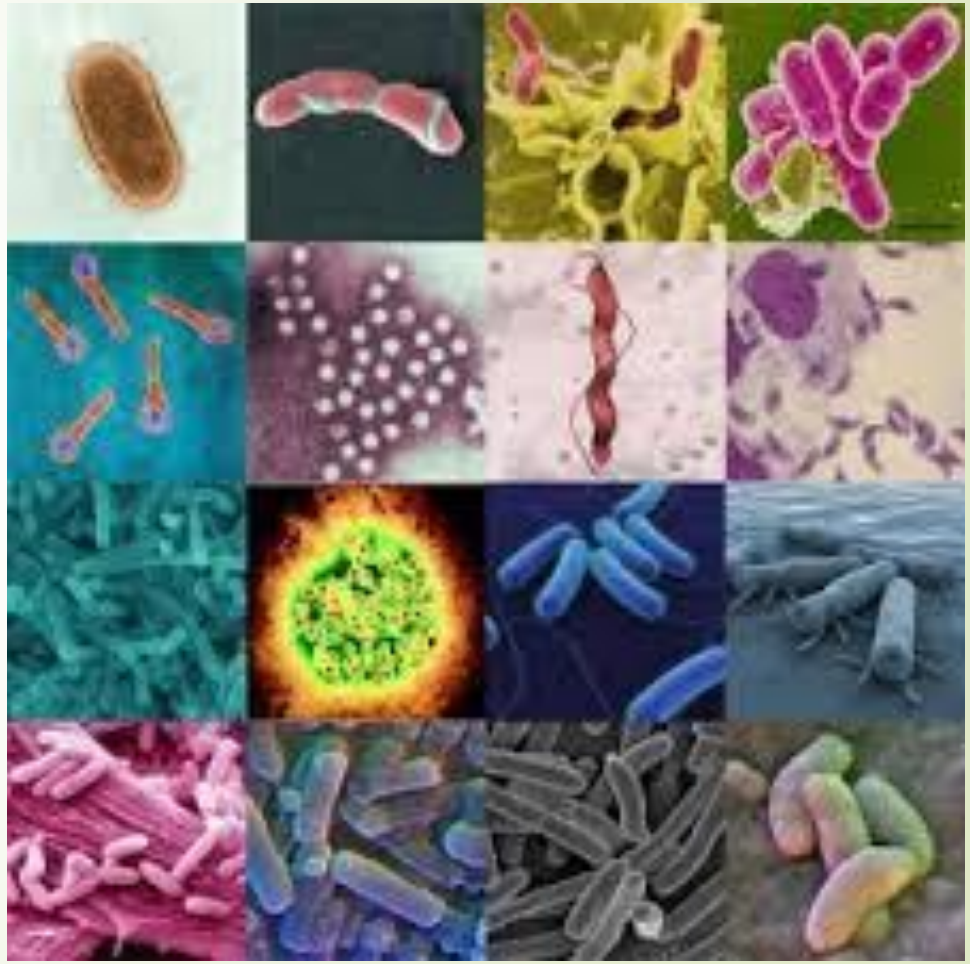
- *P. fluorescens*
- *P. paucimobilis*
- *P. viridiflava*
- *P. luteola*
- *Xanthomonas maltophila*
- *Flavobacterium* spp.

Food borne pathogens :-

- *Listeria monocytogenes*
- *Salmonella poona*
- *Shigella* spp.
- *S. aureus*
- *C. botulinum*

Yeast and molds :-

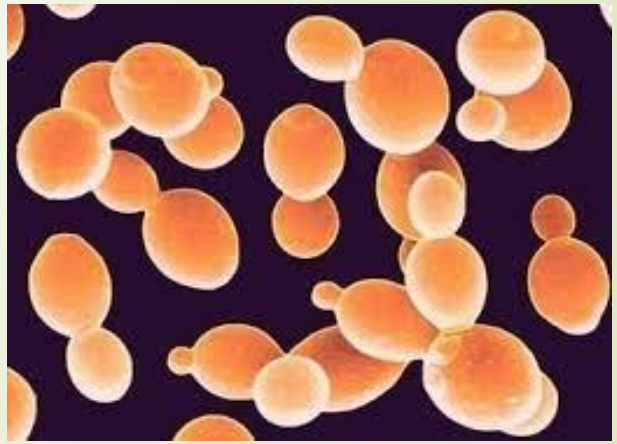
- *Basidiophora*
- *Peronospora*
- *Phytophthora*
- *Plasmopara*



Microbial Spoilage Of Fruits

FACTORS AFFECTING MICROBIAL GROWTH

1. Due to ripening cell wall weakens and the amounts of antifungal chemicals in fruits decreases.
2. Physical damage during harvesting causes breaks in outer protective layers of fruits that spoilage organisms can exploit.
3. High levels of sugar and a low pH in fruits juices generally favours growth of yeasts, moulds and acid-tolerant bacteria.
4. *Saccharomyces* and *Zygosaccharomyces* are resistant to thermal processing and are found in some spoiled juices.



Microbial Spoilage Of Fruits

DISEASES CAUSED

Salmonellosis :- This disease is caused by *Salmonella spp.*. Salmonellosis can be caused due to contaminated fruits and vegetables like bean sprouts, tomatoes, melons, unpasteurised orange juice.

Shigellosis :- Caused due to *Shigella*. This disease is caused due to Lettuce, vegetable salad, potato salad containing spring onion, sliced raw papaya, watermelon.

Campylobacter enteritis :- *Campylobacter jejuni* is the major causative agent. Person suffering from this disease develops fever, abdominal cramps, nausea, vomiting and watery diarrohea.

Yersiniosis :- *Yersinia enterocolitica* is the causative organism of Yersiniosis. Incidence of Yersinia is higher on root and leafy vegetables than on tomatoes or cucumbers.

Listeriosis :- Caused by *Listeria monocytogenes* . It can grow on endive, lettuce, tomatoes asparagus, broccoli, cauliflower and cabbage.

Microbial Spoilage Of Fruits

DISEASES CAUSED

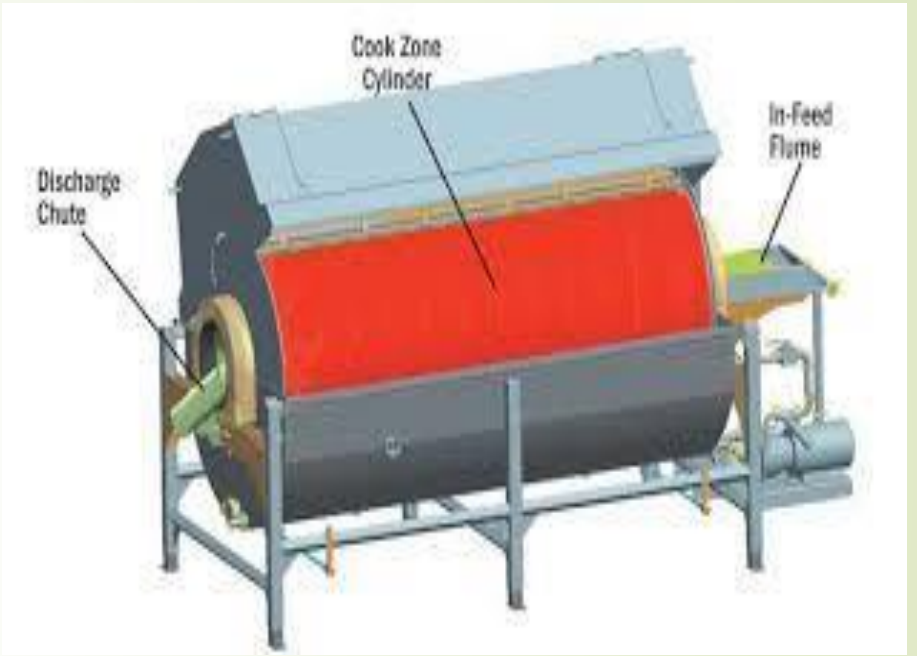
Botulism :- *Clostridium botulinum* is the causative organism. It causes fatal paralysis of muscles. It is caused due to botulinum toxin.

Norwalk-like gastroenteritis :- Caused due to Norwalk like viruses. Illness is characterized by acute onset of nausea, vomiting, abdominal cramps, and diarrohea.

Microbial Spoilage Of Fruits

PRESERVATION METHODS

- **Use of acidulants :**
  Lactic acid
  Acetic Acid
  Other Acidulants



- **Scalding or blanching in hot water :-**

- **Drying fruits :-**
  Natural sun drying
  Drying with a food dehydrator
  Oven drying

- **Pasteurizing sun dried fruits :**

- **Conditioning dried fruits :**

- **Freezing :**

- **Use of ozone :**

Microbial Spoilage Of Fruits

SOME MICROBIAL DEFECTS OF FRUITS

Food	Defect	Organisms
Apples 	• Fermentation	• Torulopsis, Candida, Pichia
Bananas 	• Storage rot • Black rot • Crown rot	• Colletotrichum • Alternaria • Fusarium
Citrus fruits 	• Soft rot • Black rot	• Penicillium • Alternaria
Strawberries 	• Gray mold rot • Fermentation	• B. cinerea • Kloeckera

Microbial Spoilage Of Egg

BACTERIAL SPOILAGE OF EGGS

- Bacteria need to overcome the anti – bacterial properties of albumen to cause spoilage of eggs.
- Also, they use the protein complexes as a source of nitrogen for growth.
- Bacterial spoilage is called as rots. Three chief ones are **green rots, colorless rots** & **black rots**.
- The other two are **pink rots** & **red rots**.

GREEN ROTS

- Caused by *Pseudomonas fluorescens* (grows at 0´C).
- Egg white in early stages, becomes bright green in color during Later stages, yolk disintegrates & blends with white.
- Odour is lacking or is fruity or sweetish.
- Contents of egg fluoresce strongly under UV light.

Microbial Spoilage Of Egg

COLOURLESS ROTS

- Caused by *Pseudomonas, Acinetobacter, Alcaligens.*
- Detected by candling.
- Yolk in later stages, disintegrates or shows a white incrustation.
- Odour varies from a scarcely detectable to fruity to highly offensive.

BLACK ROTS

- Most commonly caused by a species of *Proteus*. *Pseudomonas & Aeromonas* can also cause this.
- *Proteus melanovogenes* causes black coloration yolk & dark colour in white.
- Caused when egg is stored at temp. higher than the ordinary.
- Gas pressure develops in the egg.
- Putrid odour (hydrogen sulfide is evident).

Microbial Spoilage Of Egg

PINK ROTS

• Less often; caused by strains of *Pseudomonas*.

• They resemble colorless rots ; except for the pinkish precipitate on the yolk & a pink colour in the egg white.

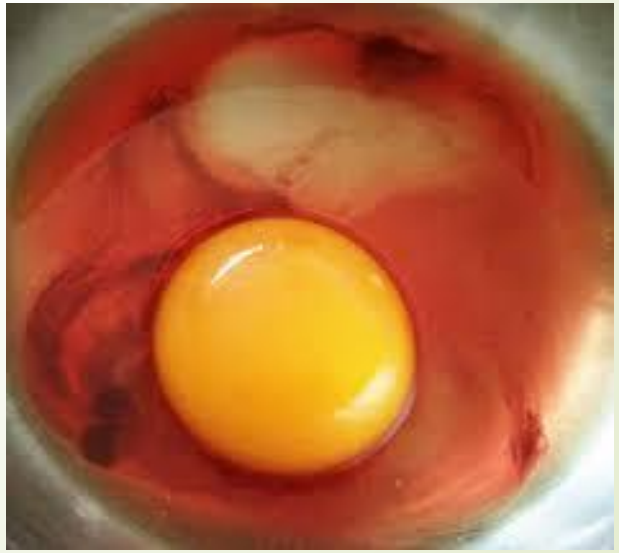
White mould or mildew growing on the shells

RED ROTS

• Most infrequently occurring one.

• Caused by a species of *Serratia*.

• Odour is mild & not offensive.



Microbial Spoilage Of Egg

FUNGAL SPOILAGE OF EGGS

There are two stages :
(1) Pin Spot Molding
(2) Fungal Rotting

Molds that cause spoilage of eggs include species of *Penicillium, Clodosporium, Sporotrichum, Mucor, Alternaria & Botrytis.*

Microbial Spoilage Of Egg

DEVELOPMENT OF OFF -FLAVOURS

- Mustiness may be caused in eggs by the bacteria sometimes.
- The growth of Streptomyces near the egg may produce earthy or musty flavors that are absorbed by the egg.
- A hay odour is caused by Enterobacter cloacae.
- Fishy flavors are produced by strains of E.coli.

METHODS OF PRESERVATION

- Use of heat
- Chilling
- Freezing
- Use of preservatives
- Use of irradiation

Spoilage of Canned Foods

Canning is a method of preserving food in which the food contents are processed and sealed in an airtight container.

Canning provides shelf life typically ranging from one to five years

STEPS OF CANNING

1. Packing the product into the container.
2. Hermetically sealing the container
3. Thermally processing for product and the container together.
4. Cooling
5. Storage.

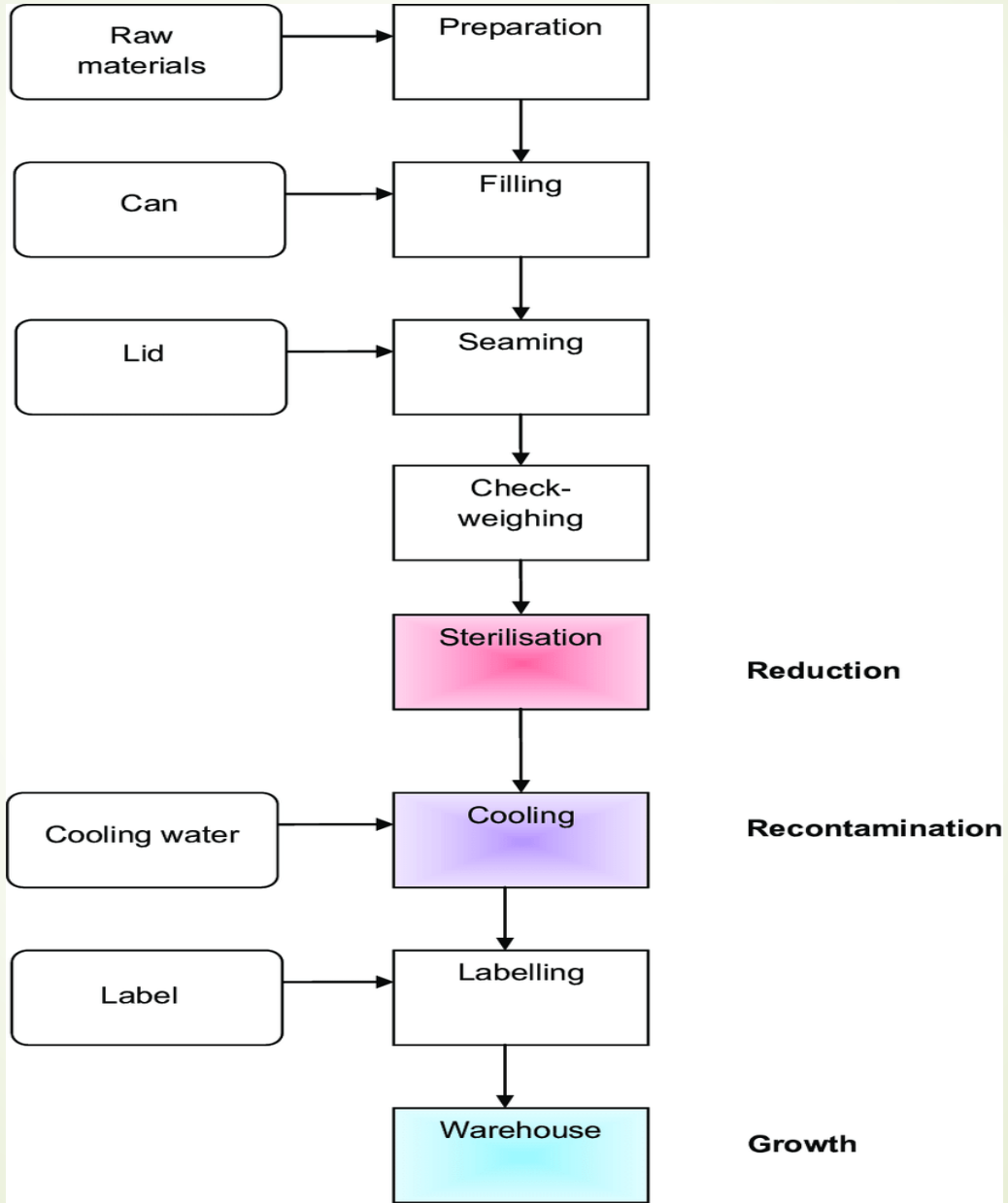
Spoilage of Canned Foods

- The canning process was started dates back to the late 18th century in France when the Emperor Napoleon Bonaparte concerned about keeping his armies fed.
- Nicholas Appert was the scientist who conceived the idea of preserving food in bottles like alcoholic beverages.
- He showed that food without preservative will not spoil if it is sufficiently heated and sealed in an airtight container.

Spoilage of Canned Foods

Spoilage of Canned Foods

SCHEMATIC DIAGRAM FOR PRODUCTION OF CANNED FOODS



Spoilage of Canned Foods

Disadvantages of Canning

High in Sugar :

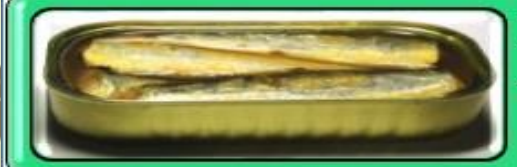
- The added sugar increases the calorie and carbohydrate count of the final product

High in Sodium:

- Salt helps preserve the food, but can elevate blood pressure

Contamination:

- Yeast, mold or bacterial spores such as Clostridium botulinum, a soil-dwelling bacterium that creates a neurotoxin-causing botulism that can lead to death.



Fewer Nutrients:

- Removing the peel of a fruit or vegetable reduces its fiber content. Since this is a common practice in canned foods, Vitamin C gets destroyed during the cooking and canning process.

Exposure to Bisphenol-A:

- Many cans are lined with bisphenol-A (BPA), despite the growing knowledge of this industrial chemical's toxic effects over recent years.

Exposure to Tin:

old or improperly stored canned food can contain tin which may cause gastrointestinal problems.

Spoilage of Canned Foods

THE STEPS IN CANNING

Packing the product into the container and then it is hermetically sealed. Hermetically sealed container is designed and intended to be secure against the entry of microorganisms. Thereafter sealing glass jars or metal cans is done.

THERMALLY PROCESSING THE PRODUCT AND THE CONTAINER TOGETHER.

- High-Acid foods (jams, jellies, sauerkraut, kimchi, pickles, fermented vegetables,) are processed at 100°C in water bath canner considering to kill botulism bacteria in boiling water. Sometimes, botulinum spores can survive boiling temperature and can be eliminated by using higher temperatures than boiling water. The higher acidity level of the ingredients and the heat treatment given during processing safely preserves the food.

- Low-Acid foods (such as meat, poultry, fish and vegetable) must be processed at 116 - 121°C in Pressure canning process.

Spoilage of Canned Foods

Cooling cans is immersed in cold water or let them to cool at room temperature from 12- 24 hours. As the temperature of the product drops, a vacuum forms inside and pulls down the lid. This is often accompanied by a popping sound and happens within minutes after removing the jar from the water bath canner. Canned product should be stored in a cool , dry, dark place and it should not be stored where temperature extremes exist. Canned product can be used within one year without any change in its quality.

Spoilage of Canned Foods

SPOILAGE OF CANNED FOOD

Spoilage of can observed due to the biological or chemical reasons or a combination of both. The biological spoilage is primarily due to microbial growth while chemical spoilage is due to hydrogen produced by the action of acids in food and iron present in can. Sometimes, swelling of canned products observed and it is mainly due to high summer temperature.

Hydrogen swell is due to production of hydrogen gas in can because of action of acid of food and iron of canned products specially in acidic foods (canned fruits) and it is not related to fermentation or bacterial spoilage. Canned products show varying degree of bulging and this problem is associated with Increase in storage temperature, higher acidity nature of food, presence of soluble sulphur and phosphorous compounds and internal surface lacquering of container.

Sulphiding (Sulphur stinker spoilage) - This type of spoilage occurs in low acid foods and causative organism involved in this is *Desulfotomaculum nigricans*. Spoilage cause discoloration inside the can showed pink to dark purple. Hydrogen sulphide formed as a result of breakdown of sulphur-containing proteins (liver, kidney) by organisms of clostridium group (*Cl. nigrificans* -sulphur stinker) with the odour resemble like rotted egg. Black discolouration observed because of H2S reaction with steel base of tin which produces iron sulphide and may lead to pitting.

Thermophilic anaerobic (TA) spoilage - This type of spoilage is caused by thermophilic anaerobes which are not able to produce hydrogen sulfide. *Clostridium thermosaccharolyticum* is the main organism involved and produces acid and gas in foods showed sour or cheesy smell in spoiled food.

Spoilage of Canned Foods

Chemical Spoilage

- Hydrogen swell
- Sulphiding
- Rust&damage

Biological Spoilage

- incipient
- leakage spoilage
- inadequate thermal
- Growth of thermophilic microorganisms
- Growth of acid-tolerant spore forming microorganisms

Spoilage of Canned Foods

Spoilage by Non-Spore Formers

Presence of non-spore formers in cans indicates post processing contamination. The organisms which are heat resistant are generally found. These organisms are more prominent:

Micrococcus

Lactobacillus

Enterococcus

Streptococcus thermophilus

Leuconostoc

Microbacterium

Presence of these organisms indicates leakage of container. Cooling water is one of the important source of contamination and coliforms may also gain entry into the can through these leakage and spoiled the canned product.

Spoilage of Canned Foods

Spoilage by Mesophillic Spore formers

Bacillus and Clostridium are involved in this type of spoilage

Characteristics of Mesophilic spore former spoilage in can

Spoilage type	Characteristic
Mesophilic *Clostridium* type	• Sugar fermenting species producing butyric acid involved e.g. *C. butyricum, C. pasteurinum* • Swelling of container due to CO_2 and Hydrogen • Putrefactive species such as *C. sporogenes, C. putrefaciens, C. botulinum* too play role • Decompose proteins and produce ammonia, indole, H_2S, skatole • Spoilage prevalent in foods processed at 100°C
Mesophilic *Bacillus* type	• *Bacillus* is most involved • Problem more prominent in poorly evacuated cans • Sea foods, meat, evaporated milk most affected • *B. polymyxa* and *B. macerans* involved • Entry of organism through leakage of cans

Spoilage of Canned Foods

NOTE

The disease is caused by *C. botulinum* are the major concern which is an anaerobic and rod shaped bacteria able to grow at low pH - 4.6 with a long temperature range of 20 to 45°C. It also produces botulinum enterotoxins that cause severe neuroparalytic condition known as botulism. The most common way of getting botulism is either by eating the contaminated foods or drinking the contaminated beverages. The patient may show blurred or double vision, vertigo, dry mouth, slurred speech, drooping eyelids, difficulty in swallowing and speaking, muscles weakness and the mortality rate is very high due to the respiratory and / or cardiac failure.

Spoilage of Canned Foods

Spoilage by Fungi

YEASTS

Yeasts and their spores are not thermo tolerant, so they are not found in properly heat treated cans. Their presence indicates faulty processing treatment or post processing contamination through leakage. Fermentative yeasts are more prominent and they often produce carbon dioxide and cause swelling of cans. Occasionally, film yeasts also showed growth on the surface of the canned food products.

MOLDS

Aspergilus and *Penicillium* are common molds found responsible in spoiling canned food. They can grow even at high sugar concentration level and acidification during processing or storage prevents the growth of these molds. Some molds are resistant to normal heat treatment applied during processing and it is generally found in home made canned foods where heating and sealing is not done under total aseptic conditions.

Spoilage of Bread

Bread is a food product that is universally accepted.

Its origin dates back to the Neolithic era and is still one of the most consumed and acceptable staple in all parts of the world.

Bread is a major product prepared using flours. Dough is prepared from flours which undergo fermentation for which desirable microorganisms must grow. If this fermentation exceeds the required limits, it causes souring. Excessive growth of proteolytic bacteria reduces the gas holding capacity which is otherwise required for dough rising. Spoilage of bread is usually of two types viz. **moldiness and ropiness**.

During bread making, it is baked at very high temperature, thereby there are less chances of survival of microorganisms. Thus the contamination usually occurs when cooling is done as well as during packing, handling and from the environment. The molds which are prevalent are *Rhizopus stolonifer* (referred as bread mold), *Penicillium expansum, Aspergillus niger*, *Mucor* and *Geotrichum* also develop.

Spoilage of Bread

Another type of spoilage of bread is chalky bread which is caused by growth of yeast like fungi *Endomycosis fibuligera* and *Trichosporon variable.* This spoilage is characterized by development of white chalk like spots.

An unusual spoilage of bread is Red or Bloody bread, which is due to the growth of bacteria *Serratia marcescens*. This organism produces brilliant red colour on starchy foods giving blood like appearance. *Neurospora* and *Geotrichum* may also be involved in imparting pigmentation during spoilage of bread.

Some spoilage of bread are summarized below:

1. Green spored mold- *Penicillium expansum*

- Bread mold- *Rhizopus stolonifer*.
- White cottony mycelium and black spots

2. Red bread mold- *Neurospora sitophila*

- Ropiness of home-made breads- *Bacillus subtilis (Bacillus mesentericus).*
- *Ropyness due to hydrolysis of flour protein by proteinase of the bacillus and capsulation of bacillus*

Spoilage of Bread

3. Chalky bread

- Chalky bread—chalk like white spots due to yeast like fungi ---
  -*Endomycopsis fibuligera* and *Trichonospora variable*.

Various molds involved in spoilage of bread include *Rhizopus, Mucor, Penicillium, Eurotium, Aspergillus* and *Monilia*

Yeast spoilage known as "Chalk mold" is caused by *Pichia butonii*.

Spoilage of Bread

BACTERIAL ROPE SPOILAGE

The chief causative organism is *Bacillus subtilis* or *B. licheniformis*. These are spore forming bacteria with their spores surviving baking temperatures. These spores can germinate into vegetative cells, once they get suitable conditions as heat treatment activates them. In ropiness, the hydrolysis of bread flour protein (gluten) takes place by proteinases. Starch is also hydrolysed by amylases, which encourage ropiness. The manifestation of ropiness is development of yellow to brown color and soft and sticky surface. It is also accompanied by odor.

Rope spoilage is a bread disease consisting in bacterial decomposition of the bread crumb. Spoilage organisms are heat-resistant spores of bacteria belonging to *Bacillus* genera, which survive the baking process. Members of the *Bacillus* genus that bring about bacterial spoilage of bread are known as rope. This is of major economic concern to the baking industry. Ropiness, which is the most important spoilage of bread after moldiness, occurs particularly in summer when the climatic conditions favor the growth of bacteria.

It is mainly caused by *Bacillus subtilis* but *Bacillus licheniformis, Bacillus megaterium* and *Bacillus cereus* have also been associated with ropy bread. Most important rope formers are *B. subtilis, B. licheniformis* and *B. mesentericus*, also known as *B. pumilus*.

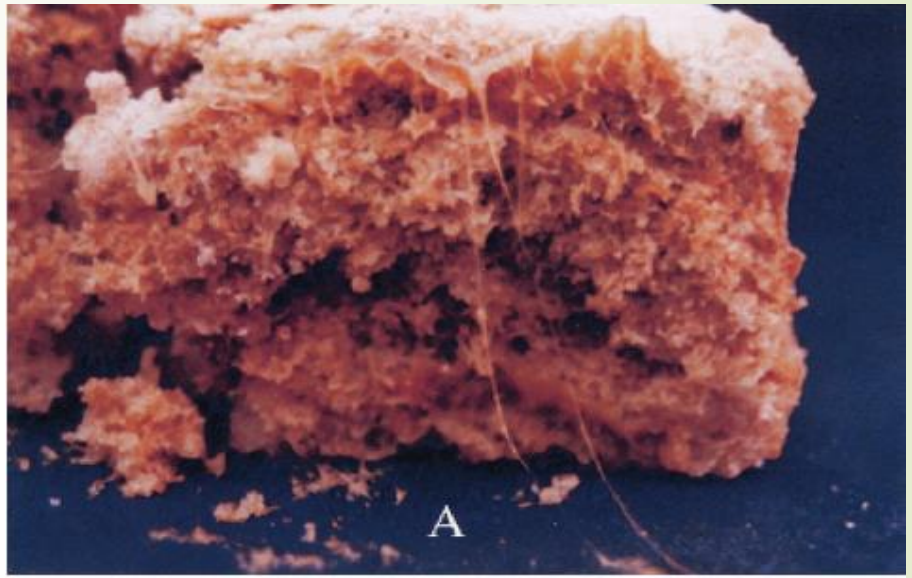
Spoilage of Bread

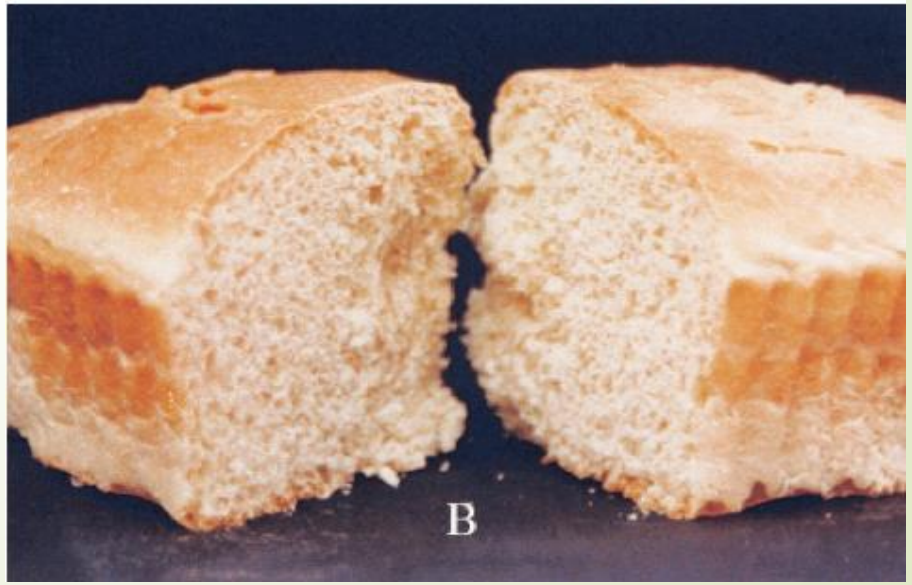
BACTERIAL ROPE SPOILAGE

Rope spoilage can first become noticeable 12–24 hr after the loaf has been removed from the oven and is characterized by a distinctive sweet, fruit odor which has been likened to that of rotting pineapple or rotting melons

Degradation of the breadcrumb is caused by the combined effects of microbial proteolytic and amylolytic enzymes breaking down the starch.

lts sticky nature is due to the slime, extracellular polysaccharides, formed by certain rope-inducing strains.





Spoilage of Bread

BACTERIAL ROPE SPOILAGE

Ropiness occurs in non-acidified breads and consists in breaking down bread components and leaving behind a sticky, pasty, stringy mass which has a fruity, melon type odor. Ropiness is referred to when the bread is pressed together and then pulled apart. If it is ropey then it will stretch into long, sticky, web-like strands. It is only visible for a short period of time; some strains do not even form ropes at all. The main characterization is therefore a fruity, melon-type odor. Discoloration of the crumb and a bitter taste may also be other symptoms. Packed wheat bread with a long shelf-life such as toast bread is highly susceptible.

Ropiness prevention can be done through chemical or biological methods. Rope forming bacteria are very sensitive to low pH values, therefore their growth is inhibited when chemicals are added to dough. The most efficient chemicals used in bread making are propionic acid, calcium propionate, acetic acid, and calcium hydrogen phosphate.

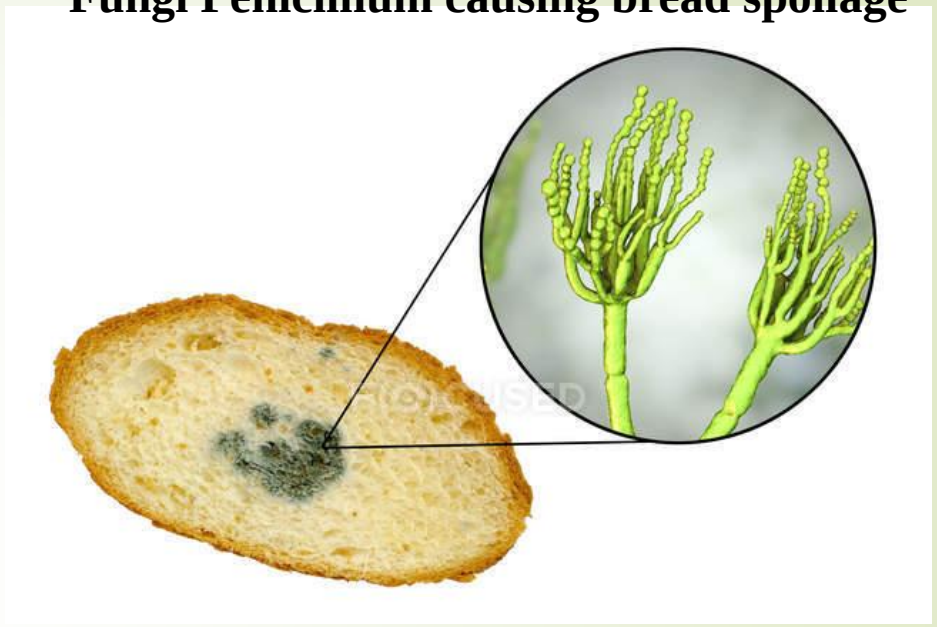
Spoilage of Bread

FUNGAL SPOILAGE

Mold spoilage in bread is a serious economic concern.
The most widespread and most important in bakery products are species of *Eurotium, Aspergillus* and *Penicillium.*
Other genera isolated from bakery products have included *Cladosporium, Mucor* and *Rhizopus*, but due to their high a_w requirement for germination and growth.

Eurotium species are usually the first fungi to colonize improperly dried, stored commodities, and when they grow, they increase the level of available water allowing other species (e.g., *Aspergillus* sp. And *Penicillium* sp.) to thrive. *Eurotium* sp. does not produce any significant mycotoxins, but it is important to know the conditions under which species of *Aspergillus* and *Penicillium* can grow and spoil the bakery products, because several species produce mycotoxins.

Fungi Penicillium causing bread spoilage



Aspergillus on bread crust

Spoilage of Bread

BREAD STALING

Bread Staling is a complex phenomenon that originates from multiple physico-chemical events (amylopectin retrogradation, water loss and redistribution and gluten-starch interactions and gluten transformations) that are not yet completely elucidated. (Curti, et al. 2011).

It is characterized by:

1. Loss of aroma
2. Changes in mouth feel
3. Development of crumbliness
4. Toughening of the crust
5. Firming of the crumb
6. Loss of moisture and flavour
7. Loss in product freshness

Reasons of bread staling:

1. Starch retrogradation
2. Water migration and redistribution
3. Protein-starch interaction
4. Gluten transformations

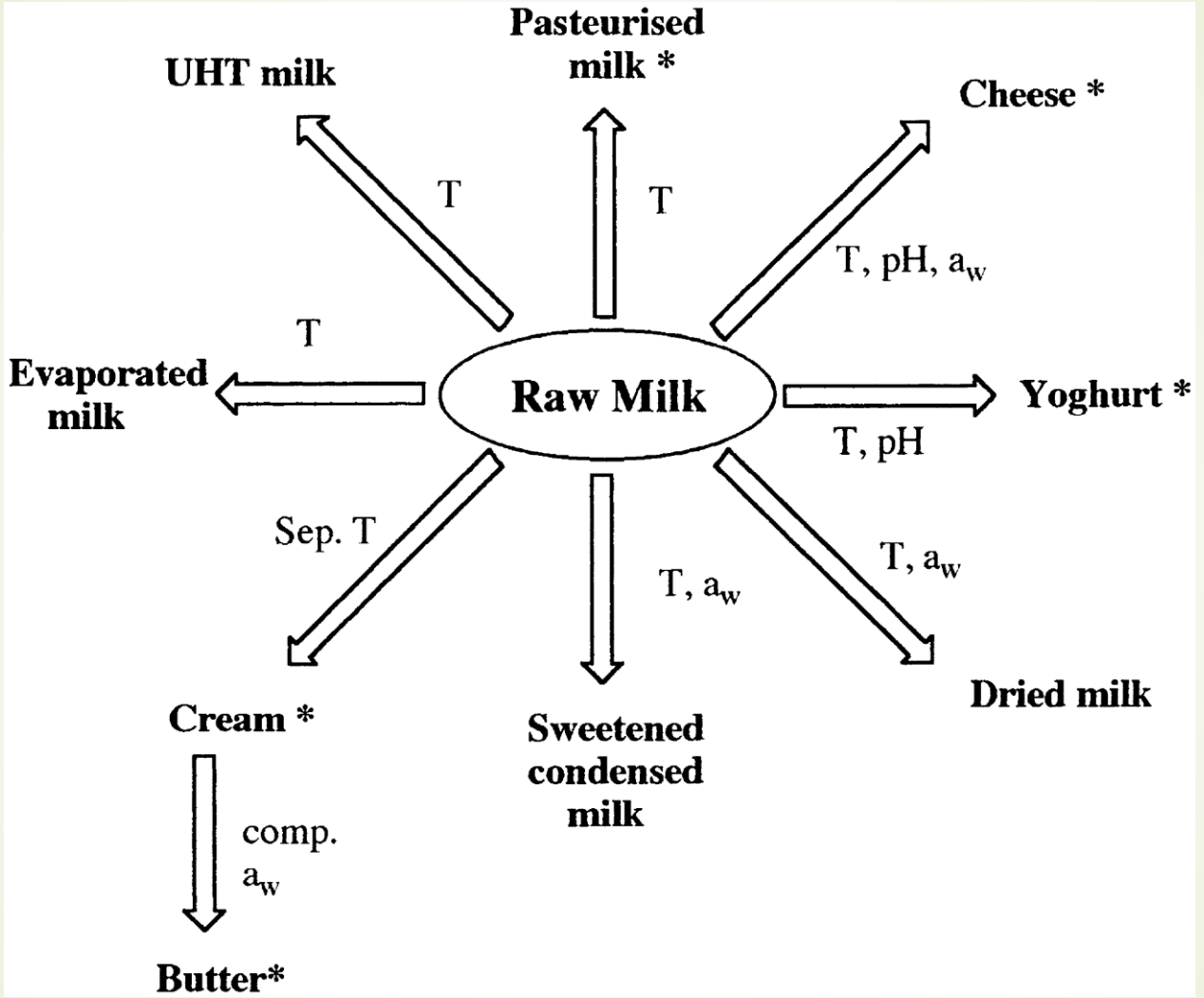
Spoilage of Milk

Spoilage of Milk and Milk Products
Book Editor(s): Osman Erkmen, T. Faruk Bozoglu
https://doi.org/10.1002/9781119237860.ch19

- Dairy processing involves pasteurization, commercial sterilization, fermentation, dehydration, refrigeration, and freezing. Spoilage of milk and milk products results from growth of fermentative bacteria when storage temperatures are sufficiently high for psychrotrophs. Heat-resistant proteinases of psychrotrophic bacteria cause spoilage in processed milk because of enzyme-retaining activity after the heat treatment. The most common fermentative spoilage of fluid milk products is souring caused by thermoduric lactic acid bacteria (LAB).
- Concentrated milk products can be divided into three groups: evaporated milk, sweetened or unsweetened condensed milk, and concentrated milk.
- Psychrotrophic bacteria have primary importance in cheese spoilage since these bacteria produce very active proteolytic and lipolytic enzymes.
- Centrifugation, clarification, or separation will remove some microorganisms from milk.

Spoilage of Milk

Adams &Moss



Milk and milk products. T indicates elevated temperature; pH, reduced pH; a_w, reduced a_w; sep., separation, comp., compartmentalization; and * stored at chill temperatures

Spoilage of Milk

Adams &Moss

Milk does possess a number of antimicrobial features.

Stimulation of lactoperoxidase activity through the addition of exogenous hydrogen peroxide has been investigated as a means of preserving raw milk in developing countries where ambient temperatures are high and refrigeration is not often available.

Three sources contribute to the micro-organisms found in milk:
1. The udder interior, 2. the teat exterior and its immediate surroundings, and 3. the milking and milk-handling equipment.

Aseptically taken milk from a healthy cow normally contains low numbers of organisms and milk drawn from some quarters may be sterile. The organisms most commonly isolated are micrococci, streptococci and the diptheroid *Corynebacterium bovis*.

Counts are frequently higher though due to mastitis, an inflammatory disease of the mammary tissue, which is a major cause of economic loss in the dairy industry.

Mastitis is also diagnosed by the presence of high numbers of polymorphonuclear leukocytes in infected milk.

Spoilage of Milk

Adams &Moss

Many organisms can cause mastitis, the most important being *Staphylococcus aureus, Escherichia coli, Streptococcus agalactiae, Strep. dysgalactiae, Strep. uberis, Pseudomonas aeruginosa and Corynebacterium pyogenes*

Several of these are potential human pathogens such as *Salmonella, Listeria monocytogenes, Mycobacterium bovis and Mycobacterium tuberculosis* are also occasionally reported.

Clostridia such as *C. butyricum* and *C. tyrobutyricum* can get into milk from silage fed to cows and their growth can cause the problem known as late blowing in some cheeses.

Milk-handling equipment such as teat cups, pipework, milk holders and storage tanks, is the principal source of the micro-organisms found in raw milk.

There are many psychrotrophic species, but those most commonly found in raw milk include Gram-negative rods of the genera *Pseudomonas, Acinetobacter, Alcaligenes, Flavobacterium*, psychrotrophic coliforms, predominantly *Aerobacter spp.*, and Gram-positive *Bacillus spp.*

Gram-negative psychrotrophs will not survive pasteurization, although some pseudomonads produce extracellular lipases and proteases which are heat resistant.

Spoilage of Milk

Microbial spoilage of milk and milk products
August 28, 2020; Gaurab Karki;
Food Microbiology

- Milk is an excellent culture media for growth of many microorganisms.
- Therefore, different types of microorganisms grow in it and cause spoilage.

Souring:

- Evidence of souring of milk are sour flavor and then coagulation of milk to form solid like curd.
- Many lactic acid bacteria, coliform and other bacteria ferment sugar of milk and produce acid.
- At temperature of 10-37°C, *Streptococcus lactis* is most likely to cause souring with possible growth of *Coliform, Enterococci, Lactobacillus* and *Micrococcus.*
- At higher temperature, 37-50°C, *Streptococcus thermophilus* and *Streptococcus faecalis* may produce 1% acid and it may be followed by *Lactobacillus* which produces more acid.
- Little souring occurs in milk held at refrigeration temperature.
- Pasteurization of milk kills more active acid forming bacteria but permit survival of thermoduric lactic acid bacteria such as *Enterococcus, Streptococcus thermophilus, Lactobacillus*, etc.
- Bacteria other than lactic acid bacteria produce acid specially if conditions are unfavorable for lactic acid bacteria.
- For example: *coliform* produce acetic acid, formic acid, ethanol, CO_2, H_2 etc.
- Similarly, *Clostridium* produce butyric acid.

Spoilage of Milk

Microbial spoilage of milk and milk products
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Gas production (Strong fermentation of milk):

- Sugar fermenting organism produce gas together with acid.
- Main gas formers, *Coliform, Clostridium, Heterofermentative lactic, Propianics bacillus,* etc.
- *Coliform, Clostridium,* and *Bacillus* produce both H_2 and CO_2, while others produce only CO_2.
- Gas production in milk is evidenced by foam at top of liquid milk by gas bubble trapped in curd, by formation of curd.
- Excessive gas production causes cracking or breakdown of curd causing so called stormy fermentation of milk.
- *Clostridium perfringens* mainly causes stormy fermentation.

Proteolysis:

- Proteolysis is facilitated by storage at lower temperature by destruction of lactic acid bacteria or by distribution of already produced acid by mold and yeast.

Changed cause by proteolytic organism include:

- Acid proteolysis in which acid production and proteolysis occur simultaneously.
- Proteolysis with little acidity or even alkalinity.
- Sweet curdling which is caused by renin like enzyme of microorganisms.
- Slow proteolysis by intracellular enzyme of bacteria after their autolysis.
- Residual proteolytic activity of some heat stable proteinase.
- Acid proteolysis is caused by *Micrococcus , Streptococcus faecalis var liquefaciens* and some lactose fermenting proteolytic *Bacillus* species.
- Sweet curdling is caused by *Bacillus cereus.*

Spoilage of Milk

Microbial spoilage of milk and milk products
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Ropiness/ sliminess:

- Ropiness of milk occur both by bacterial and non-bacterial causes non-bacterial ropiness occurs due to thickness of cream or due to film of cousin or Lactalbumin during cooling.
- Bacterial ropiness is caused by slimy capsular material of bacteria which usually develop at low storage temperature.
- Bacteria producing ropiness in milk are *Alcaligenes viscolactis, micrococcus freudenreichii, Enterobacter aerogenes, Klebsiella oxytoca, E. coli.*

Change in milk fat:

- Various bacteria, yeast and mold hydrolyses fat of milk and cause rancidity.
- Species of *Proteus, Pseudomonas fragi, Staphylococcus, Bacillus, Micrococcus, Clostridium,* etc. are lipolytic.
- *Pseudomonas fragi* and *Staphylococcus aureus* produce fairly heat resistant lipase.

Alkali production:

- *Pseudomonas fluorescence* and *Alcaligene viscolactis* produce alkali.
- Alkali production is due to formation of ammonia from urea and formation of carbonate from organic acid.

Spoilage of Milk

Microbial spoilage of milk and milk products
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Flavor defect:

- **Acid flavor:** Acid flavor may be aromatic or sharp. Sharp flavor is caused by production of acetic acid formic acid, butyric acid etc. by *Coliform* and *Clostridium.* It is undesirable. Aromatic flavor is caused by *Streptococcus lactic* and *Leuconostoc* when they grow together. It is desirable.
- **Caramel or burnt flavor:** It is caused by *Streptococcus lactic var. maltigens.*
- **Bitter flavor**: It is caused by proteolytic organism.
- **Other flavor**: They include earthy flavor by *Actinomycetes*, fruity flavor by *Pseudomonas fragi*, soapiness by *Pseudomonas sapolactic* etc.

Color defect:

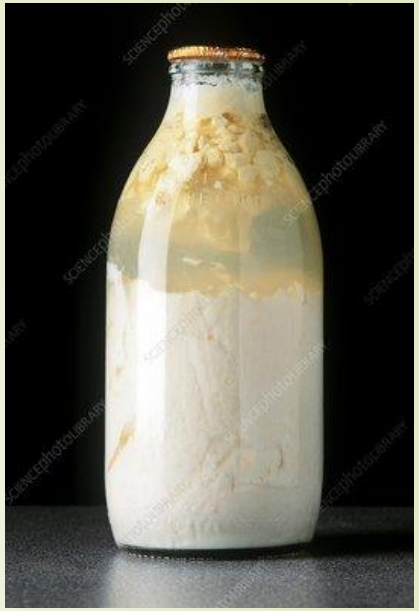
- Growth of pigmented bacteria and other organism give undesirable color. Some examples include:
- **Blue milk**: It is caused by *Pseudomonas syncyaneum*
- **Yellow milk**: caused by *Pseudomonas synxantha* and also by flavobacterium.
- **Red milk**: caused by *Serratia marcescencs* and *Micrococcus roseus.*
- **Brown milk**: caused by *Pseudomonas putrefaciens* and by enzymatic oxidation of tyrosin by *Pseudomonas fluorescence.*

Spoilage of Milk

Mold Spoilage

Rotten milk

Ropiness of milk



Curdled milk

Bacterial Spoilage

Sour Milk

Spoiled Milk


THANK YOU