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# Overview of food spoilage, microbial spoilage, sources of contamination, control of spoilage of fruits, fruit juices and vegetables





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# Overview of Food Spoilage...

- Spoilage of food can be defined as any visible or invisible change which can make food/product unacceptable for human consumption.
- Spoilage of food causes health hazard to consumers and large economic losses.
- Spoilage leads to loss of nutrients as well as causes change in original flavor and texture.
- Complex phenomena whereby; combination of microbial and biochemical activities take place.



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# TYPES OF FOODS ON THE BASIS OF SPOILAGE

**Perishable Foods:** Foods that are readily spoilt and require special preservation and storage conditions. e.g., milk, fruits, vegetables, fish

**Semi-perishable Foods:** This class of foods if properly stored can be used for a long duration e.g., potatoes

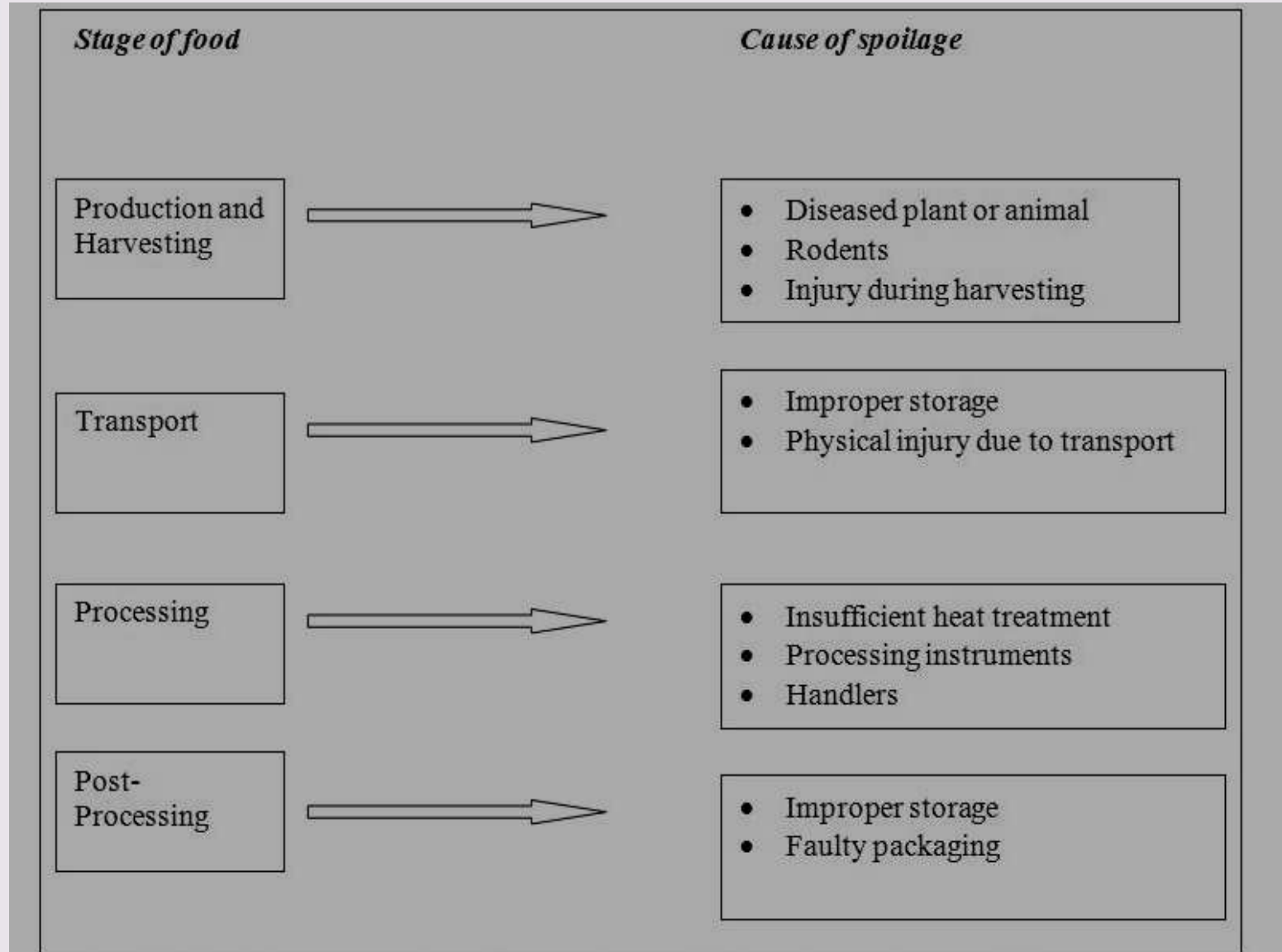
**Non-perishable Foods:** These foods remain in good form for long duration unless handled improperly. e.g., sugar, flour



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# Microbial contamination at stages of food production





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# Microorganisms in Food



Bacteria are round; rod/spiral shaped microorganisms and can grow under wide variety of conditions.

Food spoiling bacteria divided two groups: spore-forming and non-spore-forming.

Generally grow in low acid foods (vegetables and meat).



Yeasts growth causes fermentation which is result of yeast metabolism.

Two types : true yeast and false yeast. True yeast metabolizes sugar producing alcohol and carbon dioxide gas (fermentation). False yeast grows as dry film on pickle brine. Occurs in foods that have high sugar /high acid environment.



Molds grow in filaments forming tough mass which is visible as 'mold growth'.

Form spores which, when dry, float through air to find suitable conditions where they can start the growth cycle again.

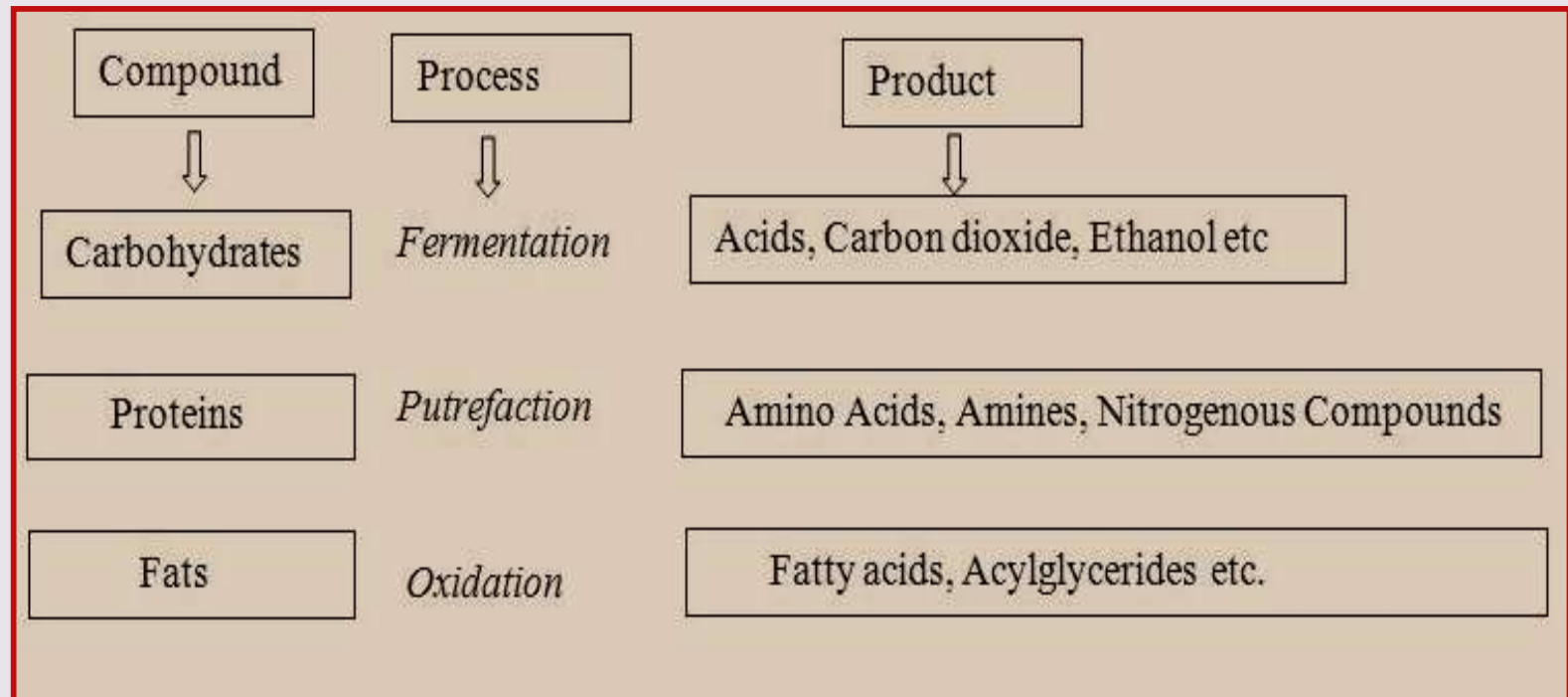
Mold can cause illness, especially if person is allergic to molds. Eating moldy food will cause nausea or vomiting.



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# Changes in foods due to microorganisms

**As microorganisms grow in food, they utilize components of foods and convert them into variety of chemical compounds.**





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## Changes in Carbohydrates:

1. Carbohydrates are used to obtain energy.
2. Besides monosaccharides, microorganisms have ability to convert polysaccharides to simpler forms before obtaining energy.
3. Utilization of glucose vary under aerobic and anaerobic conditions.
4. In aerobic conditions, it is converted into carbon dioxide and water through glycolysis and other related pathways.
5. In absence of oxygen, process yields a number of compounds (fermentation).



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### Alcoholic fermentation

- Occurs due to yeasts and carbon dioxide and ethanol are major end products

### Lactic fermentation

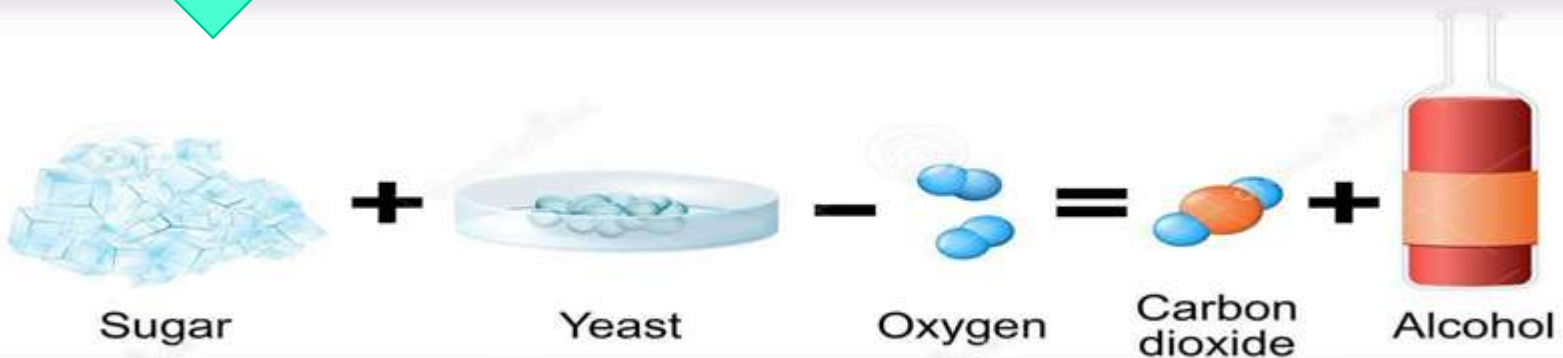
- Homolactic fermentation: lactic acid is the end product.
- Heterolactic fermentation: lactic acid, acetic acid, ethanol, glycerol, carbon dioxide are produced

### Coliform type fermentation

- Occurs in coliform bacteria.
- In this process lactic, acetic, formic, ethanol, glycerol are produced

### Propionic fermentation

- Occurs in propionic bacteria and in it along with propionic acid, succinic acid and carbon dioxide are produced







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## Changes in Nitrogenous compounds:

- 1. Proteins are major source of nitrogenous compounds in foods.**
- 2. Degradation of proteins, include hydrolysis by enzymatic reactions.**
- 3. Source of enzymes can be either of microbes or foods own enzymes.**
- 4. Proteinases are involved in conversion of proteins into polypeptide and peptidases are involved in catalyzing conversion of polypeptides to amino acids.**
- 5. Decomposition of proteins can be aerobic/anaerobic.**
- 6. Anaerobic decomposition of proteins results in obnoxious odors known as putrefaction.**
- 7. Microbial activity on amino acids cause either deamination (removal of amine group) or decarboxylation (removal of carboxyl group).**
- 8. Involved organisms include *Pseudomonas*, *E. coli*, *Clostridium*, *Desulfotomaculum*.**



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## Changes in Lipids:

- 1. Hydrolysis of lipids is accomplished by lipase enzymes produced by different microbes.**
- 2. Major end products include glycerol and fatty acids, which are further used by microorganisms for metabolism (oxidation).**
- 3. Oxidation of fats is also done by enzymes of food itself.**
- 4. High fat containing foods are prone to such processes.**



# Public Health Aspects

1. *Shigella* spp., *Yersinia* spp., *L. monocytogenes*, *Campylobacter* spp., EHEC O157:H7; *Salmonella typhimurium*, *Salmonella enteritidis* and *Mycobacterium paratuberculosis*.
2. Mycotoxins are secondary, low mol. wt, thermo-stable highly toxic, fungal metabolites formed due to growth of some strains of *Penicillium*, *Aspergillus* and some other molds.
3. Food borne disease resulting from ingestion of toxin in mold contaminated food (mycotoxicosis). Affect kidney, liver, skin irritation, birth defect and death. Carcinogenic in nature.



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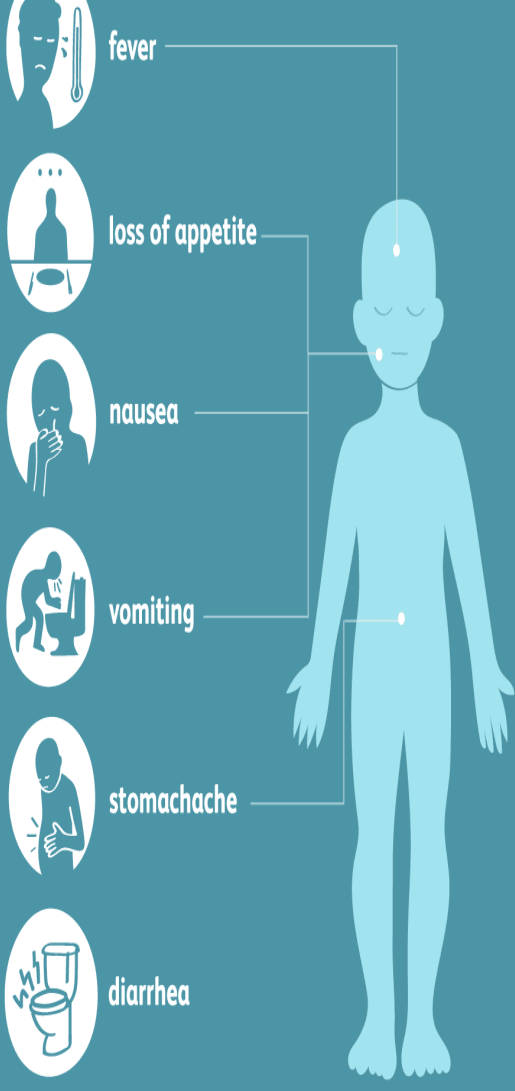
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- ❖ Aflatoxins are produced by some strains of *Aspergillus flavus* and *A. parasiticus* and occur in different chemical forms like B1, B2, G1 and G2.
- ❖ Aflatoxin M1 and M2 are hydroxylated derivatives of B1 and B2.
- ❖ Milch animals fed with aflatoxin B1 and B2, excrete aflatoxin M1 and M2 (both less toxic) in milk, urine and feces.
- ❖ Aflatoxin B1 is most toxic among all aflatoxins.
- ❖ Aflatoxins found in nuts, spices and figs and produced under hot and humid conditions during storage.

Sr. No.	Mycotoxins	Organism
1	Aflatoxins	<i>A. flavus</i> <i>A. parasiticus</i>
2	Ochra toxin	<i>Aspergillus ochraceus</i> <i>Pencillium spp.</i>
3	Tricothecenes	<i>Fucarium, Tricoderma,</i> <i>Tricothecium</i>
4	Patulin	<i>P. expansum,</i> <i>P. patulum</i>
5	Pencillic acid	<i>P. puberulum, P. cyclopium</i> <i>Aspergillus ochraceus</i>
6	Citrinin	<i>P. citrinum</i> <i>P. viridicatum</i>

# Viruses in Foods

1. Viruses are obligate intracellular parasites.
2. Host specific.
3. Implicated in food borne outbreaks.
4. Four acute gastro enteritis: calici virus, rota virus, astro virus and adeno virus.
5. Infectious hepatitis A virus enters person through contaminated food/water and it causes gastro enteritis.
6. Viruses responsible for poultry diseases have also been implicated in human aliments.





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# Microbial Spoilage of Fruits

- 1. Fruits are natural sources of minerals, vitamins, carbohydrates and other essential substances. Naturally, they contain high amount of water thereby, making them highly prone to attack by microorganisms.**
- 2. Contaminated through soil, water, diseased plant, harvesting and processing equipments, handlers, packaging material, contact with spoiled fruits and they play significant role in spoilage.**
- 3. Fungi are most dominating organisms because of their ability to grow under acidic conditions.**





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- 4. Fruits contain different organic acids in varying amounts.**
- 5. Low pH of fruits restricts the proliferation of various types of organisms.**
- 6. Fungi are most dominating organisms to grow on fruits because of the ability of yeasts and molds to grow under acidic conditions.**
- 7. Aciduric bacteria (ability to resist acidic conditions) also grow.**
- 8. Dry conditions prevailing on skin and surface as well as certain antimicrobial components do not allow growth of certain microorganisms.**





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# Yeasts

- **32 genera are associated with fruits and fruit products (few are pathogenic for man and other animals).**
- **Fruit damaged by birds, insects or pathogenic fungi usually contain very high yeast populations.**
- **Yeasts are introduced into exposed tissue, often via insects, and are able to use sugars and other nutrients to support their growth.**
- ***Saccharomyces, Candida, Torulopsis* and *Hansenula* are associated with fermentation of apples, strawberries, citrus fruits, and dates.**
- **Carbon dioxide and ethanol are predominant metabolic products of yeasts. Glycerol, acetaldehyde, pyruvic acid, and  $\alpha$ -ketoglutaric acid are also formed.**
- **Though yeasts produce hydrolytic enzymes which degrade pectins, starch and certain proteins, enzymatic activity is much less than exhibited by other aciduric microorganisms and molds.**





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# Molds

- **Being aerobic, many are very efficient scavengers of oxygen. Due to this, processed fruits including those hermetically sealed in cans or glass, are susceptible to spoilage.**
- **Some of molds are xerophilic, thereby having potential to spoil foods of low water activity (dried fruits and fruit juice concentrates).**
- **Some of the species have heat resistant spores such as ascospores that survive commercial pasteurization treatments given to most fruit products.**
- **Growth of molds on processing equipment such as wooden tanks can result in the generation of off-flavors in wines, juices, and other fruit products.**
- **Mold-infected raw fruit may become soft after processing because pectinases were not inactivated by the thermal treatment.**



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- Fresh fruits are susceptible to rot by *Penicillium*, *Aspergillus*, *Alternaria*, *Botrytis*, *Rhizopus* and others and designated as black rot, gray rot, soft rot, brown rot.
- *Penicillium italicum* (blue mold) and *P. digitatum* (green mold) seen in oranges, lemons and citrus fruits.
- *R. stolonifer* cause soft and mushy food, cottony growth of mold.
- Watery soft rot occurs on lower part of heads. The tissue is water soaked and light or pinkish brown. A white, cottony mold spreads over decayed tissue, and head eventually becomes watery mass.



1: Green and blue mold by *Penicillium* growth on oranges and lemons 2. Soft rot of apples- *Penicillium expansum*



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# Bacteria

- **Lactic acid bacteria:** Growth of LAB in juices and other fruit products cause formation of haze, gas, acid and number of other changes. Certain heterofermentative lactobacilli lead to slime in cider. Lactobacilli and leuconostocs that are present in citrus juices generate acetylmethylcarbinol and diacetyl compounds that give juices an undesirable, buttermilk-like flavor.
- Have ability to decarboxylate malic acid to lactic acid. This malolactic fermentation is often desirable in high-acid wines because acidity is reduced and desirable flavors are produced.

**Some pathogens (acid-tolerant *Salmonella* spp. and *E. coli* O157:H7 strains in unpasteurized orange juice and apple cider) can remain viable for long time (30 d) in acid products.**



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- **Acetic acid bacteria:** Oxidize ethanol to acetic acid under acidic condition. *Acetobacter* species can oxidize acetic acid to CO<sub>2</sub>. Being obligate aerobes, juices, wines and cider are most susceptible to spoilage while held in tanks prior to bottling. Some strains of *Acetobacter pasteurianus* and *Gluconobacter oxydans* produce microfibrils composed of cellulose, which leads to formation of flocs in different fruit juice beverages.
- **Spore formers:** *Bacillus coagulans*, *B. subtilis*, *B. macerans*, *B. pumilis*, *B. sphaericus* and *B. pantothenicus* grow in different types of wines. Some of these organisms are involved in canned fruits. Spore-forming bacilli that prefer low pH are responsible for spoilage of apple juice and a blend of fruit juices.



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# Spoilage of Fruit Products

<b>Spoilage organisms</b>	<b>Products</b>
<i>Alicyclobacillus</i>	Heat-treated fruit juices
<i>Aspergillus ochraceus</i> , <i>Aspergillus flavus</i> , <i>Byssochlamys fulva</i> , <i>Penicillium notatum</i> , <i>Penicillium roquefortii</i>	Fruit juices and soft drinks
<i>Pichia</i> , <i>Candida</i> , <i>Saccharomyces</i> and <i>Rhodotorula</i>	Soft juices
Patulin (mycotoxin)	Apple juice



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# Spoilage of Vegetables

1. Fresh vegetables (rich in carbohydrates (5% or more), low in proteins (1-2%)) contain microorganisms coming from environmental sources, and can include some plant pathogens.
2. Grow more rapidly in damaged or cut vegetables.
3. Presence of air, high humidity, and higher temperature during storage increases the chances of spoilage.
4. Common spoilage is caused by *Penicillium*, *Phytophthora*, *Alternaria*, *Botrytis*, and *Aspergillus*, *Pseudomonas*, *Erwinia*, *Bacillus* and *Clostridium*.





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<b>Bacteria</b>	<b>Fungi</b>
Alcaligens	Alternaria
Bacillus	Aureobasidium
Erwinia	Botrytis
Micrococci	Fusarium
Pseudomonas	Penicillin
Lactic acid bacteria	Rhizopus
Xanthonomas	

**Normal microflora of vegetables**



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**Spoilage due to pathogens:  
The plant pathogens which  
infect stem, leaves, roots,  
flowers and other parts or  
the fruit itself**

**Spoilage due to saprophytes:  
Vegetables have general  
microflora inhabiting them.  
These organisms under  
certain conditions grow on  
these vegetables and spoil  
them**

**Most of the spoilage causing pathogens in  
vegetables are fungi. The fungi produce  
characteristic pigmented spores which helps in  
identification of the type of spoilage by fungi.**





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Type of Spoilage	Causative organisms	Symptoms
Bacterial soft rot	<i>Erwinia carotovora</i> <i>Pseudomonas marginalis</i> <i>Clostridium</i>	Water soaked appearance, soft-mushy, bad odor
Alternaria rot	<i>Alternaria tenuis</i>	Greenish brown to black brown spots
Rhizopus soft rot	<i>Rhizopus sp</i>	Cottony mold growth with small black dots
Blue mold rot	<i>Penicillium digitatum</i>	Bluish green color
Downy mildew	<i>Phytophthora, Bremia</i>	White woolly mass
Black mold rot	<i>Aspergillus niger</i>	Brown to black mass, referred as smut
Fusarium rot	<i>Fusarium</i>	

**Spoilage in vegetables is largely affected by composition of vegetable. The non-acidic foods are thus spoiled by bacterial rot while acidic foods with dry surfaces are more prone to mold spoilage**



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- **Bacterial Soft Rot: Breaks down pectin, giving rise to a soft, mushy consistency, sometimes a bad odour and water-soaked appearance. Vegetables affected- onions, garlic, beans, carrot, beets, lettuce, spinach, potatoes, cabbage, cauliflower, radishes, tomatoes, cucumbers, watermelons.**
- **Caused by *Erwinia carotovora*, *Pseudomonas marginalis*, *Bacillus*, *Clostridium* spp.**



. Black rot of cabbage and cauliflower- *Xanthomonas campestris*

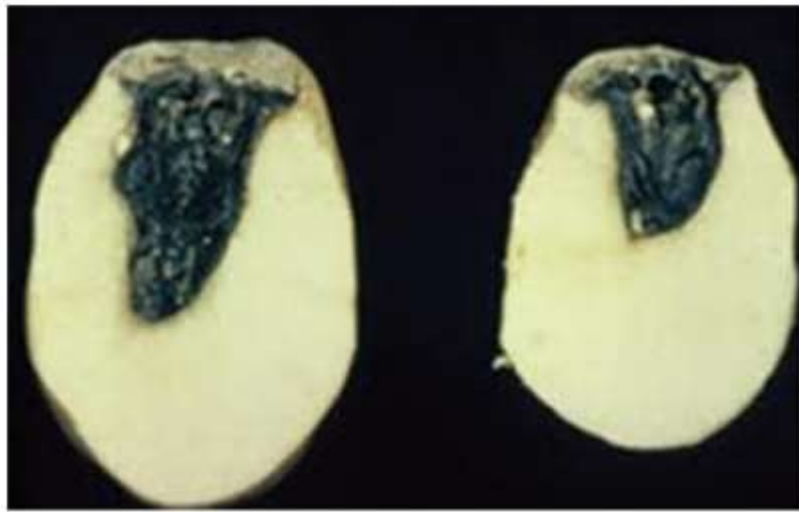


Bacterial soft rot in Tomato



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**Black leg of potatoes- *Erwinia carotovora* var. *atroseptica***



**Sliminess/souring**



**Slime of lettuce- *Pseudomonas marginalis***



**Bacterial wilt of beans- *Corynebacterium flaccumfaciens***



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➤ Fungal spoilage of vegetables: *Penicillium*, *Cladosporium*, *Rhizopus*, *Aspergillus* spp. are responsible for various defects in vegetables. Gray mold rot caused by *Botrytis cinerea* in vegetables is favoured by high humidity and warm temperature.



**Black mold rot – *Aspergillus niger*, dark brown to black masses**



**Fusarium Rot – *Fusarium* spp.**



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**Gray mold rot in peas and Tomato**



**Pink mold Rot – *Trichothecium roseum***



**Green Mold Rot – *Cladosporium* and *Trichoderma***



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Examples of Commodities Most Affected	Genus	Type of Spoilage
Most vegetables especially carrot, lettuce, celery, cabbage	<i>Botrytis</i>	Grey mould rot
Most vegetables. Especially carrot, lettuce, legumes, <i>Brassica</i> spp.	<i>Sclerotinia</i>	Watery soft rot
Legumes, carrot, <i>Brassica</i> spp.	<i>Rhizopus</i>	Soft rot
Tomato, cucumber, asparagus, potato	<i>Fusarium</i>	Dry rots
Tomato, potato, carrot	<i>Phytophthora</i>	Brown rots (blight)
Tomato, potato, beetroot Cucumber, legumes	<i>Phoma</i> <i>Pythium</i>	Dry brown, black rots Cottony leak

**Vegetable juices can have molds, yeasts, and lactic acid bacteria along with *B. coagulans*, *C. butyricum*, and *C. pasteurianum*.**

