



THE UNIVERSITY OF
MELBOURNE

FOOD20006

Food Microbiology & Safety

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Sources of microorganisms in food_Plants

Ray and Bhunia Chapter 3

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Intended learning outcomes

Differentiate between normal flora in plant and animal derived foods, contaminants, spoilage organisms, pathogens and functional organisms

Relate the intrinsic and extrinsic factors of food substances to how microorganism can grow and survive

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Plants

There are many types of plants products and the intrinsic factors are specific for each type . As a general guide they are higher in carbohydrates and lower in lipids than meat.

Eh, Aw and pH vary for each type

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CDC



PLANTS- natural microflora

Plants grown for food will have natural microbial flora

Some plant associated microbes are plant pathogens –some fungi, bacteria or viruses

Some are spoilage organisms

Some are contaminants

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pH values of some fruits and vegetables

Fruits	pH	Vegetables	pH
Apples	2.9 - 3.3	Asparagus	5.4 - 5.8
Apricots	3.3 - 4.4	Broccoli	5.2 - 6.5
Bananas	4.5 - 5.2	Cabbage	5.2 - 6.3
Cherries	3.2 - 4.7	Carrots	4.9 - 6.3
Grapefruit	3.0	Cauliflower	6.0 - 6.7
Grapes	3.4 - 4.5	Celery	5.6 - 6.0
Limes	2.0 - 2.4	Lettuce	6.0 - 6.4
Melons	6.2 - 6.7	Parsnip	5.3
Oranges	3.3 - 4.3	Rhubarb	3.1 - 3.4
Pears	3.4 - 4.7	Runner beans	4.6
Plums	2.8 - 4.6	Spinach	5.1 - 6.8
Raspberries	2.9 - 3.5	Sweet potato	5.3 - 5.6
Tomatoes	3.4 - 4.9	Turnips	5.2 - 5.6

Natural protection

Plants have mechanisms to prevent microbial invasion of their tissues.

- **phenolic** metabolites with antimicrobial activity
- **phytoalexins**, metabolites produced by plants in response to microbial attack i.e allicin (onions), phaseollin (beans)

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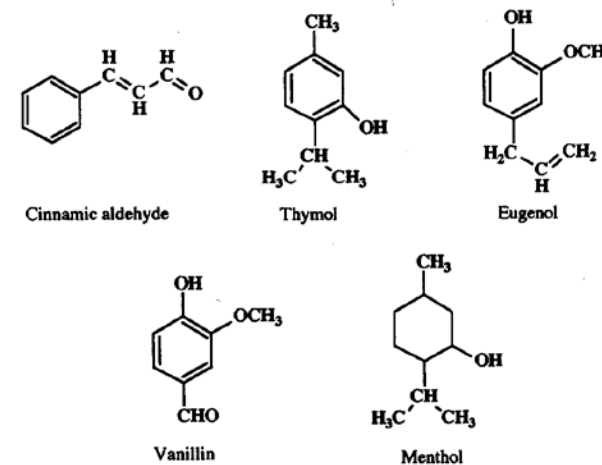


Figure 3.4 Essential oil components with antimicrobial activity

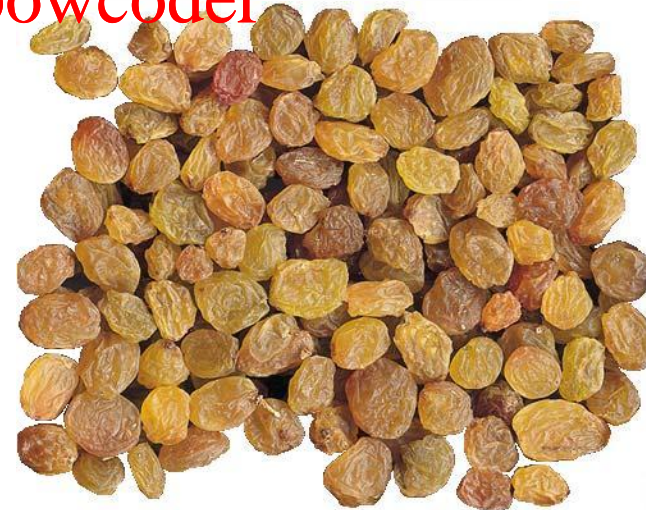
Physical factors affecting spoilage: A_w

Another physical factor influencing the pattern of spoilage is the availability of **water**.

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Physical factors affecting spoilage: Aw

Another physical factor influencing the pattern of spoilage is the availability of **water**.

Concentration reduces water activity to $a_w=0.8-0.83$

Keep frozen -9°C

Concentrated citrus juice

Minimally processed, no heat treatment

Spoilage by *Candida* and *Saccharomyces* (yeasts)

Spoilage by *Lactobacillus* and *Leuconostoc*

produces buttery flavour (diacetyl)

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Water activity of some foods of plant origin

Foods	Water activity
Fresh and raw fruit and vegetable	0.98 <
Fresh Bread	0.95 - 0.98
Flour, rice, bean, peas	0.80 - 0.87
Jam, marmalades	0.75 - 0.80
stewed fruits	0.60 - 0.65
Pastes, spices	0.20 - 0.60

Cereals

Cereals are rich in carbohydrates

They are susceptible to fungi

Field fungi

- Form on maturing plant
- Need fairly high water activities for optimal growth
- Can cause spoilage after harvest at higher aw

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*Fusarium blight in
wheat heads*

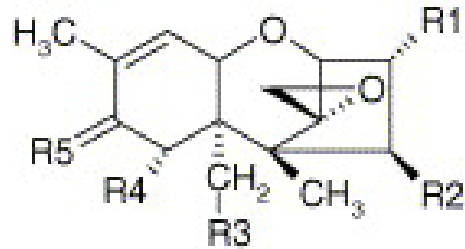
Fusarium mycotoxins

Some fungi produce toxins which are harmful
mycotoxins

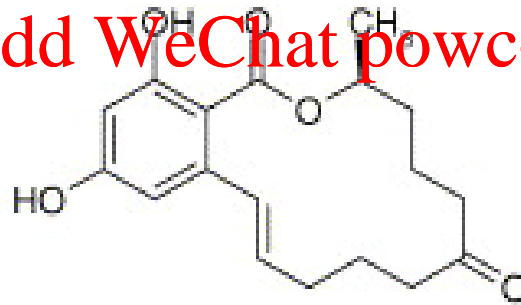
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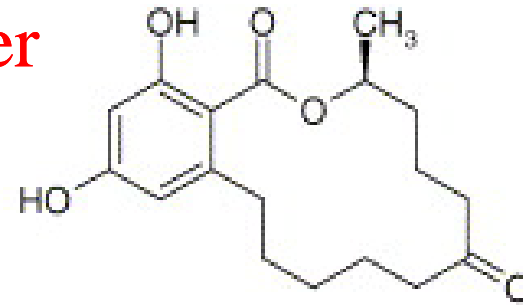
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Trichothecene



Zearalenone (MW=318)



Zearalanone (IS) (MW=320)

Cereals

Storage fungi are adapted to grow at the lower water activities that are usually used to store grain important genera ***Penicillium*** and ***Aspergillus***

Infection of grains by *Claviceps purpurea* causes ergotism

The fungus produces hallucinogenic alkaloids which can cause altered behaviour, abortion or death if eaten

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Yellow-green powdery growth of *Aspergillus flavus* on a corn rootworm-damaged ear. (Alison Robertson)





Aflatoxins

Fungus derived carcinogens include aflatoxins and fumonisins

Aflatoxins

Discovered in 1960s-turkey X disease caused by fungus infected peanut meal

Aflatoxins intercalate with the cells nucleic acids and causes mutations

Occurs primarily in the liver where the toxins are converted to unstable derivatives

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If cattle ingest aflatoxin-contaminated feed then the aflatoxins can occur in the milk

Aflatoxins observed in beer, cocoa, raisins and soymeal

Fumonisin

Produced by *Fusarium moniliforme*

Linked with oesophageal cancer in humans

Occurs in corn and corn-based feeds that have not been stored dry

: Minimum water activity requirements of some spoilage fungi

Species	Minimum a_w
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Field fungi

<i>Fusarium culmorum</i>	0.89
<i>Fusarium graminearum</i>	0.89
<i>Alternaria alternata</i>	0.88
<i>Cladosporium herbarum</i>	0.85

Storage fungi

<i>Penicillium aurantiogriseum</i>	0.82
<i>Penicillium brevicompactum</i>	0.80
<i>Aspergillus flavus</i>	0.78
<i>Aspergillus candidus</i>	0.75
<i>Eurotium amstelodami</i>	0.71
<i>Willemia sebi</i>	0.69



Fruits

Penicillium italicum and *Penicillium digitatum* commonly found on citrus fruits, blue mould and green mould respectively of oranges, lemons and other citrus fruits.

Penicillium expansum

- causes a soft rot of apples
- Produces a mycotoxin called patulin
- Mycotoxin detected in unfermented apple juice

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Patulin

Patulin is a mycotoxin that is produced by certain species of *Penicillium* and *Aspergillus* molds grow on a variety of foods including fruit, grains, and cheese (patulin is activated in cheese).

Patulin has been found to occur in a number of foods including apple juice, apples and pears with brown rot

Patulin is reported to be destroyed by fermentation

Thermal processing causes only moderate reductions in patulin levels

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Fruits

Gray mould *Botrytis cinerea*

Infection of grapes on the vine by this same mould

Grapes dry out and an increase in sugar concentration

referred to as the **noble rot**.

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Vegetables

Vegetable generally have a higher pH than many fruit

more susceptible to spoilage by bacteria than fungi

There are also important spoilage fungi of stored vegetables.

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Spoilage bacteria are generally able to break down the pectin in the plant tissue pectinolytic species of the Gram-negative genera ***Erwinia***, ***Pseudomonas*** and ***Xanthomonas***

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Not usually plant pathogens but opportunistic microorganisms gain access to plant tissue through wounds

Relative humidity below 90-95% (limited because you don't want the veges to wilt)

Low temperature, gas phase with reduced oxygen (ca. 2-3%) and enhanced CO₂ (ca. 2-5%)



Some microorganisms causing spoilage of fresh vegetables

Microorganisms	Vegetable	Symptom
Bacteria		
<i>Corynebacterium sepedonicum</i>	Potato	ring of tubers
<i>Pseudomonas solanacearum</i>	Potato	soft rot
<i>Erwinia carotovora</i>	Potato	soft rot
<i>Streptomyces scabies</i>	Potato	scab
<i>Xanthomonas campestris</i>	Brassicas	black rot
Fungi		
<i>Botrytis cinerea</i>	Many	gray mould
<i>Botrytis allii</i>	Onions	neck rot
<i>Mycocentrospora acerina</i>	Carrots	liquorice rot
<i>Trichotecium roseum</i>	Tomato	pink rot
<i>Fusarium coeruleum</i>	Potato	dry rot
<i>Aspergillus alliaceus</i>	Onion, Garlic	black rot

Sources of microorganisms in food

The internal tissues of healthy plants and animals are sterile. i.e. there are no bacteria present

The outer surfaces have normal flora and contaminants

Diseased plants or animals may have microorganisms in the tissues however we generally do not use diseased plants or animals as food.

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Contamination

direct contamination of food plants from faeces of birds and animals, the use of manure or sewage sludge as fertilizer, or the use of contaminated waters for irrigation is a serious public health concern

Minimally processed fresh vegetables such as celery, watercress, lettuce, endive, cabbage and bean sprouts have all been associated with *Salmonella* and pathogenic *E. coli* infections

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Sources of microorganisms in food: Plants

Proper methods of growing food plants reduces the risk of contaminants.

- Using untreated sewage for watering or fertilising may introduce human pathogens
- Damage reduction during harvest reduces tissue damage and minimises spoilage
- Washing with good quality water removes external contaminants
- Storage at low temperature reduces the opportunity for microbes to multiply



A tanker dumps untreated faecal sludge in a wheat field. Photo: Vikas Choudhary

Sources of microorganisms in food: Plants

Most foods from plant sources are essentially sterile in the inside

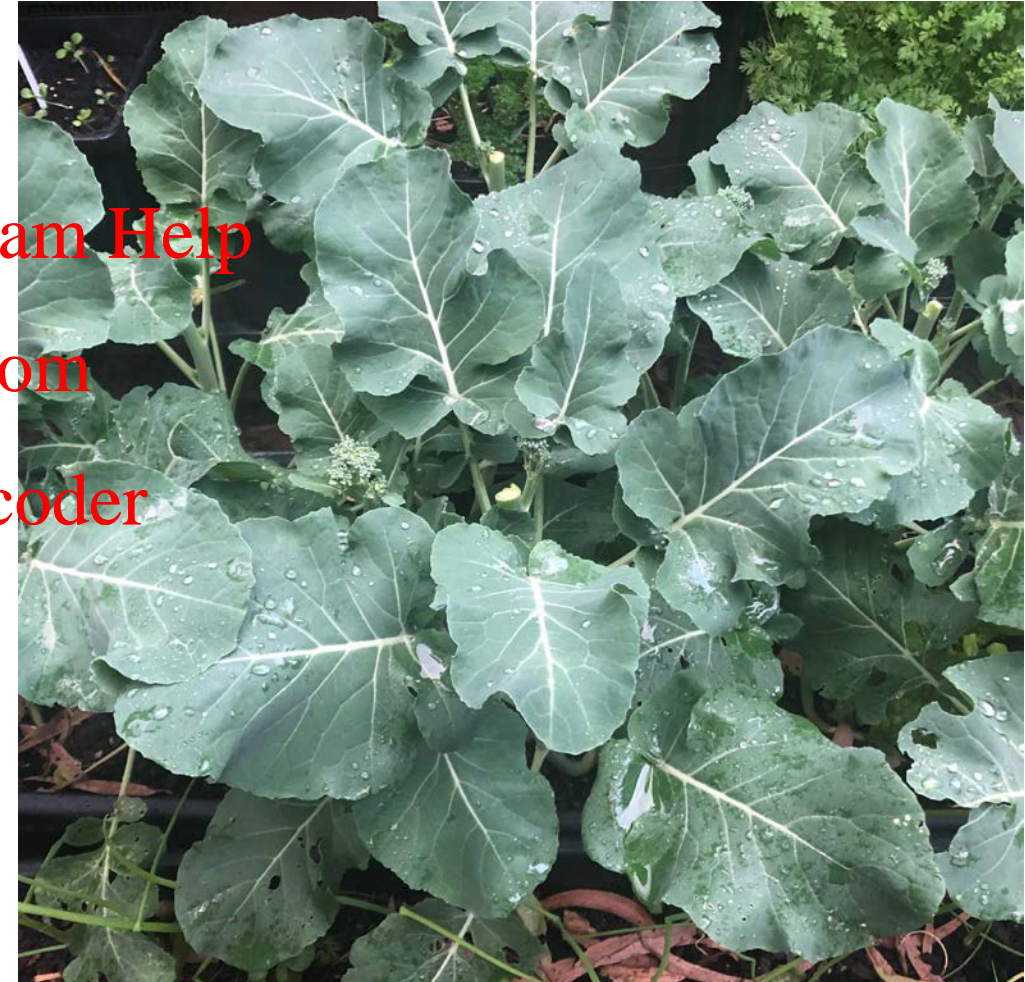
Most fruit and vegetables carry microorganisms on the surface

The sources of surface microbes are soil, fertilisers, water and air

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Sources of microorganisms in food

There are many ways that microorganisms can get into food

Natural sources of contaminants for food of plant origin:

- surfaces of fruits vegetables and grains
- damaged tissues

Natural sources of contaminants for food of animal origin:

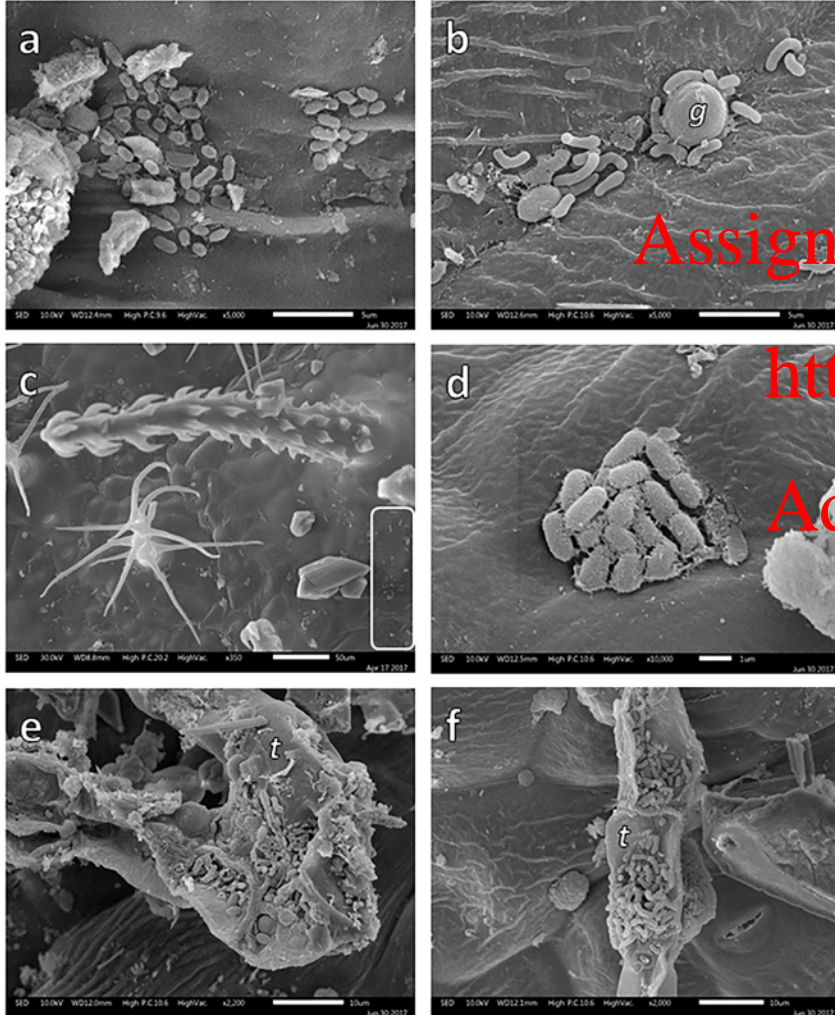
- The natural microflora of the host

Other sources of contamination

- Air, soil, sewage, water, feeds, humans, food ingredients, equipment, packages and insects



Normal flora on surfaces of plants



Some plants have associated microbial communities as part of their normal flora

- Leafy vegetables of the brassica family (e.g. cabbage, broccoli) have a microbial community on the surface

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- Expected microbes: moulds, yeasts, lactic bacteria and bacteria from the genera *Pseudomonas*, *Micrococcus*, *Erwinia*, *Bacillus*, *Clostridium*

Sprouts



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“Cook sprouts thoroughly to reduce the risk of illness. Sprouts are a particular concern because the warm, humid conditions needed to grow sprouts also are ideal for germs to multiply.

Therefore, eating raw or lightly cooked sprouts may lead to food poisoning. It’s especially important to avoid raw sprouts if you are in a group more likely to get seriously sick from food poisoning: pregnant women, young children, older adults, and people with weakened immune systems” CDC



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