THE UNIVERSITY OF MELBOURNE

FOOD20006

Food Microbiology & Safety

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Factors influencing microbial growth in food : Intrinsic factors

Ray and Bhunia Ch 6

Intended learning outcomes

Distinguish between intrinsic, extrinsic and implicit factors

List the categories of intrinsic factors in food that affect microbial growth

Describe the intrinsic factors of samples of food

Explain how intrinsic factors affect the growth and survival of microorganisms in food

Implicit, Intrinsic and Extrinsic factors

The ability of microbes to grow or multiply in food is determined by their biology (implicit factors), the food environment (intrinsic factors) as well as the environment in which it is stored(extrinsic factors).

Intrinsic factors are factors relating to the food itself

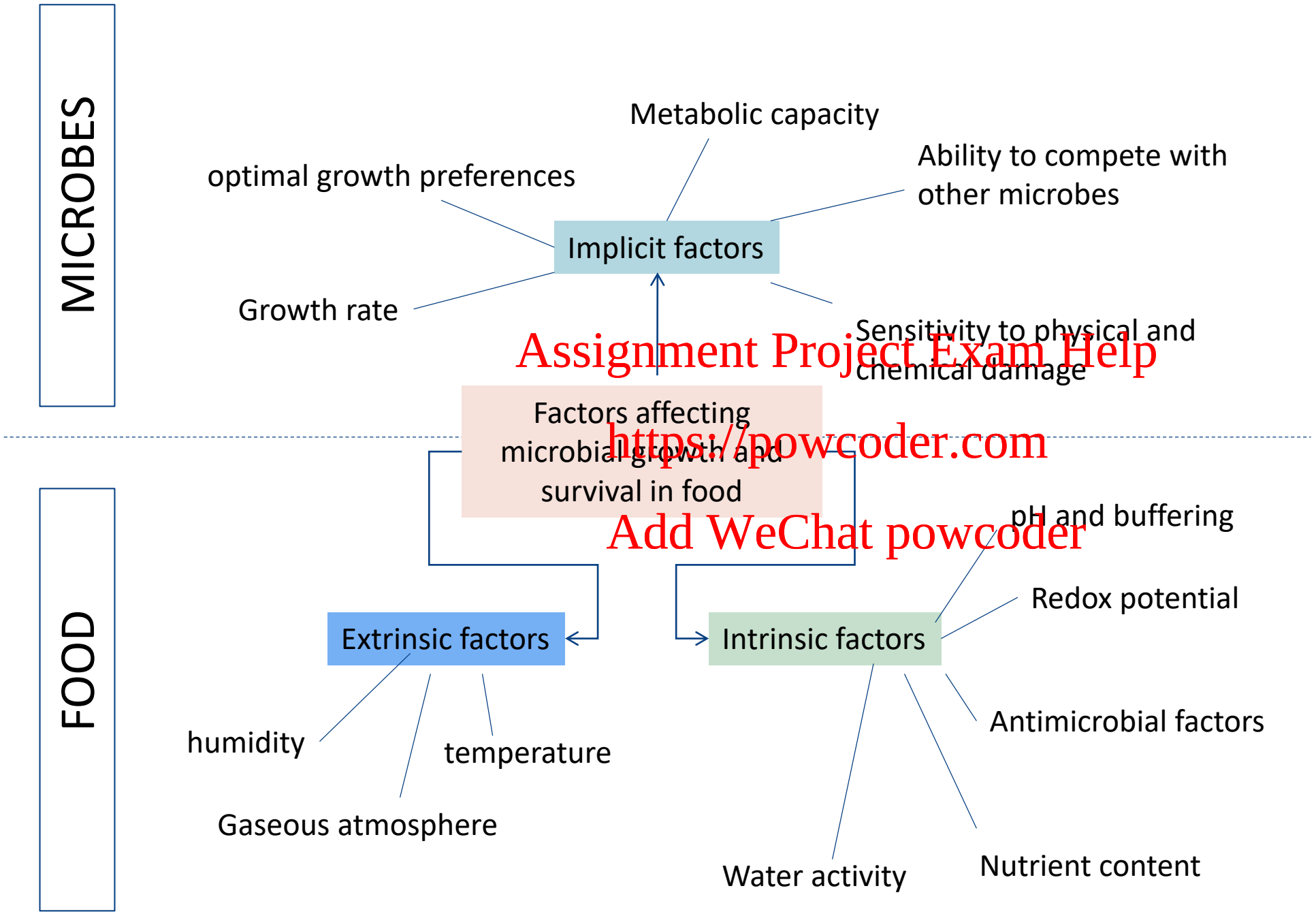
- Nutrients
- Growth factors
- Inhibitors
- Water activity
- pH
- Oxidation-reduction potential

Extrinsic factors are factors relating to the environment of food

- Temperature
- Gasous atmosphere
- Humidity

Implicit factors are properties of the microbe

- Growth temp
- Oxygen requirement
- Hydrolytic capability
- Ability to compete
- Sensitivity to physical and chemical damage



Factors influencing microbial growth in food

1. **Intrinsic factors**: food related

   - nutrients,
   - growth factors,
   - inhibitors
   - water activity (Aw)
   - pH
   - oxidation-reduction potential (Eh)

2. **Extrinsic factors**: environment related

   - temperature
   - relative humidity
   - gaseous environment

Intrinsic factors: Nutrients

- Microbes derive their nutrients from their immediate environment
- Microbes growing in food derive their nutrients from that food
  - e.g. carbohydrates, protein, lipids, minerals, vitamins
- Microorganisms present in food in their nutrient requirements and ability to extract nutrients from food
- The microbes will need to breakdown complex molecules using extracellular enzymes so they can absorb smaller molecules
  - E.g. proteases break down proteins into amino acids and peptides

Nutrients: carbohydrates

Carbohydrates present in different foods can be grouped on the basis of their chain length or complexity

Polysaccharides: polymers of glucose units i.e starch, glycogen, cellulose
polymers of fructose units i.e inulin

Oligosaccharides
- raffinose=glucose+ fructose+ galactose
- stachyose =glucose+ fructose+ galactose

Disaccharides
- lactose= galactose+ glucose
- sucrose= fructose+ glucose
- maltose= glucose+ glucose

Monosaccharides
- Hexoses: glucose, fructose, mannose, galactose
- Pentoses: xylose, arabinose, ribose, ribulose, xylulose

Intrinsic factors: Nutrient uptake

- Digestion of complex polymeric carbohydrates is often difficult for many microbes (e.g. starch, cellulose) but molds are usually more capable of degrading these.
- In this example the intrinsic factor is the presence of cellulose and the implicit factor is the ability of the fungi to degrade the cellulose

"The archive of the Universidad de Costa Rica maintains a nineteenth-century French collection of drawings and lithographs in which the biodeterioration by fungi is rampant."

Coronado-Ruiz, Carolina, et al. "Two new cellulolytic fungal species isolated from a 19 th-century art collection." *Scientific reports* 8.1 (2018): 1-9.

Composition of wheat

Starchy endosperm (80-85%)

protein, starch, & very few fibres (2%)

Aleurone layer (6-9%)

- *Insoluble dietary fibres & very few soluble fibres(< 5%) (xylans, β-glucans)*
- *Proteins, enzymes*
- *Phenolic compounds, lignans*
- *Vitamin E, B vitamins*
- *Minerals and phytic acid*
- *Lipids, plant sterols*

Hyaline layer

Testa (1%)

- *Alkylresorcinols, sterols, steryl ferulates*

Inner pericarp

Outer pericarp (3-5%)

- *Insoluble dietary fibres (xylans, cellulose, lignin)*
- *Antioxidants bound to cell walls (phenolic acids)*

Germ (3%)

- *Lipids, plant sterols*
- *Antioxidants*
- *Vitamin E, B vitamins*
- *Minerals*
- *Enzymes*

Outer layers

International Journal of Food Science & Technology, Volume: 50, Issue: 12, Pages: 2509-2518, First published: 14 November 2015, DOI: (10.1111/ijfs.12935)

Nutrient uptake: proteins

Proteins are polymers of amino acids

~ 15-18% nitrogen

e.g. albumen (in eggs), globulins (milk), gluten (cereal)

•Bacteria/fungi usually transport short peptides/amino acids into cells

•Many secrete **proteases** to break down proteins in foods – can be desirable (cheese) or undesirable (spoilage)

•Metabolism of proteins can:

- release 'off flavour' compounds like ammonia, H_2S
- produce toxins like histamine (from histidine)

Intrinsic factors: Nutrients Lipids

Examples of lipids are phospholipids, glycerides, fatty acids, sterols

Generally a less preferred substrate for microbial growth than carbohydrates

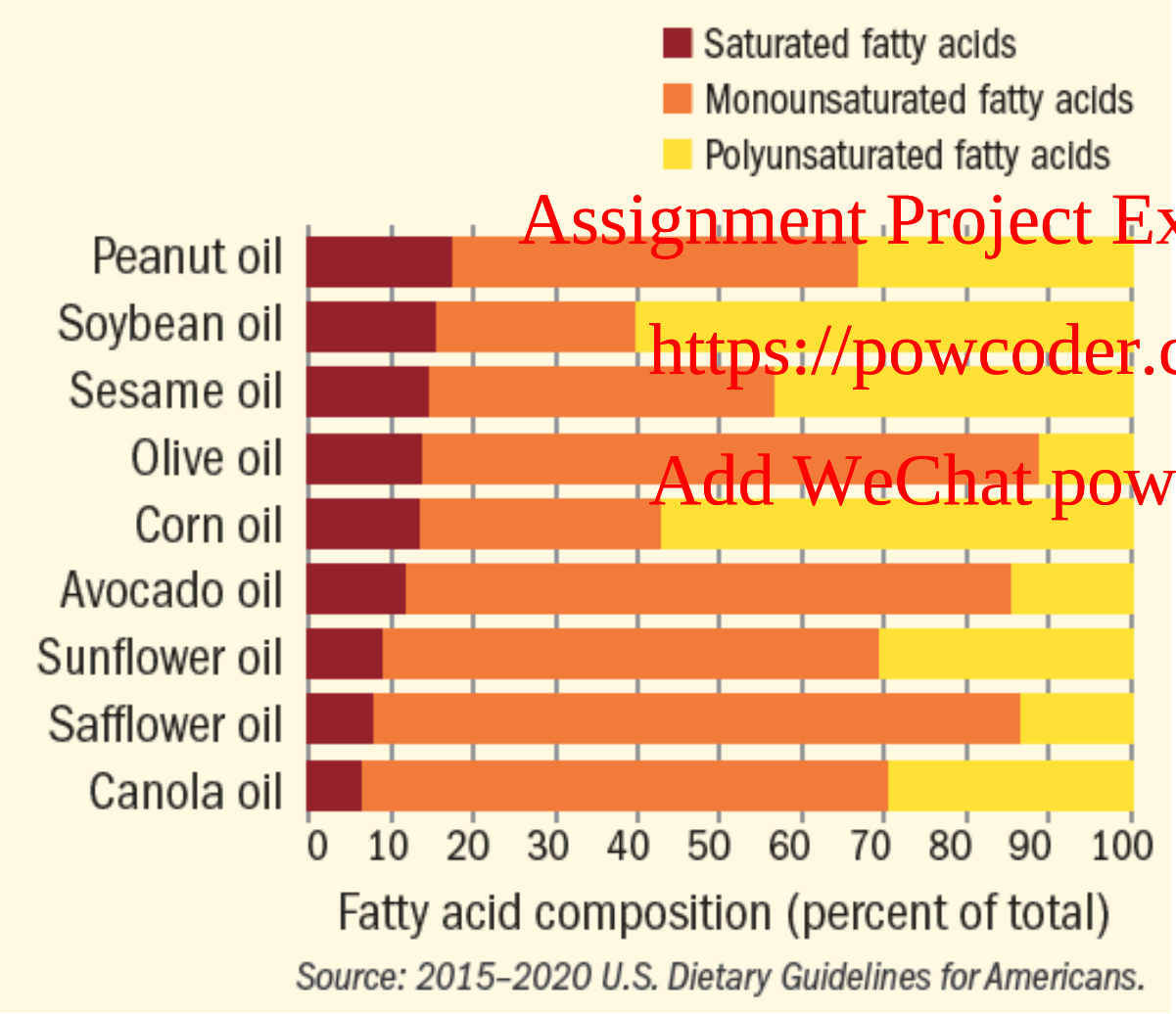
Microbes can produce lipases to break down phospholipids to smaller molecules like fatty acids and glycerol, and transport these into the cell for metabolism for carbon and energy

Cell lysis can release intracellular lipases that lead to spoilage

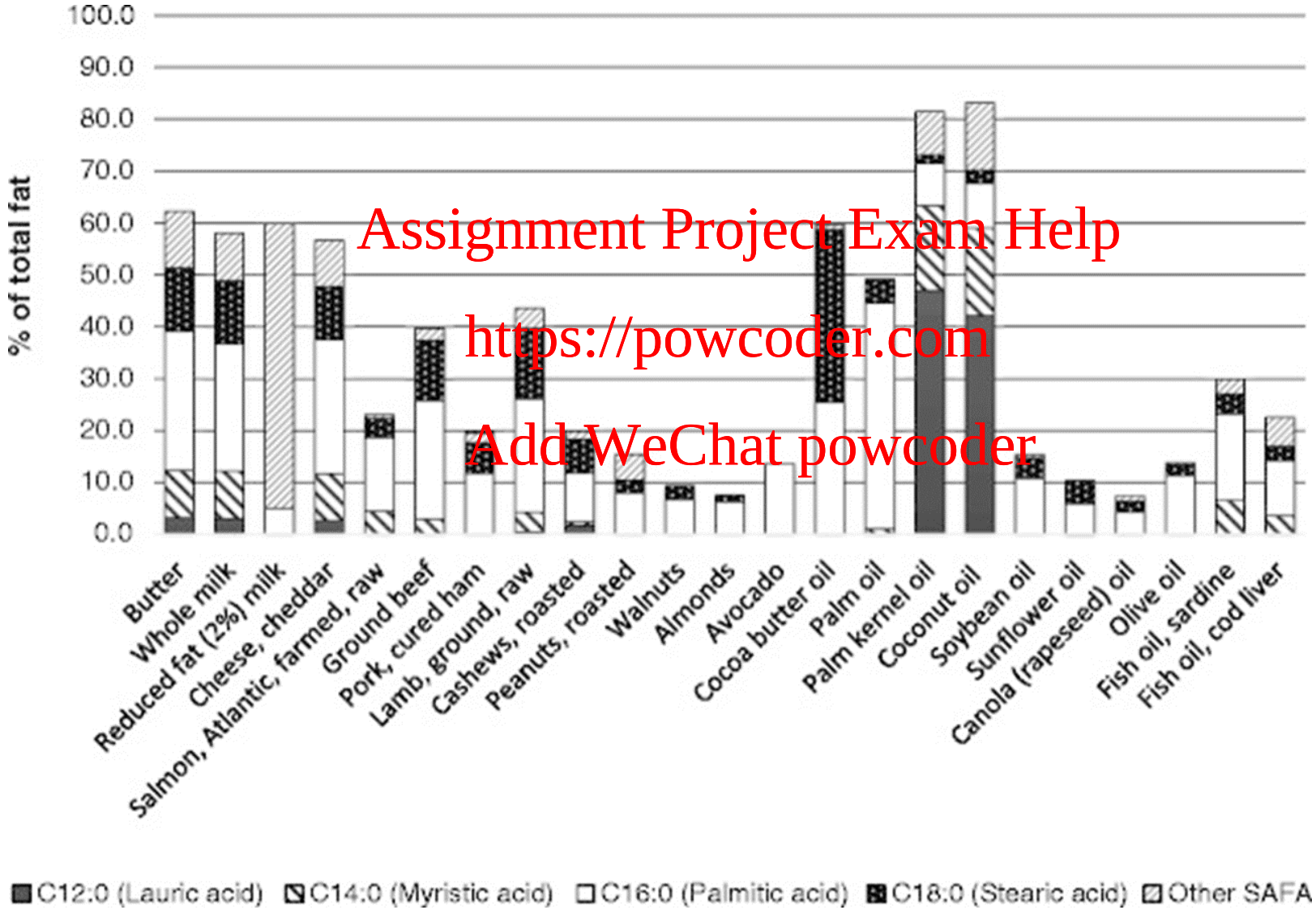
Some plant-based foods are rich in lipids e.g. nuts, oil-seeds, coconuts, olives, avocados

Foods rich in cholesterol are typically from animal products

Composition of plant-based oils



Fats and Lipids in various foods



Zock et al 2006

Nutrients: Growth factors, minerals and vitamin C

Microbes need small amounts of certain minerals and vitamins

The small amounts are usually present in foods

Not usually a restriction to microbial growth

Most microbes can make organic factors like vitamins (that we can't!)

Not possible or practical to try and limit growth by restricting the availability of one or more nutrients

Intrinsic factors:
Stimulators and inhibitors of growth

These are compounds are naturally present substances that either stimulate or inhibit microbial growth

They affect the growth of microbes but are not nutrients.

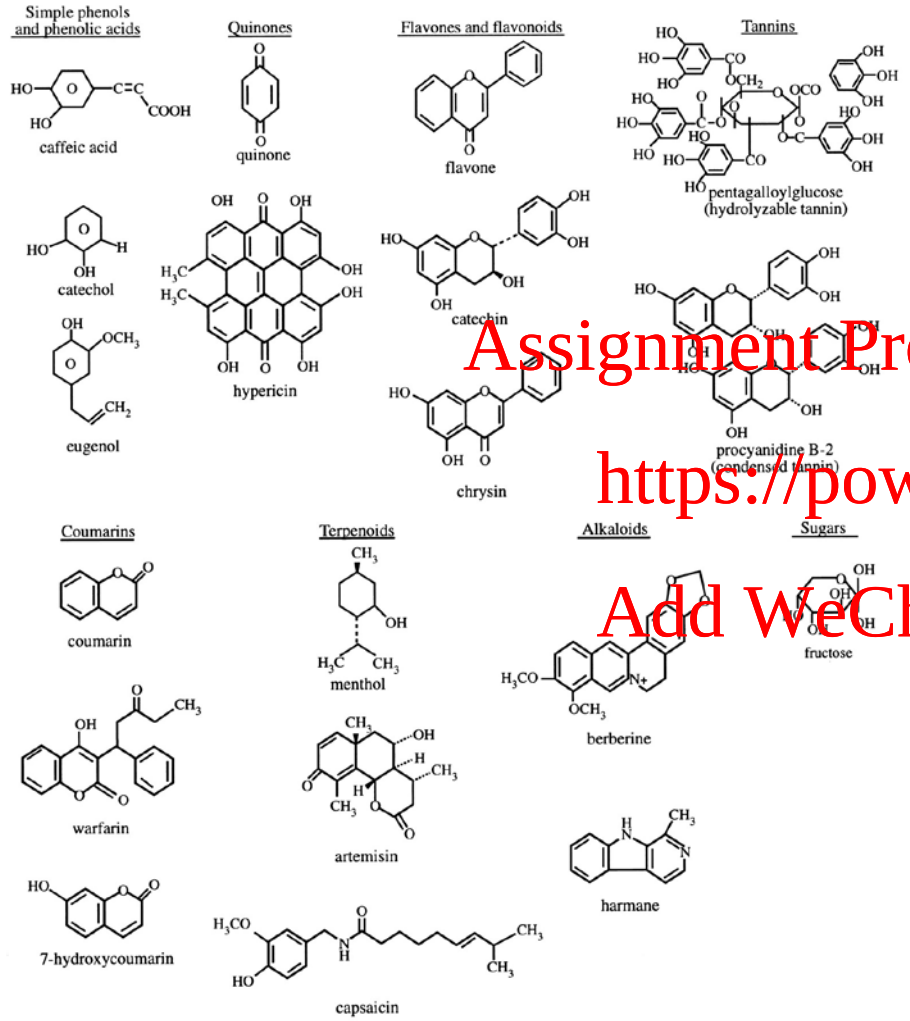
Inhibitors are more common

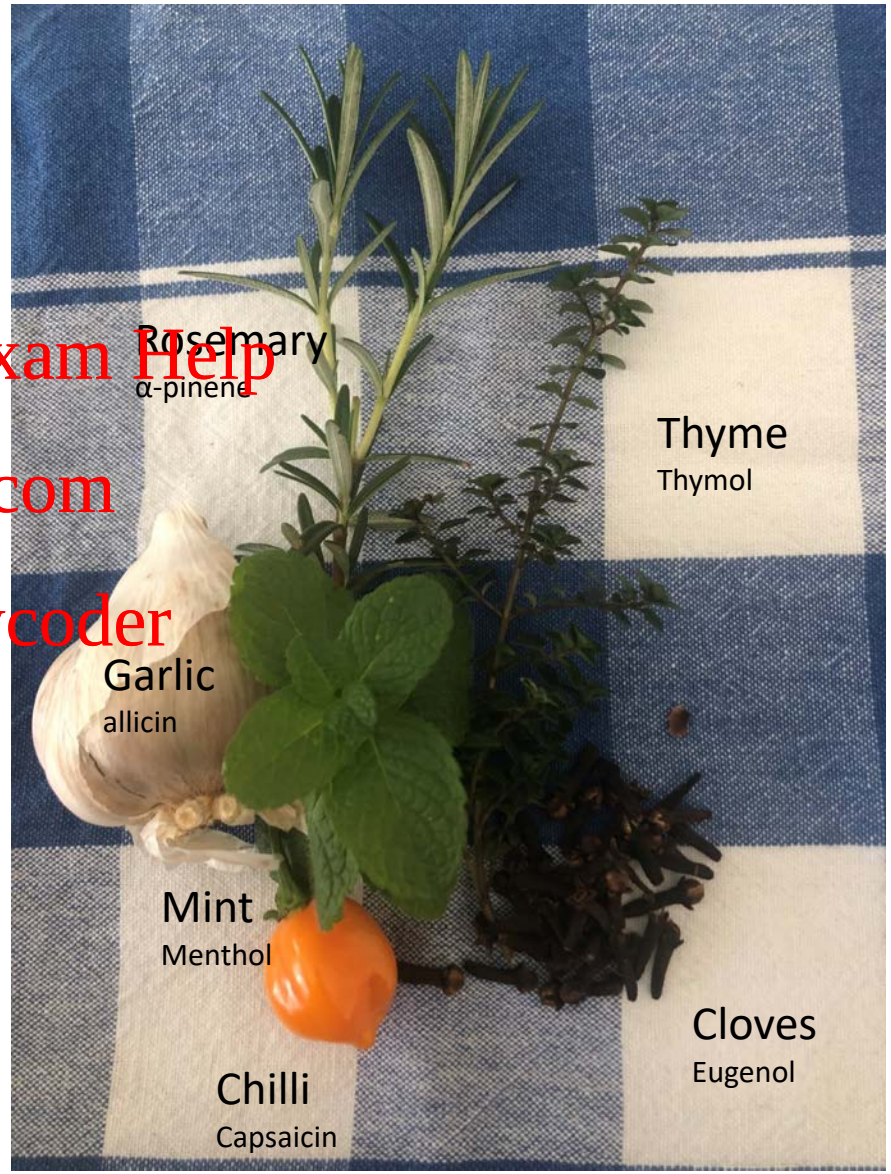
Lysozyme (high levels in egg white) – this is an enzymes breaks the peptidoglycan of bacterial cell walls. It is a natural defence.

Euganol (cloves). This is an essential oil in the spice. It is a natural defense of the plant against insect attack and microbial attack

Agglutinin, lactoperoxidase (raw milk)

Common antimicrobial plant chemicals





Marjorie Murphy Cowan Clin. Microbiol. Rev. 1999; doi:10.1128/CMR.12.4.564

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To be continued