Factors Affecting Microorganism Growth & Survival

Intrinsic Factors

Factors of the food itself, i.e. nutrients, growth factors, inhibitors, water activity, pH, and redox potential.

Nutrients – microbes take nutrients rom their immediate surroundings, the microbes in food are mixed and will have different nutritional requirements.
– polymeric carbohydrates are harder for bacteria to digest, but moulds are more capable.
– sometimes the death of microbes release enzymes that breakdown the food.

- Proteins – many microbes have protease, microbial cells require short peptides and amino acids.
  – protein metabolism can release 'off' odours and toxins such as histamine.

- Carbohydrates – metabolised by microbes as a carbon and energy source.

- Lipids – some microbes can metabolise lipids for energy, but not a preferred substrate.
  – cell lysis can release intracellular lipase that cause spoilage.

- Vitamins/Minerals – most microbes can produce these, therefore not a restriction.

Growth Factors/Inhibitors – naturally present substances that stimulate or inhibit microbe growth.
– inhibitors are more common than growth factors, e.g. lysozyme in egg white that break down peptidoglycan.

Water Activity (A_w) – measure of available water for biological functions (i.e. free water). It does not include water bound by ions/polymers as microbes can't use it.
– ratio of water vapour pressure of the food and water vapour pressure of pure water.
– most microbes can't grow below $A_w = 0.6$
– most bacteria can't grow below $A_w = 0.9$
– Osmotolerant, Xerotolerant, and Halotolerant microbes can grow at low A_w.

pH – optimum pH for microbes: bacteria at pH 6 - 8; yeasts at pH 4.5 - 6; filamentous fungi at pH 3.5 - 4.
– most foods are acidic - neutral pH.
– pH of post-slaughter meat decreases (to ~5.6) due to fermentation of muscle glycogen to lactate.

Redox Potential (E_h) – redox potentials affect microbe growth in that microbial metabolism depends on redox potentials, e.g. anaerobes are inhibited by high E_h due to high O_2 / low pH.
– E_h is affected by O_2 and pH: $\uparrow O_2 = \uparrow E_h$; $\downarrow pH = \uparrow E_h$
– microbial growth decreases E_h as they use up O_2.
– fresh foods usually have lower E_h than processed foods.

Extrinsic Factors

External environmental factors, e.g. temperature, humidity, and gaseous atmosphere.

Temperature – directly affects rate of biochemical reactions in microbes.

– There are different microbe temperature groups with different optimum growth temperatures:
- thermophiles – optimum 55°C; thermoduric microbes can survive pasteurisation
- mesophiles – optimum 35°C
- psychrophiles – optimum 15°C; psychoduric microbes can survive refrigeration

Humidity – affects A_w due to the moisture in the air.

Gaseous Atmosphere – gasses in air affects E_h, e.g. more oxygen in air increases E_h.
– method of microbe inhibition is increase CO_2 around food as CO_2 inhibits microbe growth due to it dissolving to form a weak acid.

Microbial Metabolism

Heterotrophs – use organic carbon compounds for growth.
Chemoorganotrophs – use organic compounds as electron donors for energy.

Microbes can produce energy in 3 ways:
- Aerobic respiration using oxygen
- Anaerobic respiration using NO_3^- or SO_4^{2-}
- Fermentation without oxygen (slower growth)

Yeast fermentation – produced CO_2 and ethanol

Lactic acid bacteria (LAB) fermentation – lactic acid

Food Atmosphere Modification

Modified Atmosphere Packaging (MAP) – mixture of CO_2, O_2, and N_2; ratios vary.
– CO_2 inhibits growth; N_2 slows growth

A problem with MAP is that the gas composition can change time due to product/microbial respiration, gas exchange, dissolution of CO_2, etc. This will affect the inhibitory effect.

Controlled Atmosphere Packaging (CAP) – similar to MAP, but gas environment is controlled to prevent any changes that may occur like in MAP.
– usually requires special containers or silos.

Vacuum Packing (VP) – removal of O_2 in product environment, preventing fast growing aerobes.
– has little effect on anaerobes and facultative anaerobes.

Active Packaging (AP) – components added into packaging that interact with the product atmosphere, e.g. controls moisture, gases, etc., to extend product shelf life.
– example is the pads at the bottom of packaged fresh meats, they release CO_2 when in contact with moisture.