Factors influencing Microbial Growth

Food and Microorganism

- An understanding of the interactions between microorganisms and food.
- The ecological role of microorganisms and their importance in all the bio-geochemical cycles.
- The human food supply consists basically of plants and animals or products derived from them, it is understandable that our food supply contain microorganisms in interaction with food.

Interaction between microorganism and food

- Pathogenic/spoilage, or disease causing microorganisms can cause illness

- Beneficial

A knowledge of the factors that favor or inhibit the growth of microorganism is essential to an understanding of the principles of food spoilage and preservation.

What are the governing factors in these interactions?

Factors affecting microbial growth in food

(a) Intrinsic factors:

These are inherent in the food. They include:

- pH
- Water activity
- Oxidation reduction potential
- Nutrient content
- Antimicrobial contents

(b) Extrinsic factors:

Are factors external to the food that affect microbial growth.

- Temperature
- Humidity

HYDROGEN-ION CONCENTRATION (pH)

- Every microorganism has a **minimal, maximal and optimal pH** for growth. Microbial cells are significantly affected by the pH of food because they apparently have no mechanism for adjusting their internal pH.

- The buffer in a food, i.e., the compounds that resist changes in pH, are important not only for their **buffering capacity** but also for their ability to be especially effective within a certain pH range.

- The value of pH alone may not be sufficient for predicting microbial responses. It is also desirable, for example, to know the **acid responsible** for a given pH, because some acids, particularly the **organic acids**, are more inhibitory than others. eg- Citric, acetic acid, benzoic, lactic, proprionic, and sorbic acids

- **Most bacteria** grow best at neutral or weakly alkaline condition usually between **6.8 -7.5 pH**.
- Some bacteria can grow within a **little wider pH range** of 4.5 to 9.0, e.g. ***Salmonella***
- Other microorganisms especially **yeasts** and **molds** and some bacteria grow within a **wide pH range**, e.g. molds grow between 1.5 to 11.0, while yeasts grow between 1.5 and 8.5.
- Microorganisms that are able to grow in acid environment are called **acidophilic microorganisms**. These microorganisms are able to grow at pH of around 2. Yeasts and molds grow under acidic conditions.
- Other microorganisms such as ***Vibrio cholerae*** are sensitive to acids and prefer **alkaline conditions**.

pH values of some food products

Food type	Range of pH values
Beef	5.1 - 6.2
Chicken	6.2 – 6.4
Milk	6.3 – 6.8
Cheese	4.9 - 5.9
Fish	6.6 - 6.8
Oyster	4.8 - 6.3
Fruits	< 4.5 (most < 3.5)
Vegetables	3.0 – 6.1

Minimum and maximum pH for growth of some specific microorganism

Microorganism	Minimum	Maximum
Salmonella typhi	4.5	8.8
Molds	1.5	11.0
Yeast	2.0	8.5

MOISTURE REQUIREMENT: THE CONCEPT OF WATER ACTIVITY

Microorganisms have an absolute demand for water, for without water no growth can occur. As might be expected, the exact amount of water needed for growth of microorganisms varies. This water requirement is best expressed in terms of available water or **water activity (a_w)**, the vapor pressure of the solution (of solutes in water in most foods) divided by the vapor pressure of solvent (usually water).

$$a_w = VP_{Food}/VP_{Water}$$

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No water **Pure water**

Basically, it is the free water required for the growth of the organism.

- The effect of moisture is in terms of water activity: the amount of **free water** in a food medium.

- The amount of free water is important for growth of microorganisms.

- If there is lack of free water microorganisms will not grow.

Water is made unavailable in various ways

- **Solutes and ions tie up water in solution. Therefore, an increase in the concentration of** dissolved substances such as sugars and salts is in effect a drying of the material.

- **Hydrophilic colloids (gels) make water unavailable. As little as 3 to 4 percent agar in a** medium may prevent bacterial growth by leaving too little available moisture.

- **Water crystallization or hydration is usually make water unavailable to microorganisms. Water itself,** when crystallized as ice, no longer can be used by microbial cells. The a*w of water-ice* mixtures (vapor pressure of ice divided by vapor pressure of water) decreases with a decrease in temperature below 0 C. The a*w* values of pure water are 1.00 at 0°C, 0.953 at −5°C, 0.907 at −10°C, 0.846 at −15°C, 0.823 at −20°C, and so on.

Reduction of a*w* by a solute

The reduction of a*w* by a solute depends primarily on the total **concentration of dissolved molecules** and ions, each of which is surrounded by water molecules held more or less firmly.

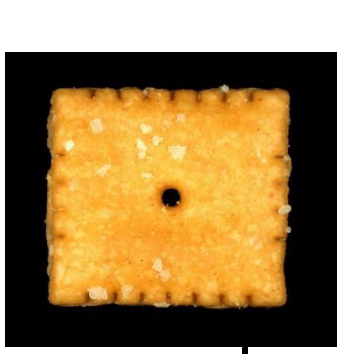
The solution then has a lower freezing point and a lower vapor pressure than does pure water. The organisms must compete with these particles for water molecules.

Raoult's law

$$p/p0 = n2/(n1 + n2)$$

where *p and p0 are the vapor pressures of the solution and solvent and n1 and n2 are the number* of moles of solute and solvent, respectively.

Water activity of common foods



0.5 0.75 1.0

WATER ACTIVITY AND MICROORGANISM GOWTH

Each microorganism has a maximal, optimal, and minimal a*w* for growth

Aw	Microorganism	Foods
1.0-0.95	Bacteria	Meat, fish, sausage, milk
0.95-0.91	Bacteria	Moist cheeses, cured meat (ham), fruit juice conc
0.91-0.87	Yeasts	Fermented sausages (salami), dry cheeses
0.87-0.80	Molds	Juice conc, syrups, flour, fruit cakes, honey, jellies, preserves
0.30-0.20	No microorganisms proliferate	Cookies, crackers

Minimum water activity that supports growth of some microorganisms

Group of microorganisms	*Minimal aw value*
Many bacteria	0.91
Many yeasts	0.88
Many molds	0.80
Halophilic bacteria	0.75
Xerophilic fungi	0.65
Osmophilic yeasts	0.60

Factors affecting a*w* requirements of microorganisms

1. The kind of solute employed to reduce the a*w*. Potassium chloride, for example, usually is less toxic than sodium chloride, and it in turn is less inhibitory than sodium sulfate.
2. The nutritive value of the culture medium. In general, the better the medium for growth, the lower the limiting a*w.*
3. Optimal temperature. Most organisms have the greatest tolerance to low *aw* at about optimal temperatures.
4. Oxygen supply. Growth of aerobes takes place at a lower *aw* in the presence of air than in its absence, and the reverse is true of anaerobes.
5. Optimal pH. Most organisms are more tolerant of low *aw* at pH values near neutrality than in acid or alkaline media.
6. Inhibitors. The presence of inhibitors narrows the range of *aw* for growth of microorganisms.

Oxidation- Reduction Potential

The oxygen tension or partial pressure of oxygen about a food and the O-R potential, or reducing and oxidizing power of the food itself, influence the type of organisms which will grow and hence the changes produced in the food.

The O-R potential of the food is determined by

(1) Characteristic O-R potential of the original food.
(2) The poising capacity- the resistance to change in potential of the food.
(3) The oxygen tension of the atmosphere around the food.
(4) The access which the atmosphere has to the food.

Air has a high oxygen tension but the head space in an evacuated can of food would have a low oxygen tension.

Foods affected by various groups

- Anaerobic -sporeformers are most likely to grow in canned foods . eg- *Bacillus, Micrococcus, Pseudomonas, Acenatobacter*
- Aerobic are most likely not able to grow in vacuum packed foods. eg – *Clostridium*, Bacteriodes
- Facultative anaerobes- are anaerobic in nature but can also survive in presence of oxygen.
- Facultative aerobes- are aerobic in nature but can also survive in absence of oxygen.

Nutrients content of the food

- **Food for energy**
- **Food for growth**

- Microorganisms require proteins, carbohydrates, lipids, water, energy, nitrogen, sulphur, phosphorus, vitamins, and minerals for growth.
- Various foods have specific nutrients that help in microbial growth.
- Foods such as milk, meat and eggs contain a number of nutrients that are required by microorganisms.
- These foods are hence susceptible to microbial spoilage.

ACCESSORY FOOD SUBSTANCES AND VITAMINS

- Some microorganisms are **unable to manufacture vitamins** needed and must have them furnished.
- Most natural plant and animal food stuffs contain an array of these vitamins, but some may be low in amount or lacking.
- Thus **meats are high in B vitamins** and fruits are low, but **fruits are high in ascorbic acid**.
- Egg white contains **biotin** but also contains **avidin** which ties up biotin, making it unavailable to microorganisms and eliminating as possible spoilage organisms those which must have biotin supplied.
- The processing of foods often reduces the vitamin content. Thiamine, pantothenic acid, the folic acid group, and ascorbic acid (in air) are heat-labile, and **drying causes a loss in vitamins** such as thiamine and ascorbic acid.
- Even storage of foods for long periods, especially if the storage temperature is elevated, may result in a decrease in the level of some of the accessory growth factors.

INHIBITORY SUBSTANCES

- Examples of **inhibitors** naturally present are the **lactenins** and **anticoliform** factor in freshly drawn milk, **lysozyme** in egg white, and **benzoic acid** in cranberries.

- **Propionic acid** produced by the propionibacteria in Swiss cheese is inhibitory to molds.

- **Nisin** produced by certain strains of *Streptococcus lactis* may be useful in inhibiting lactate-fermenting, gas-forming clostridia in curing cheese and undesirable in slowing down some of the essential lactic acid Streptococci during the manufacturing process.

Destruction of inhibitory compounds in foods by microorganisms

- Certain molds and bacteria are able to **destroy some of the phenol compounds** that are added to meat or fish by smoking or benzoic acid added to foods.

- Sulfur dioxide is destroyed by yeasts resistant to it. ***Lactobacilli* can inactivate nisin**.

- Heating foods may result in the formation of inhibitory substances. Heating lipids may hasten autoxidation and make them inhibitory.

- **Browning concentrated sugar sirups** may result in the production of **furfural** and **hydroxymethyl furfural**, which are inhibitory to fermenting organisms.

COMBINED EFFECTS OF FACTORS AFFECTING GROWTH

Each of the compositional factors of foods-aw, pH, O-R potential, and nutrient content can significantly affect the resulting microbial flora. Many of these factors interact, and therefore one must be concerned with the total ecology of the food.

Thank you…