

Extrinsic factors for Growth and survival of microorganisms in food

Extrinsic parameters

Extrinsic parameters refer to those properties of the environment to which the food is exposed. This includes the characteristics of the storage environment of the food which have profound effect on the food as well as the microorganisms associated with the food. The intrinsic factors of the food are influenced by the conditions of storage environment, and there by affect the quality of food. The environmental factors which have influence on the food associated microorganisms are;

- ✚ Storage temperature
- ✚ Relative humidity of storage environment
- ✚ Presence or absence of gases
- ✚ Presence and activities of other microorganisms.

Temperature of storage

Storage temperature refers to temperature at which the food is handled and stored. Microorganisms growing over a wide range of temperature have been reported from food. The minimum temperature supporting the growth of microorganism was found to be well below the freezing temperature of water, and the highest temperature close to boiling temperature of water. However, no single microorganism is capable of growing over this wide temperature range. Thus, selecting a proper temperature for the storage of different food types helps in maintain quality. Each microorganism exhibits minimum, optimum and maximum temperature at which growth occurs, called cardinal temperature. This temperature is characteristic for an organism and is influenced by factors such as nutrient availability, pH of growth medium, water activity etc.

Grouping of microorganisms based on temperature requirement for growth

Microorganisms are grouped in to 4 broad types based on cardinal temperature:

Groups	Minimum temperature for growth (°C)	Optimum temperature for growth (°C)	Maximum temperature for growth (°C)
Psychrotrophs	-5 to +5	25-30	30-35
Psychrophiles	-5 to +5	12-15	15-20
Mesophiles	5-15	30-40	40-47
Themophiles	40-45	55-75	60-90

Psychrophiles



Microrganisms capable of growing at low temperature are called psychrophiles. These are further divided in to 2 types based on their optimum temperature for growth.



Obligate psychrophiles (cold loving) – These have temperature optima of 12-15°C, but unable to grow above 20°C. These are confined to polar regions and deep marine environment.

Psychrotrophs (facultative psychrophiles)



These have same minimum temperature for growth as psychrophiles but have higher optimum and maximum growth temperature. Thus are found in most diverse habitats, grow well in refrigerated temperature and cause spoilage of chilled food.



Ex: *Alcaligenes*, *Cornybacterium*, *Flavobacterium*, *lactobacillus*, *Pseudomonas*, *Enterococcus* etc. These bacteria grow well at 5-7°C (refrigerator temperature) and cause spoilage of meat, fish, poultry, eggs etc.

Mesophiles



These grow well under normal temperature conditions of 30-40°C. As a rule mesophiles grow quickly at their optimum temperature than psychrotrophs. Thus the spoilage of food at mesophilic temperature range is rapid than at chill temperature. Mesophiles are found in most genera of bacteria.

Thermophiles



These are high temperature loving microorganisms with the optimum temperature in the range of 55- 75°C. Thermophiles are generally less important in food microbiology. But thermophilic spore formers of the genus *Bacillus* and *Clostridium* cause spoilage of canned foods.

Molds and yeasts



Like bacteria, many molds and yeasts are associated with food. Many spoilage molds are able to grow over a range of temperature. Some molds grow at refrigerated temperature (*Aspergillus*, *Cladosporium*, *Thamnidium Sp*).



Yeasts also grow and involve in spoilage of food under appropriate conditions. These grow over psychrophilic and mesophilic temperature range.

Storage temperature and spoilage

- ✚ Temperature of storage is most important parameter affecting the spoilage of highly perishable foods (Ex. fish).
- ✚ Nature of food need to be considered while selecting storage temperature. Maintaining all foods at refrigerated temperature is not advisable as it affects the quality of food.

Ideal temperature for storage of most vegetables is 10°C , banana: 13-17°C and refrigerator temperature for most foods.

Relative humidity (RH)

Relative humidity of the food storage environment refers to percentage of moisture present in the atmosphere. RH and water activity are closely related and RH is measure of a_w of the gas phase of atmosphere.

$$RH = 100 \times a_w$$

Effect of RH on food being stored

RH of storage environment influences a_w of foods and growth of microorganisms on food surface. Foods of low a_w stored in high RH environment leads to transfer of water from environment to the food, increasing a_w of food until equilibrium is reached. Condensation of moisture on food surface results in localized regions of high a_w on surface and subsurface. This favors growth of microorganisms which were viable but unable to grow due to low a_w , increases a_w of immediate environment due to metabolic activity of microorganisms which produce water as end product of respiration. Thus microorganisms grow and cause spoilage of food which was considered safe microbiologically due to the growth of microorganisms requiring high a_w .

Foods of high a_w when stored in low RH environment lose moisture, become flaccid and unfit for consumption due to loss of quality.

RH and spoilage of food

- ✚ RH and temperature of environment are related, and as the temperature increases RH decreases.
- ✚ Foods that are susceptible for spoilage by yeasts, molds and certain bacteria should be stored under low RH conditions.
- ✚ Improperly wrapped animal meat kept in refrigerator (high RH) undergone surface spoilage.
- ✚ Selection of suitable RH condition for storage is necessary to avoid surface microbial growth and maintain desirable qualities of food as food may lose/take up moisture under improper RH condition and lose its quality.

Presence and concentration of gases in the environment

Exposure of foods to gases in the storage environment (gaseous environment) affects growth and survival of microorganisms in foods. Since exposure of food to oxygen favors growth of aerobic microorganisms, gaseous environment need to be modified to ensure reduced microbial activity and resultant spoilage. This approach is commonly employed in the preservation of fruits and vegetables.

Gases used to control microorganisms in foods

Carbon dioxide, ozone and nitrogen are most important gases used to control microorganisms in food. Several ready to eat foods are packed in the presence of these gases to reduce microbial activity and extend shelf life of packed foods. Such foods are referred to as Modified Atmosphere Package (MAP) foods.

Carbon dioxide is single most important atmospheric gas used to control microorganisms in foods and is used in varying concentration depending on the type of food. Carbon dioxide in elevated pressure is also used in carbonated water and soft drinks. Molds and Gram negative microorganisms are more sensitive to CO₂ than Gram positive bacteria. *Lactobacilli* are resistant to CO₂. Yeasts show considerable resistance and tolerate high CO₂ level but can cause spoilage of carbonated beverage (Ex. *Brettanomyces* *sp.*)

Mechanism of inhibition

Carbon dioxide mainly acts as bacteriostatic agent. But some microorganisms are killed by prolonged exposure. Mechanism of inhibition of CO₂ is due to the formation of carbonic acid which lowers pH. Lowered pH affects physical properties of plasma membrane of microorganisms and affects solute transport, inhibits key enzymes, and reacts with amino group of proteins causing changes in their property and activity.

Ozone (O₃) is also has antimicrobial properties and extends shelf life of certain fruits and vegetables foods. O₃ concentration of 0.15-5 ppm is known to double the shelf life by inhibiting spoilage bacteria and yeast.

Presence and activities of other microorganisms

The nature of microorganisms (microbial associations) encountered in foods can affect micro-flora of food which are called implicit factors. These include

- Properties of organisms present in food
- Response of these organisms to their environment
- Interaction with other organisms in food

Effect of activities of microorganisms on food micro-flora

- ✦ Among several organisms present in food, microorganisms which find condition suitable (in food) for growth dominate over other organisms. Ex. Molds can grow on dry fish, but slowly, than bacteria. In fresh fish bacteria overgrow molds as conditions are most favourable. Faster growing bacterial growth is inhibited by low a_w or low pH where moulds grow and cause spoilage.
- ✦ Some food borne microorganisms produce metabolite /substances such as antibiotics, bacteriocins, hydrogen peroxide, organic acids etc which are inhibitory /lethal to other microorganisms.
- ✦ Spoilage microorganisms can interact wherein growth of one favours the growth of others. Ex: In low a_w food (grain) growth of few molds increases a_w leading to growth of other xerophilic molds.
- ✦ One organism may increase nutrient availability to others by degrading complex food substrates to simple forms.
- ✦ Some microorganisms may remove inhibitory substances thereby permit the growth of others.