Food as a substrate for microorganism

The interactions between microorganisms,plants,and animals are natural and content.The ecological role of microorganisms and their importance in all the geochemical cycles in nature.Since the human food supplyconsists basically of plants and products derived from them, it is understandable that our food supply can contain microorganisms in interaction with the food.

In most cases microorganisms use our food supply as a source of nutrients for their own growth. This,ofcourse,can result in deterioration of the food.By increasing their numbers,utilizingnutrients, producing enzymatic change,and contributing off-flavors by means of breakdown of a product or synthesis of new compounds they can "spoil"afood.This is a normal consequence of the action of microorganisms,since one of their functions in nature is to convert reduced forms of carbon,nitrogen,and sulfur in dead plants and animals to the oxidized forms required by plants,which in turn are consumed by animals. Sq by simply "doing their thing" in nature they frequently can render our food supply unfit for consumption.To prevent this we minimize the contact b/w microorganisms from our foods, or at least adjust conditions of storage to prevent their growth preservation.

A knowledge of the factors that favors or inhibits the growth of microorganisms is essential to an understanding of the principles of spoilage and preservation.

The chief compositional factors of a food that influence microbial activity are;- hydrogen-ion concentration,moisture,oxidation reduction(o-R) potential,nutrients,and the presence of inhibitory substances or barriers.Relative humidity, Temperature, Gaseous atmosphere.

Intrinsic factors

Hydrogen-ion concentration (pH)

Every microorganism has a minimal, amaximal, and an optimal pH for growth.Microbial cells are significantly affected by the pH of because they apparently have no mechanism for adjusting their internal pH.In general, yeasts and molds are more acid-tolerant than bacteria.The inherent pH of foods varies,although most foods are neutral or acidic. Foods with low pH values(below 4.5)usually are not readily spoiled by bacteria and are more susceptible to spoilage by yeasts and molds. A food with an inherently low pH would therefore tend to be more stable microbiologically than a neutral food.The excellent keeping quality of the following foods is related to their restrictive pH.

Fruits,softdrinks,fermentedmilks,sauerkraut, and pickles, some foods have low pH because of inherent acidity; others, e.g., the fermented products, have low pH because of developed acidity from the accumulation of lactic acid during fermentation.

In general, bacteria grow fastest in the pH ranges 6.0-8.0, yeasts 4.5-6.0 and filamentous fungi 3.5-4.0.As with all generalizations there are exceptions,particularly among those bacteria that produce quantities of acids result of their energy yielding metabolism. Examples important in food microbiology are the lactobacilli and acetic acid bacteria with optima usually b/w pH 5.0 and 6.0.

Molds can grow over a wider range of pH values than can most yeast and bacteria and many molds grow at acidities too greatof yeasts and bacteria.Most fermentative yeasts are favored by a pH of about 4.0 to 4.5 as fruit juices.

Buffer capacities in food,i.e., the compounds that resist changes in pH, are important not only has their buffering capacity but also for their ability to be especially effective within a certain pH ranged. Buffer permits an acid fermentation to go longer with a greater yield of products and organisms than would otherwise be possible.

Not only are the rates of growth of microorganisms affected by pH, so are the rates of survival during storage, heating drying and other forms of processing. Also, the initial pH may be suitable, but because of competitive flora or growth of organism itself, the pH may become unfavorable.

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 divided by the vapor pressure of the solvent.The$a_w$for pure water would be 1.00, and for a1.0 *m* solution of the ideal solute the a_w would be 0.9823.

A_W of food.

The ***aw***of food ranges from 0.1 to 0.99. The *Aw* values of some food groups are as follows;Cerealscrackers,sugar,salt,dry milk,0.10 to 0.20;Noodles,Honey,chocolate dried egg,<0.60; jam,jelly,dried fruits, parmesan cheese,nuts,0.60 to 0.85;Fermented sausage, dry cured meat,sweetened condensed milk,syrup,0.85 to 0.93; Evaporated milk,tomatopaste,bread,fruit juices, salted fish,sausage,processed cheese, 0.93 to 0.98;fresh meat, fish,fruits, vegetables,milk, eggs,0.98 to 0.99.The water activity of foods can be reduced by removing water and increased by the adsorption of water.

Factors affects the $a_w$requirements of microorganisms include the following,

1.The kind solute employed to reduce the a_w.For many organisms, especially molds, the lowest a_w for growth is practically independent of the kind of solute used. Other organisms,however, have lower limiting a_w values with solutes than with others. Potassiumchloride,fore.g.,usually is less toxic than Nacl,and it in turn is less inhibitory than $NaSo_4$.

2.The nutritive value of the culture medium. In general,the better the medium for growth,the lower the limiting a_w

3.Temperature.Most organisms have the greatest tolerance to low a_w at about optimal temperatures.

4.Oxygensupply.Growth of aerobes takes place at a lower a_w in the presence of air than in its absence, and the reverse is true of anaerobes.

5.pH. Most organisms are more tolerant of low a_w at pH values near neutrality than in acid or alkaline media.

6.Inhibitors.The presence of inhibitors narrows the range of $a_w$for growth of microorganisms.

Water activity of microorganism.

Most bacteria grow well in a medium with a water activity a_w approaching 1.00; i.e., they grow best in low concentrations of sugar or salt.Culture media for most bacteria contain no more than 1 percent sugar and 0.85 percent sodium chloride. The optimal a_w and the lower limit for growth vary with the bacterium as well as with food,temperature,pH,and the presence of oxygen, co_2&inhibitors;they are lower for bacteria able to grow in high concentrations of sugar or salt.

E.g.;-Lower limits of a_w for growth of some food bacteria are 0, 97 for *Pseudomonas,* 0.96 for *E.coli.* Other bacteria will grow with the $a_w$below 0.90.Some Optimal a_w figures reported for food bacteria are 0.99 to 0.995 for *Staph. AureusandSalmonella* spp,.0.995 For E.coli.

Molds differ considerably in optimal a_w for germination of the asexual spores.The minimal a_w for spore germination has been found to be as 0.62 for some molds &as high as 0.93 for others. Each mold also has an optimal a_w and range of a_w for growth. E.g., optimal a_w are 0.98 for an *Aspergillus*

Oxidation-reduction potential

The oxygen tension or partial pressure of oxygen about a food &the O-R potential,or reducing and oxidizing power of the food itself, influence the type of organisms whichwill grow and hence the changes produced in the food.The O-R potential of the food is determined by (1)the characteristic of O-R potential of the original food (2) the poising capacity,(3) the oxygen tension of the atmosphere about the food &(4)the access which the has to the food.

The O-R potential of a system is usually written *Eh*& measured &expressed in terms of millivolts(mV).A highly oxidized substrate would have a positive *Eh* ,&a reduced substrate a negative *Eh* .Aerobic microorganisms including bacilli, micrococci, pseudomonades,&acinetobacters require positive *Eh* values or positive mV O-R potentials. Conversely, anaerobes including clostridia &bacteriodes require negative *Eh* values or negative mV O-R potentials.

Most fresh plant & animal foods have a low & well-poised O-R potential in their interior: the plants because of reducing substances such as ascorbic acid & reducing sugars & animal tissues because of-SH &reducing groups.As long as the plant or animal cells respire & remain active, they tend to poise the O-R system at a low level, resisting the effect of oxygen diffusing from the outside.Heating may reduce the poising power of the food by means of destruction or alteration of reducing &oxidizing substances & also allow more rapid diffusion of oxygen inward,either because of destruction of poising substances or because of changes in physical structure of the food.

In the presence of limited amounts of oxygen the same aerobic or facultative organisms may produce incompletely oxidized products,such as organic acids, from carbohydrates, when with plenty of oxygen available complete oxidation to CO_2& H_2O might result. Protein decomposition under anaerobic conditions may result in putrefaction, where as aerobic conditions the products are likely to be less obnoxious.

Nutrient content

The kinds & proportions of nutrients in the food are all-important in determining what organism is most likely to grow. Consideration must be given to (1) foods for energy (2) foods for growth& (3) accessory food substances,or vitamins, which may be necessary for energy or growth.

Foods for energy

The carbohydrates ,especially the sugars ,are most commonly used an energy source, but other carbon compounds mays serves ,e.g., esters,alcohols,peptides, amino acids,& organic acids & their salts .Complex carbohydrates, e.g., cellulose,can be utilized by comparatively few organisms &starch can be hydrolyzed by only a limited number of organisms.Microorganisms differ even in their ability to use some of the simpler soluble sugars Bacteria are classified on the basis of their ability or inability to utilize various sugars &alcohols.

The ability of microorganisms to hydrolyze pectin,which is characteristic of some kinds of bacteria & many molds, is important, of course, in the softening or rotting of fruits & vegetables or fermented products from them.

Foods for growth

Microorganisms differ in their ability to use various nitrogenous compounds as a source of nitrogen for growth. Many organisms are unable to hydrolyze proteins & hence cannot get nitrogen from them without help from a proteolyses organism.

Many kinds of molds are proteolysis,but comparatively few genera and species of bacteria & very few yeast are actively photolytic. In general, photolytic bacteria grow best at pH values near neutrality & are inhibited by acidity, although there are exceptions, such as proteolysis by the acid-proteolysis bacteria that hydrolyze protein while producing acid.

Accessory food substances or vitamins

Some microorganisms are unable to manufacture some or all of the vitamins needed & must have them furnished. Most natural plant & animal food-stuffs contain an array of this vitamin,but some may be low in amount or lacking.Thus meats are high in B vitamins & fruits are low, but fruits are high in ascorbic acid.The processing of foods often reduces the vitamin content. Thiamin, Pentatonic acid, the folic acid group, & ascorbic acid are heat-labile, & drying causes a loss in vitamins such as thiamin &ascorbic.Even storage of foods for longs periods, especially if the storage temperature is elevated, may result in a reuse in the level of some of the accessory growth factors.

Each kind of bacterium has a definite range of food requirements.& growth takes place in a variety of substrates, as is true for coliform bacteria; but for other, e.g., many of the pathogens.

Inhibitory substances and biological structure

Inhibitory substances, originally present in the food, added purposely or accidentally or developed there by growth of microorganisms or by processing methods, may present growth of all microorganisms or, more often, may deter certain specific kinds ,Examples of inhibitors naturally present are the lactenins&anticoliform factor in freshly drawn milk, lysozyme in egg white, & benzoic acid in cranberries. A microorganism growing in a food may produce one or more substances inhibitory to other organisms, products such as acids, alcohols, peroxides & even antibiotics propionic acid produced by the prop ionic bacteria in Swiss cheese is inhibitory to molds.

The effect of **the biological structure** of food on the protection of foods against spoilage has been noted. The inner parts of whole, healthy tissues of living plants & animals are either sterile or low in microbial content. Therefore, unless opportunity has been given for their penetration, spoilage organisms within may be few or lacking.Covering of food e.g. the shell on eggs. Or we may have surrounded the food with an artificialcoating,e.g., plastic or wax.This physical protection of the food not only may help its preservation but also may determine the kind, rate, & course of age.

Extrinsic Factors (Environmental limitation)

Relative Humidity

The relative humidity & water activity are interrelated, thus relative humidity is essentially a measure of the water activity of the gas phase.When food commodities having a low water activity are stored in an atmosphere of high relative humidity water will transfer from the gas phase to the food .It may take a very long time for the commodity to increase in water activity, but condensation may occur on surfaces giving rise to localized regions of high water activity.The increase the water activity of their own immediate environment so that eventually microorganisms requiring a high a_w are able to grow and spoil a food which was initially considered to be microbiologically stable. Large-scale storage units such as grain silos occur because the relative humidity of air is very sensitive to temperature.If one side of a silo heats up during the day due to the sun then the relative humidity on that side is reduced & there is a net migration of water molecules from the cooler side to re-equilibrate the relative humidity.

The storage of fresh fruits & vegetables requires very careful control of relative humidity. If it is too low then many vegetables will lose water & become flaccid. If it is too high then condensation may occur and microbial spoilage may be initiated.

Temperature

Microbial growth can occur over a temperature range from -8^0c up to 100^0c at atmospheric pressure .The most important requirement is that water should be present in liquid state & those available to support growth. Bacteria are normally limited to a temperature span of around 35^0c & molds rather less, about 30^0c

In food microbiology mesophilic&psychrophytic organisms are generally of greatest importance .mesophilic, with temperature optima around 37^0c, arefrequently of humans or animal origin & include many of the common food borne pathogens such as *salmonella, staphylococcusAureus and clostridium perfringens.*

As a role mesophilic grow quickly at their optima then psychrophs and so, spoilage of perishable products stored in the mesophilic growth range is more rapid than spoilage under chill conditions. Because of the different groups of organisms in mold,it can also be differencing character.

Among the organisms capable of growth at low temperatures, two groups can be distinguished: the true or strict psychrophiles have optima of 12-15^0c & will not grow above about 20^0c. As a result of this sensitivity to quite moderate temperatures, psychrophiles are largely confined to Polar Regions the marine environment.The psychrophiles tolerate of a wider range of temperature means that psychrotrophs are found in a more diverse range of habitats and consequently are of greater importance in the spoilage of chilled foods.

Thermopiles are generally of far less importance in food microbiology, although thermopilic spore formers such as certain *Bacilli* and *clostridium* species do pose problems in a restricted number of situations.

As the temperature increase above the optimum, the growth rate declines much more sharply as a result of the irreversible denaturation of proteins and thermal breakdown of the cell’s plasma membrane.At the temperature above the maximum for growth, these changes are stuffiest to kill the organism – the rate at which this occurs increasing with increasing temperature.

Gaseous Atmosphere

Oxygen comprises 21% of the earth's atmosphere & is the most important gas in contact with food under normal circumstances. Its presence & its influence on redox potential are important determinants of the microbial association that develop & their rate of growth.

The inhibitory effect of carbon dioxide(co_2) on microbial growth is applied in modified-atmosphere packing of food; co_2 is not uniform in its effect on microorganisms.Moulds & oxidative gram-negative bacteria are most sensitive & the gram-positive bacteria,particularly the lactobacilli, tend to be most resisted.

The mechanism of co_2 inhibition is a combination of several processes whose precise individual contributions are yet to be determined.One factor often identified is the effect of co_2 on pH.

Other contributory factors are thought to include changes in the physical properties of the plasma membrane adversely affecting solute transport; inhibition of key enzymes,particularly those involving carboxylation/decorboxylation reaction in which co_2 is a reactant; & reaction with protein amino groups causing changes in their properties & activity.

Combined effects of factors affecting growth

Each of the compositional factors of foods- a_w, pH, O-R potential,& nutrient content- can significantly affect the resulting microbial flora. Many of these factors interact,& therefore one must be concerned with the total ecology of the food.For example, a microorganism growing near its optimal pH will be more tolerant to changes in a_w than will one growing close to its minimal or maximal pH, Therefore, a combined inhibitory effect of an unfavorable pH &a_w can be noted. To prevent and retard growth,several of these factors can be manipulated rather then adjusting one to an inhibitory level.

Factors affecting the germination of spores of clostridium botulinum have indicated interactions or combined effects involving water activity, pH, and temperature O-R potential, and sodium chloride and sodium nitrate concentrations'. Techniques for describing the effect of two factors affecting growth (pH and a_w) plus temperature have been used to predict the level of a possible hazard resulting from the growth of *staph. Aureus* and *salmonella typhimurium.*

Conclusion

By this topic I conclude that, Foods are the substrate for the growth of the microorganisms it supply the nutrients to for their survival. It leads to spoilage of foods because of the increase in the microbial load on the food. Hence individuals use the food preservative for preserve the food & also check the odour, texture, color, etc, before use.

References

1. Microbiology -4th Edition

William C.Frazier &Dennis C.Westhoff

2.Microbiology-An application based approach

Pelczar, Chan,& Notel Krieg
Tata McGraw Hill Education Private limited
Pg No;-843

2. A text book of Microbiology

Chandrakanth Kelmani

United publishers

Pg.No;-1-3