

Paper Title: Food microbiology
Module – 20: Microbial spoilage of foods

1. Introduction

The microorganisms (although invisible) are present in soil, water, air and even in and on our bodies. Therefore, they can enter the food and grow rapidly if conditions are suitable for their growth and multiplication. This can lead to food spoilage that brings a disagreeable alteration in normal state of food making it unsuitable for human consumption or industrial uses. Spoilage of food can also cause wastage of food due to deterioration and can reduce the nutritive value of food. The food spoilage can be broadly classified on the basis of food item.

A : Stable or non-perishable foods like flour and sugar.

B: Semiperishable foods like apple that remain unspoiled if handled and stored properly.

C: Perishable foods like milk that spoil easily without special preservative methods.

The spoilage microbes can cause a variety of changes in the food items as discussed below:

A. Unwholesome effects due to biogenic amines, toxins and metabolites of pathogenic microorganisms.

B. Changes in organoleptic features like color change, texture problem, production of flavor and aroma compounds by spoilage organisms as given in Tables 1, 2 & 3.

Table 1: Flavour /aroma products

Flavour/ aroma	Food	Chemical	Organisms
Nitrogenous	Egg, Meat, Fish	NH ₃ , H ₂ S	<i>Pseudomonas</i> <i>Clostridium</i> , Lactic acid bacteria, <i>Bacillus</i>
Souring	Dairy, beer, wine	Acetic, Citric and	Lactic acid bacteria,

		Lactic acids	<i>Bacillus.</i>
Alcoholic	Fruit Juice	Ethanol	Yeast
Garlic	Vegetables etc.	Trimethylarsine	Unknown
Fruity	Meat	Ester of short chain fatty acids	<i>Pseudomonas</i>
Potato like	Meat, egg.	2methoxy3isopropyl pyrazine	<i>Pseudomonas</i>

Table2: Texture problem

Texture	Food	Chemical or Bio-Chemical Causes	Organisms
Slime	Meat, Confectionary	Polysaccharides	<i>Pseudomonas</i> <i>Leuconostoc</i> <i>Bacillus</i>
Ropiness	Bread, Milk	Polysaccharides	<i>Alcaligenes</i> <i>Bacillus, Leuconostoc</i>
Holes	Hard cheese	Gas production	Coliforms
Softening or rotting	Fruits and vegetables	Pectinase, Cellulase, Xylanase	<i>Erwinia</i> , <i>Clostridium</i>
Curdling	Milk, Meat	Acid Production	Yeast, Lactic acid Bacteria.

Table 3: Color Change

Problems	Organism
Red spot	<i>Lactobacillus plantarum</i>
Browning	<i>P. nigrifaciens</i>
Blackening	<i>Lactobacillus viridescens</i>

Purple color	<i>Halobacterium</i>
Greenish color	<i>Pseudomonas</i>
Bluish green color	<i>Penicillium</i>
Pink	<i>Rhizopus , Serratia.</i>

2. Biochemical changes causing food spoilage

Most of the changes brought about in foods are due to alteration in biochemical properties of the food by microbes. These can be due to carbohydrate, protein, lipid or pectin degradation.

2.1 Carbohydrate decomposition

When degraded by microorganisms, they produce CO₂, H₂, lactate, acetate, butyrate, isovalerate, ethanol, propanol, butanol, diacetyl, acetoin, butanediol, dextran etc. depending upon nature of carbohydrate and type of microorganism involved. The food stuffs may turn slimy and they may taste or smell unpleasant and are termed stale foods.

Different types of fermentations can be classified as:-

Fermentation	Product
Alcoholic	Ethanol, CO ₂
Homofermentative	Lactic Acid
Heterofermentatic	Lactic acid, acetic acid, ethanol, CO ₂ .
Propionic acid	Propionic acid, acetic acid, CO ₂ .
Butyric Acid	Butyric acid, CO ₂ , H ₂ .
Mixed Acid	Lactic acid, acetic acid, H ₂ , Ethanol, CO ₂ , butanediol, formate.

Most common out of them are butyric acid, mixed acid and butanediol fermentations.

2.2 Protein decomposition

Proteins are degraded by microorganisms into CO₂, H₂, H₂S, amines, keto acid, mercaptans, organic acid, putrescine, cadaverine etc. In other words, proteins undergo putrefaction and foods rot and produce a very bad smell. However, protein degradation does not start until there is lack of nitrogen source. Once it happens, proteases and peptidases are secreted by microorganisms and protein is degraded into amino acids. Many peptides contribute to spoilage due to their bitter or sweet taste.

2.3 Lipid degradation

Lipids are degraded by microorganisms into fatty acid, glycerol, aldehydes, ketones etc. This is also called rancidity and it produces bad smell and taste when food becomes old. The lipid peroxidation requires factors like oxygen, fat with unsaturated fatty acid, light, high temperature and metal ion. Alcohols, ketones, aldehydes thus produced impart an unpleasant odour and taste. β -oxidation is a common method of fat degradation and each time breakdown produces acetyl coA and fatty acid shorter by 2C atoms. In addition to this, some fungi have lipoxydases that oxidize the unsaturated fatty acid to hydroperoxide and ultimately aldehyde and ketones. The lipid degradation can be avoided by reducing exposure to O₂, adding antioxidants ; and by lowering temperature.

2.4 Pectin hydrolysis

Pectins are carbohydrates of partially methylated poly- α - (1-4)-D- galacturonic acid. Pectin present in fruits and vegetables provides mechanical rigidity. Pectin can be degraded by pectinases that may get activated upon ripening of fruits. It may turn the fruit soft. Once mechanical damage has taken place, microbial attack is initiated .

In general, preference of spoilage is carbohydrates, followed by proteins and lipids. However, amount and availability of carbohydrate and degrading microorganism is also equally important.

3. Sources of Microorganisms Causing Food Spoilage

3.1. Primary Sources

Viable organisms are found in very wide range of habitats; from polar regions to hot spring; from highly acidic to alkaline conditions; in the presence as well as absence of oxygen. In addition to this, they are also found on surface of plants and animals. This normal flora can affect original quality of raw material used in

manufacture of food, the type of contamination during processing, food spoilage or food borne illness. Therefore, the normal flora of food, soil, water or atmosphere it is exposed to while preparation contributes a major role in microbial spoilage of food.

3.1.1 Microorganisms in air

Air is only a means of dispersal rather than growth of microorganisms. Air contains many Gram +ve rods and cocci, including flora generated from animal or human source or water. Common examples of bacteria in air are *Micrococcus*, *Corynebacterium*, *Bacillus*, *Streptomyces* etc. Common fungi found in air include spores of *Penicillium* and *Aspergillus* besides *Fusarium* and *Cladosporium*. Coughing and sneezing also generate aerosol that may carry viable microorganisms

3.1.2 Microorganisms of soil

Soil has got diverse microflora like bacteria, protozoa, fungi and algae. Therefore, food should be protected from dirt to reduce spoilage. Moreover, soil is a reservoir of resistant structures like endospores of *Bacillus* and *Clostridium* and chlamydospores and sclerotia of many fungi that can easily spoil foods.

3.1.3 Microorganisms of Water

Freshwater of rivers and lakes have microflora of terrestrial animal and plant sources. It can also act as vehicle for bacteria, protozoa, viruses etc. leading to spoilage of food if it is used for washing the foods.

3.1.4. Microorganisms of Plants

Plant surfaces have natural microflora called phylloplane flora (on leaf) and rhizoplane flora (on roots) and this can include fungi like *Cladosporium*, *Penicillium*, *Aspergillus* etc. yeast of genera *Sporobolomyces* and *Bullera* and some bacteria like *Erwinia*, *Pseudomonas*, *Xanthomonas*, *Lactobacilli*, *Streptococci*, *Leuconostoc* etc. *Erwinia* can cause blackleg disease of potato; and soft rot of potatoes during storage. Fungi like *Botrytis cineria* may infect strawberry. Cereal grains can be infected by *Cladosporium*, *Alternaria*, *Chaetomium*, *Helminthosporium*, *Penicillium*, *Aspergillus* etc.

3.1.5 Microorganisms of Animals

Intestinal tract of animals has many microorganisms and if shed into waterbodies can cause spoilage of food when used for washing foods. Their skin also contains many microorganisms that can cause food contamination. *Staphylococcus* and *Corynebacterium* are important in this regard.

3.2 Utensils

The utensils used to store the harvested fruits and vegetables are contaminated with surface organisms present on them. These may lead to contamination of other products put into them later on.

3.3 Food handlers

Microorganisms on hands and outer garments of handlers can contribute towards microflora of the concerned food. Nasal cavity and mouth are also important sources of microorganisms.

4. Other Parameters of Food Spoilage

In addition to this above factors, food spoilage has also been co-related with intrinsic extrinsic and implicit factors.

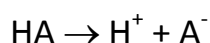
4.1 Intrinsic Parameters

These are the parameters that are the inherent properties of the food .They include:

- pH
- Moisture content.
- Nutrient content.
- Antimicrobial constituents.
- Oxidation Reduction potential.

4.1.1 pH

pH is a very important factor in food spoilage. Most microorganisms prefer a pH of around 7.0 (bacteria) but some can grow even below pH of 4.0 (mainly fungi or acidophiles) ; or at pH around 11.0. Many foods naturally have weak acids like acetic acid and citric acid present in them eg. some citrus fruits. The acids can dissociate depending upon pH of solution as follows :-



Undissociated acids can cross cell membrane and when they enter the cell, internal pH becomes higher than the pH outside and these acids become dissociated into H^+ and A^- . Once internal surface is acidified, there is a breakdown of normal membrane transport system, inhibition of normal biochemical pathways and cell growth leading to spoilage of food . However, the rate of microbial growth, toleration to heat, drying etc. is decreased with reducing pH. pH of a food can be naturally acidic as in citrus fruits, or it can be turned acidic by adding an acid; or due to fermentation products like lactic acid .

Common foods have been categorized according to the following pattern :-

High Acid	pH < 4.5	Lemon/ Raspberry
Medium acid	pH 4.5 – 5.0	Bread/ Cheese
Low Acid	pH 5.0 – 7.0	Milk, vegetables.
Alkaline	pH > 7.0	Eggs.

Different microorganisms need a different pH for growth and this pH range of growth of different types of bacteria is represented as :

Microorganisms	Minimum pH	Optimum pH	Maximum pH
Gram+ve Bacteria	4.0	7.0	8.5
Gram-ve bacteria	4.5	7.0	9.0
Yeast	2.0	4.0-6.0	8.3 – 9.0
Mold	1.5	7.0	11.0

Acidophilic bacteria include Lactic acid bacteria- LAB while alkalophilic bacteria include *Vibrio cholerae*.

4.1.2 Moisture content

The water requirement of a microorganism is represented as a_w . All microorganisms have optimum and minimum a_w requirement. The maximum limit for growth of microbes is almost less than 1.0. Yeast and mold, however, can tolerate lower a_w than bacteria. The Gram +ve bacteria have lower a_w than

Gram –ve bacteria. The a_w is an important factor since it affects growth, toxin production, spore germination and heat resistance of microorganisms. With decrease in a_w , the heat resistance increases. Generally microorganisms do not grow at a_w less than 0.60 and pathogens are inhibited at a_w less than 0.9 except for *Staphylococcus aureus*. Many fresh foods have very high a_w value (0.98 – 0.99).

The different microbes need different minimum a_w for their growth as represented :

Microorganism	a_w
Spoilage bacteria	0.90 – 0.91
Spoilage yeast	0.87 – 0.94
<i>Clostridium botulinum</i>	0.70 – 0.80
<i>Salmonella</i>	0.95- 0.96
<i>S. aureus</i>	0.86-0.92

Completely dehydrated foods have a_w 0.0 . The a_w can be controlled by methods like drying, addition of salt, sugar or by concentrating them.

4.1.3 Nutrient Content

Chemical composition of a food item generally influences the type of spoilage microbe as well the products liberated during growth. Foods rich in nutrients have microbes that are generally chemoheterotrophs using organic compounds as source of energy and carbon requirement. Foods also provide enough water, nitrogen, minerals and vitamins to microorganisms.

4.1.4 Antimicrobial Substances

Some foods naturally contain the antimicrobial substances to prevent them from spoilage. These substances have been reported from plants, foods as well as microorganisms.

4.1.4.1 Plants

They contain antimicrobial agents like eugenol in cloves, cinnamon etc; allicin in garlic, onion; and thymol in oregano. They are reported to act on cell membrane of microorganisms.

4.1.4.2 Foods

Eggs contain antimicrobial agents like lysozyme that weakens cell wall of Gram +ve bacteria; conalbumin that chelates metals; avidin that binds biotin; ovoflavoprotein that sequesters riboflavin. Milk contains lactoperoxidase system. Hypothiocyanite is an oxidizing agent present in foods that can inhibit growth and metabolism of many gram +ve and Gram-ve bacteria. Lactoferrin is an iron binding protein inhibitor that inhibits microbes. Fatty acids present in foods are also bacteriostatic.

4.1.4.3 Microorganisms

They contain H_2O_2 , organic acids and bacteriocins as the antimicrobial agents. Bacteriocins are antimicrobial proteins that can inhibit related bacteria and have a narrow inhibitory spectrum. They are added to dairy items like cheese and also in canned products to prevent bacterial spores.

4.1.5 Oxidation Reduction Potential

The Redox potential of a substrate is the ease of particular substrate to either gain or lose electrons. It is represented as E_h and is measured in terms of millivolts. It depends upon available oxygen, pH and access of food to atmosphere. The microbes are classified according to their oxygen requirement as:-

- (i) Microaerophilic :- Require O_2 at less than atmospheric level.
- (ii) Obligate aerobe:- They require sufficient amount of O_2
- (iii) Obligate anaerobe :- Oxygen may be harmful.
- (iv) Facultative anaerobe :- Grow well in presence as well as absence of oxygen.

In presence of oxygen, some extremely toxic superoxide radicals are made. However, the microbes that can grow in presence of O_2 have an enzyme system that can detoxify harmful by-products. This includes catalase, peroxidase etc. The value of E_h can be controlled by vacuum packaging, skin tight packaging.

4.2 Extrinsic Parameters

These parameters refer to the factors involved in processing, handling of food etc. The various extrinsic parameters contributing to food spoilage are:-

- Temperature.
- Humidity.
- Atmospheric conditions.
- Processing, hygiene, cleaning.

4.2.1 Temperature

The spoilage microbes of food have been found to grow from - 10°C to 80°C. If the temperature of storage is below the temperature required for growth of spoilage organism, the growth of the pathogen may stop temporarily. However, if the temperature exceeds the maximum temperature tolerated by microbes; the pathogen is harmed. Commonly, mesophiles grow from 20-45°C, psychrotrophs (-5 to 35°C), and thermophiles (40-80°C). However, most of the pathogens are mesophilic. Storage at low temperature therefore inhibits most microbes but for *Listeria monocytogenes*, *Yersinia*, *Vibrio parahemolyticus* and *Clostridium botulinum*. *C. botulinum* can grow at temperature as low as 10°C; *S. aureus* at 7°C and *Salmonella typhimurium* at 5-6°C. At chilling temperature, psychrotrophic and psychrophilic organisms are mainly encountered. The a_w , pH, pO_2 of storage temperature also play an important role in spoilage. At -18°C, almost all microbes are inhibited. However, gram -ve organisms are more sensitive at this temperature although *Salmonella* may survive.

4.2.1 Atmospheric conditions

An increase in CO_2 concentration and decrease in O_2 concentration is reported to inhibit aerobic microbes and moulds. The modified atmosphere generally called Modified Atmosphere for Packaging (MAP) can have an influence on food spoilage. Modification of atmosphere can be done by active or passive methods. The active methods include vacuum in packaging and using O_2 adsorbent while passive effects are brought about by respiration of microbes in the product.

4.2.3 Humidity

The packaging of the foods should be moisture proof. Any fresh food loses slight water during storage. Products with low a_w stored in humid conditions, absorb moisture and go mouldy. The chilled foods, if exposed to warm damp air show moisture condensation on foods leading to rapid bacterial growth.

4.2.4 Processing, hygiene and cleaning

The raw material always contains microflora. This can be reduced by washing, sorting and peeling, good hygiene practices and cleaning by good quality water. On the other hand, comminuting, mincing and putting additives increase microbial number. The chilled minced meat having low a_w , high O_2 and high E_h has been found to be rich in *Pseudomonas* & *Acinetobacter*.

4.3 Implicit Parameters

In addition to intrinsic and extrinsic parameters, implicit parameters like growth and reproduction rate, generation time and association between spoilage microbes are important. Dominant microbes grow faster than others. If a_w is >0.98 and $pH > 4.5$, bacteria predominate as spoilers. Interactions exist between microbes due to utilization of nutrients, alteration in pH , alteration in E_h , alteration in a_w and production of metabolites like antibacterial substances or vitamins that affect the type of microflora in the food.

5 Types of Spoilage Microbes

5.1 Bacteria

They are the most abundant microbes in nature and a variety of them can spoil different kind of food items. The common type of bacteria that can spoil food may belong to one of the following types:-

- Psychrotrophs.
- Thermotolerant psychrotrophs.
- Mesophiles.
- Thermophiles.
- Thermotolerant vegetative bacteria.
- Acidophiles.
- Gram -ve rods.
- Gram +ve spore formers.
- Lactic acid bacteria.
- Gram +ve vegetative bacteria.

5.1.1 Psychrotrophs

They can be either aerobic or facultatively anaerobic. Aerobes include *Pseudomonas*, *Moraxella*, *Flavobacterium* etc. while facultative anaerobes include *Leuconostoc*, *Lactobacillus saki*, *L. viidescens*, *L. curvatus*

5.1.2 Thermotolerant Psychrotrophs

They can be facultative anaerobic spore formers as *Bacillus coagulans*, *B. megaterium* or anaerobic spore formers like *Clostridium lavamie*, *C. estertheticum*, *C. algidicarni*.

5.1.3. Mesophiles

If food is kept at temperature greater than 5°C, true mesophilic bacteria grow.

5.1.4 Thermophiles

They grow between a temperature range of 40-90°C with optimum temperature 55-65°C. Heat treated food contains spores of thermophilic bacteria like *Bacillus and Clostridium*.

5.1.5. Thermotolerant Vegetative Bacteria

They survive low heat processing and can enter the food as post heat contamination. They can grow at temperature around 50°C.

5.1.6. Gram –ve rods

They include coliforms like *Escherichia*, *Enterobacter*, *Klebsiella*, *Proteus*, *Serratia*, *Hafnia*, *Erwinia* etc.

5.1.7 Gram +ve sporeformers

Bacillus and Clostridium are important in this category. They survive longer than vegetative cells.

5.1.8 Acidophiles

They grow on foods with pH 4.6 or less and can spoil fruit juice, pickle, fermented sausage etc.

5.1.9 Lactic acid bacteria

They cause souring of foods and can grow even at chilling temperature eg. *Lactobacillus*, *Streptococcus*, *Leuconostoc*.

5.1.10 Gram +ve Vegetative Bacteria

Brocothrix, *Micrococci* are important in this category. They can induce pungent and cheesy odor. *Micrococcus* can spoil food with high salt concentration. They can also cause slime production in fresh milk.

5.2 Moulds

They develop as multicellular structures visible to naked eye and generally grow from spores present in air. They grow as fluffy mass, prefer moisture and temperature of 20-40°C. They are active at refrigeration temperature but are destroyed above 70°C. They prefer acidic pH for growth. Food with fungal growth may appear safe to eat since growth is limited mainly to surface but harmful substance produced may be present in the entire food and therefore it should not be consumed. The growth of molds is generally accompanied by production of enzymes that breakdown food and cause spoilage. In addition to this, mycotoxins may also be produced. Common moulds in food spoilage are given in Table 4.

Table 4: Food Spoilage caused by moulds

MOULDS	Disease	Plant
<i>Alternaria</i>	Stem end rot, black rot, brown to black rot.	Citrus fruits, Apple, Fig.
<i>Aspergillus</i>	Black rot	Peach, citrus fruit
<i>Botrytis</i>	Grey mold rot	Carrot, lettuce, cabbage, apple, pears, grapes, citrus fruit etc.
<i>Cladosporium</i>	Black spot	Mutton
	Black rot	Grapes
<i>Mucor</i>	Black spot	Mutton
<i>Geotrichum</i>	Sour rot	Fig
<i>Fusarium</i>	Dry rot	Tomato, cucumber

	Brown rot	Citrus fruit, Pineapple
	Soft rot	Fig
<i>Penicillium</i>	Blue and green mould rot	Apples, grapes, pears.
<i>Colletotrichum</i>	Brown, black spot	Mangoes, papaya
<i>Phytophthora</i>	Brown rot	Tomato, potato
<i>Pythium</i>	Cottony leaks	Cucumber, Legume
<i>Peronospora</i>	Downy mildew	Onion, Brassica.
<i>Rhizopus</i>	Soft rot , Watery soft rot	Legume, carrot , apples ,figs

Other moulds leading to food spoilage are from genera *Tricothecium*, *Cephalosporium*, *Diplodia*, *Neurospora*, *Cephalosporium* and *Chrysosporium*.

5.3 Yeast

They are unicellular microbes resembling fungi, larger than bacteria, oval, elliptical and 5-8 μ m in diameter or larger. They divide by budding or fission, grow at highly acidic pH, high alcohol and sugar concentration. Some yeast grow as red or pink colored microbes. Some important yeast and foods affected by them are given in Table 5.

Table 5: Foods spoiled by some common Yeast

Yeast	Foods
<i>Candida</i>	Poultry, dates, pineapple.
<i>Cryptococcus</i>	Strawberry
<i>Hanseniaspora</i>	Fig, tomato, strawberry, dates, fig, citrus fruit

<i>Kluyveromyces</i>	Fruits and cheese.
<i>Pichia</i>	Fresh fish, shrimp, olive, tomato.
<i>Rhodotorula</i>	Poultry, shrimp, olive, butter surfaces.
<i>Saccharomyces</i>	Tomato sauce, mayonnaise, salad dressing, soft drink, fruit juice, olive, dates, fig.
<i>Trichosporon</i>	Shrimp, poultry
<i>Zygosaccharomyces</i>	Mayonnaise, salad dressing
<i>Torulopsis</i>	Sauerkraut, cucumber, fig.

5.4 Viruses

They do not generally grow or multiply in food but can survive on food. Common viruses present on food can be Rotavirus, Hepatitis A virus, Norwalk virus.

6. Microbial Examination of Food

The examination of food for types and numbers of microorganisms is very important to comment on food quality. There are four basic methods used to count or estimate the total numbers of microbes present in a food .

- Standard plate count (SPC) for viable microbes.
- Most probable number (MPN) method.
- Dye reduction test (Methylene blue/ Resazurin).
- Direct microscopic count (DMC) .

6.1 Standard plate count

For this, portions of food samples are homogenized, serially diluted and plated on suitable agar medium, incubated for fixed time at optimum temperature and colonies counted by Quebec colony counter. It is one of the most widely used methods for counting the number of viable cells in a food product. The food sample can be spread on a premade media plate (spread plating); or pour plating method . Based on the number of total viable count (TVC) , spoilage spectrum can be ranged as below :

Range A : TVC 10^3 - 10^6 cfu/g

- Range B : TVC 10^6 - 10^7 cfu/g
- Range C : TVC 10^7 - 10^8 cfu/g
- Range D : TVC 5×10^7 - 10^8 cfu/g
- Range E : TVC $>5 \times 10^8$ cfu/g

6.2 Most probable number

In this technique, dilutions of food sample are prepared. Three serial dilutions are then plated into 15 or 9 tubes of an appropriate medium for 3 or 5 tube method. The approximate number of bacteria in a given food sample are determined from standard MPN table given in manuals. It is a statistical method and number of microbes generally comes out to be higher than SPC.

6.3 Dye Reduction

Methylene blue and Resazurin dyes are used in this procedure to estimate count of viable microbes in a product. In this method, properly prepared supernatants of foods are added to standard solutions of methylene blue or resazurin and color change from blue to colourless in case of Methylene Blue and red to colourless in case of Resazurin that gives an idea of microbial load. In this method, time taken for reducing dye to change color is inversely proportional to the number of microbes in a sample.

6.4 Direct Microscopic Count

In this method, smears of food product are made on microscopic slide, stained with dye and cells counted under 100X objective of microscope. Breed's smear test is a modification of this method in which 0.01ml of sample is added to 1cm^2 area on slide and after fixing, defatting and staining, microbes or clumps are counted.

7. Indicators of Food Safety

Some microbes and /or their metabolites in foods at certain levels can be used to assess the existing quality of food as represented in Table 7 and 8 .

Table 7: Corelation of metabolites and food quality

Metabolite	Food quality
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Cadevarine, Putrescine	Vacuum packed food.
Diacetyl	Frozen fruit concentrate
Histamire	Canned tuna
Lactic Acid	Canned vegetables
Trimethylamine (TMA)	Fish
Total volatile base (TVB)	Seafish
Total volatile Nitrogen (TVN)	Seafish
Volatile fatty acid	Butter

Table 8 : Microbes as indicators of food quality of some foods

Microbe	Product
<i>Acetobacter</i>	Fresh cider
<i>Bacillus</i>	Bread dough
<i>Clostridium</i>	Hard cheese
<i>Lactic Acid bacteria</i>	Beer, wine
<i>Leuconostoc mesenteroides</i>	Sugar
<i>Yeast</i>	Fruit Juice
<i>Pseudomonas putrifaciens</i>	Butter

8. Summary

The microbes are present almost everywhere and can enter the food items leading to their spoilage . Spoilage can turn the food unfit for consumption ;can

cause diseases ; and lead to huge economic losses . Spoilage can be indicated by production of flavor products ,change in texture ,bad odour or bad taste .Microorganisms bring about biochemical changes in constituents of food like carbohydrates , lipids , proteins and pectin that lead to spoilage of food . Many intrinsic , extrinsic and implicit parameters also contribute in spoilage of food . The chief categories of microbes causing food spoilage are bacteria , yeast and mould . Acidic foods are prone to damage by yeast and mould as compared to foods with neutral pH that are spoiled by bacteria . The microbial load of a food item can be determined by various methods like SPC, MPN or DMC .

