B.TECH FOOD TECHNOLOGY **2018-2019**

Semester-III

18BTFT303 **FOOD MICROBIOLOGY** **3H-3C**

Instruction Hours/week: L:2 T:1 P:0 **Marks:** Internal**:40** External**:60** Total**:100**

End Semester Exam:3 Hours

Course Objectives

- Describe the basic concepts and factors affecting the growth of microorganisms.
- Define the preservation of foods using temperature as a parameter.
- State the role of drying, additives and radiation in the food preservation..
- Investigate the microorganisms associated with the food fermentation processes.
- Explain food borne illness and sanitation in food industries.

Course Outcomes

1. Recognize the general concepts and factors affecting the growth of microorganisms.
2. Apply the different temperature range as a control agent for food preservation.
3. Employ the methods include drying, additives and radiation to prevent microbial spoilage.
4. Use microbial cultures for preparing various fermented food products.
5. Evaluate the pathogenesis of food borne pathogens and food poisoning.
6. Assess the bacteriology of water and sanitation measures in food industries

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UNIT I FOOD AND MICROORGANISMS

General concepts about molds, bacteria and yeasts. Factors affecting growth of microorganisms – pH, water activity, oxidation – reduction potential, nutrient content, inhibitory substances and biological structure – combined effects of factors affecting growth.

UNIT II MICROBIOLOGY OF PRESERVATION – HIGH AND LOW TEMPERATURES

Heat resistance of microorganisms and their spores, Determination of heat resistance Effect of high temperature on microbes – TDT, D value, Z value, 12D concept, F value**.** Pasteurization and canning Growth of microorganisms at low temperatures, temperatures employed in low temperature storage, Freezing – preparation, freezing and changes occur in foods, response of microorganisms to freezing,

UNIT III MICROBIOLOGY OF PRESERVATION – DRYING, ADDITIVES AND RADIATION

Drying – Methods, factors in the control of drying, treatments before and after drying, microbiology of dried foods and specific dried foods, IMF. Additives – Antimicrobial preservatives, antibiotics and developed preservatives. Radiation – Ultraviolet radiation, factors influencing, ionizing radiations - effect on microorganisms and foods, Microwave processing.

UNIT IV FOOD FERMENTATION

General principles of culture maintenance and preparation – Bacterial, Yeast and mold cultures. Manufacture, spoilage and defects of Bread, malt beverages – beer and related beverages, wines, distilled liquors, vinegar, fermented vegetables – sauerkraut and pickles, fermented dairy products – yogurt, kefir, kumiss, probiotics and prebiotics cheese, oriental fermented foods – soy sauce, tempeh, miso, ang-khak, idli, natto, soybean cheese, Minchin, fermented fish, preserved eggs, and poi.

UNIT V FOOD BORNE ILLNESS AND SANITATION

Food borne diseases – Clostridium, E.coli, Listeria, Bacillus, Mycotoxins – Aflatoxin, Patulin and ochratoxin, seafood toxicants – shellfish poisoning, ciguatera, scombroid fish poisoning, poisoning by chemicals, Bacteriology of water supplies – Sewage and waste treatment and disposal – Microbiology of the food product - Good Manufacturing Practices (GMP) – Hazard Analysis and Critical Control Points (HACCP).

SUGGESTED READINGS

1. Adams M.R and Moss M.O. (2008). Food Microbiology. 3rd Edition RSC Publishing.
2. William C Frazier and Dennis C. West off. (2014). Food Microbiology. 5th Edition. Springer, The Mc Graw-Hill Companies,.
3. James M. Jay.(2005).Modern Food Microbiology. 4th Edition.CBS Publishers and Distributors Pvt. Ltd.

Food Microbiology

Unit - 2

Heat Resistance of Microorganisms and their spores

1. The heat resistance of microorganisms usually is expressed in terms of their thermal death time, which is defined as the time it takes at a certain temperature to kill a stated number of organisms (or spores) under spaified conditions.
2. This sometimes is referred to as the absolute thermal death time to distinguish it from the majority thermal death time for killing most of the cells or spores present and the thermal death rate, expressed as the rate of killing.
3. Thermal death point, now used little, is the temperature necessary to kill all the organisms in 10 min.
4. The reports of different workes on the comparative heat resistance of various kinds of yeasts, molds and bacteria and their spores do not entirely agree due to the differences between the cultures used and the conditions during heating.

Heat resistance of yeasts and yeast spores

1. The resistance of yeasts and their spores to moist heat varies with the species and strain and with the substrate which they are heating.
2. Asiospores of yeasts need 5 to 10°c more heat than vegetative cells.
3. Most asiospores are killed by 60c for 10 to 15 min, a few are more resistant, but none can survive even a brief heating at 100c
4. Vegetative yeasts usually are killed by 50 to 58°c for 10 to 15 min.
5. Both yeasts and their spores are killed by the pasteurization treatment given milk (62.8°C for 30 min or 71.7°C for 15 sec)
6. Yeasts in bread are readily killed during baking of bread, where the temperature reaches about 97°C.

Heat resistance of Molds and mold spores

- Most molds and their spores are killed by moist heat at 60°C in 5 to 10 min, but some are heat resistant.
- The asexual spores are more resistant than ordinary mycelium and requires a temperature 5 to 10°C higher for their destruction in a given time.
- Many species of Aspergillus, Penicillium and Mucor are more resistant to heat than other molds.
- A very heat resistant mold on fruits is Byssochlamys fulva, with resistant ascospores.
- Sclerotia are difficult to kill by heat, can survive a heat treatment of 90 to 100°C, known to cause spoilage in canned foods / fruits.
- It was found that 1000 min at 82.2°C or 300 min at 85°C was necessary to destroy sclerotia.

Heat Resistance of Bacteria and Bacterial Spores

- The heat resistance of vegetative cells of bacteria varies widely with the species
- A few general statements can be made about the heat resistance of vegetative cells of bacteria:
  1. Cocci usually are more resistant than rods
  2. Bacteria with higher optimal and maximal temperatures for growth, the greater the resistance of heat.
  3. Bacteria that clump or form capsules are more difficult to kill than those which do not.
  4. Cells high in lipid content are harder to kill than other cells.

Thermal Death Times of Bacterial Cells

Bacterium	Time, (min)	Temperature °C
Neisseria gonorrhoeae	2-3	50
Salmonella typhi	4-3	60
Staphylococcus aureus	18-8	60
Escherichia coli	20-30	57-3
Streptococcus thermophilus	15	70-75
Lactobacillus bulgaricus	30	71

Thermal Death times of Bacterial Spores

Spores of	Time to kill at 100 C. (min)
Bacillus anthracis	1.7
Bacillus subtilis	15 - 20
Clostridium botulinum	100 - 330
Clostridium calidotolerans	— 520
Flat sour bacteria	over 1.030

Heat Resistance of Enzymes

- Although most food and microbial enzymes are destroyed at 79.4°C, some may withstand higher temperatures - short time heating is employed.
- One of the goals of thermal process is to inactivate enzymes that can cause product deterioration during storage.
- Generally, thermal processes designed to inactivate microorganisms will also inactivate enzymes.
- Some proteinases and lipases are active after an UHT process.
- These activity of these enzymes may spoil the processed product during long-term storage.
- Another, enzyme, bovine phosphatase is actually used as a "monitor" in the pasteurization of milk.
- Detection of the bovine enzyme in processed milk usually indicates that the milk was not properly pasteurized.

Determination of heat resistance (Thermal Death time)

- The complete discussion of all aspects of thermal resistance determinations can be found in the National Canners Association Manual (1968)
- Only the more followed method by Canning laboratories is outlined.

Tube Method

- ~~Tubes are~~ A quantity of standardized spore (or cell) suspension in a buffer solution or a food liquor is sealed in small glass tubes, which are heated in a bath thermostatically controlled at a selected temperature.
- Tubes are removed periodically, cooled immediately, and either incubated directly or subcultured into an appropriate medium for incubation to test for the growth of survivors.

Preparation of the spore (or cell) suspension

1. Several bacteria are used as 'test-organisms' depending on the process employed.
2. The organisms to be tested are grown in a culture medium, with particular temp or time, which will produce resistant spores (or cells).
3. They are washed from media or centrifuged from liquid media, usually are washed and made into a suspension.
4. The clumps may be removed by shaking with glass beads, Sand or by filtration through cotton, gauze, filter paper.
5. These suspensions again re-incubated for 24 hr to complete sporulation.
6. These spore suspensions are pasteurized to kill vegetative cells.
7. The number of spores per unit volume of suspension is determined by a cultural or direct count method.
8. The known concentration of spore suspensions are transferred into 1 ml glass vials, which are sealed and refrigerated.
9. These spore suspensions may be heated in a phosphate buffer, food or food liquor.
10. The volume added may be small (1 or 2%), Appx : 1 million (1×10^6) cells per ml is recommended.

Heating to determine the thermal death time

1. The heating of the vials is done in an agitated and thermostatically controlled bath of oil for higher temperatures or water for temperatures below 100°C.
2. Tubes are heated at one temperature for varying intervals of time.
3. The vials are brought to a definite temperature before introduction into the bath usually at 0°C. just for 30 seconds.
4. Atleast five replicate vials should be used in exploratory runs to determine the accuracy.

Test for viability (Survival)

1. After heating, determination may be for anaerobes, the vials can be incubated to test for the growth of survivors.
2. Otherwise the contents of vials are subcultured into a good culture medium, which is incubated under optimal conditions for the organism.
3. If the number of survivors is desired, a quantitative count is made by the agar-plate or another cultural method.

Thermal Death Time (TDT) Curves

1. A method for obtaining data and plotting TDT curves is referred to as the growth-no-growth method.
2. Eg. Using a series of six tubes or vials at each time interval. is
3. At a heating temperature of 110°C for 110 min none of six tubes contained survivors, but there were survivors following 80 min of heating.
4. Thus. for these specific conditions, the thermal death time at 110°C is greater than 80 min but less than or equal to 110 min.

Table-1 TDT data

Temperature	Corrected heating time (min)	Number of Samples	
		Heated	Positive
110°C (230°F)	25	6	6
	40	6	6
	60	6	6
	80	6	5
	110	6	0
	140	6	0
115.6°C (240°F)	10	6	6
	14	6	6
	18	6	6
	22	6	2
	28	6	0
	36	6	0
121°C (250°F)	3	6	6
	4	6	6
	5.5	6	2
	7.5	6	0
	10	6	0
	13	6	0

5. If the TDT values from table-1 are plotted on semilogarithmic paper, the curve in fig-1 can be obtained.
6. Temp is plotted as arithmetic values and time in minutes as logarithms or on a logarithmic scale.
7. In this example, a single line (line-1) is drawn above all the superior points and below all the destruction points.
8. Alternatively, all the survivor points are connected with a line and all the destruction points are connected with a line.
9. Then the average of the slope of these two lines is drawn as a single line.

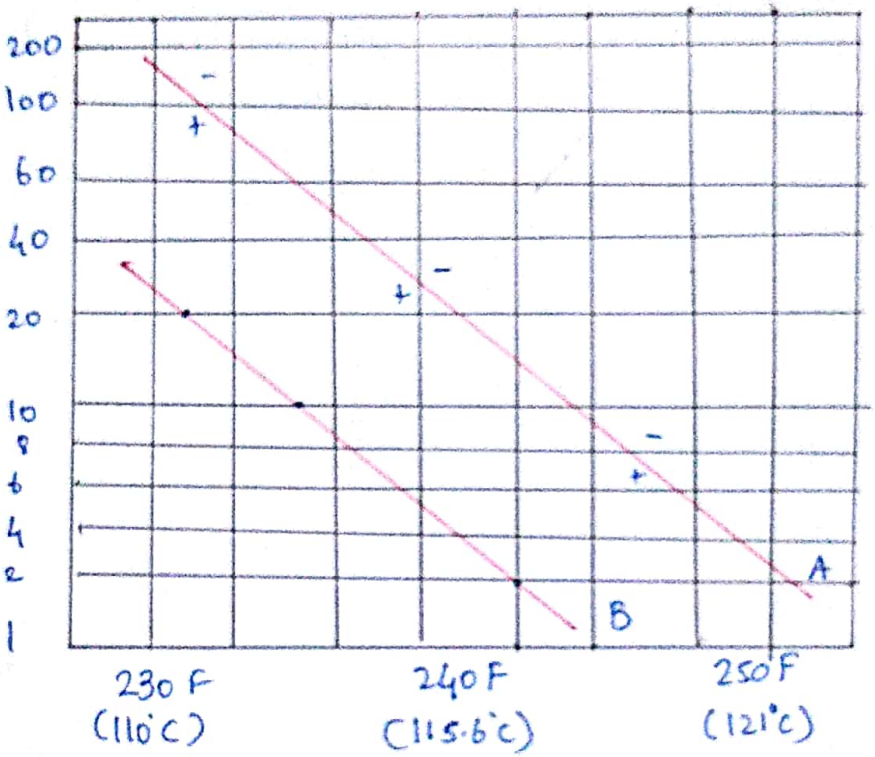


Fig-1: TDT curve from data in table-1

10. from this curve,
D-value (Decimal reduction time).
- Time of heating at a temperature to cause 90% reduction in the count of viable spores.
- This is the time required for the survivor curve to traverse one log cycle.

F-value
- Time required to kill all organism in a population, measured at 121°C.

2-value

- determine the time values with different D-values at different temperatures

$$Z = \frac{T_2 - T_1}{\log D_1 - \log D_2}$$

T is the temperature in °C / F
D - Decimal value

12-D

- The processing time will reduce the amount of bacteria by 10^{12} bacteria per gram / ml.

Growth of Microorganisms at Low Temperatures

1. Low temperatures are used to retard chemical reactions, action of food enzymes and to slow down or stop the growth and activity of microorganisms in food.
2. Each microorganism present has an optimal, or best, temperature for growth and a minimal temperature below which it cannot multiply. Cooler temperatures will prevent growth but slow metabolic activity may continue.
3. In general, freezing prevents the growth of most food borne microorganisms and refrigeration temperatures slow growth rate.
4. Commercial refrigeration temperatures (5 to 7.2°C), effectively retard the growth of many food borne pathogens.
5. Clostridium botulinum - type E min temp at growth of about 3.3°C
   Yersinia enterocolitica - Survive and grow at 0 to 3°C.
   Cladosporium & Sporotrichum - grow at -6.7°C
   Penicillium & Monilia - grow at -4°C
6. Bacteria have been reported growing at temperatures as low as
   -5°C on meats
   -10°C on cured meats
   -11°C on fish
   -12.2°C on vegetables
   -10°C on ice cream
   -5°C on meats (yeast)
   -17.8°C on oysters
   -7.8°C on meats & vegetables (Molds)
   -6.7°C on berries

Temperatures Employed in Low temperature storage

- The term "cold storage" may refer to the use of temperatures above or below freezing.
- The term "frozen storage" is more obvious, the product is stored in a frozen state, but the exact temperature would depend on the products
- Most commercial storage freezers are at or below -18°C.

a. Common, or Cellar, Storage.

- The temperature in common, or cellar storage usually is not usually below that of the outside air and is lower than 15°C.
- Root crops, potatoes, cabbage, celery, apples and similar foods can be stored for limited periods.
- The deterioration of such fruits and vegetables by their own enzymes and by microorganisms is not prevented but it is slower than at atmospheric temperatures.
- low humidity in the storage cellar results in losses of moisture from the stored food, and too high humidity favors Spoilage by microorganisms
- In locations, where no refrigeration is available common storage of all foods is the rule.

b. Chilling or Cold storage

- Chilling storage is at temperatures not far above freezing and usually involves cooling by ice or by mechanical refrigeration.
- It may be used as the main preservative method for foods or for temporary preservation until some other preservative process is applied.
- Most perishable foods, including eggs, dairy products, meats, seafood, vegetables, and fruits may be held in chilling storage for a limited time with little change in their original condition
- Enzymatic and microbial changes in the foods are not prevented but are slowed
- Factors to be considered during chilled storage include temperature, relative humidity, air velocity, composition of atmosphere and use of UV rays or other radiations

Temperature

- The lower the temperature of storage, the greater the cost. Although, most foods will keep best at a temperature just above their freezing point.
- Certain foods have an optimal range of storage temperature or temp well above the freezing point and may be damaged by \$ lower temperatures
- eg: banana, which should not kept in the refrigerator. it keeps best at about 13.3 to 16.7°C.

Some varieties of apples undergo "low temperature breakdown" at temperatures near freezing and sweet potatoes at 10 to 12.8°C

Relative humidity

- The optimal relative humidity of the atmosphere in chilling storage varies with the food stored and with environmental factors such as temperature, composition of atmosphere and ray treatments.
- Too low rH result in loss of moisture and hence weight loss, wilting and softening of vegetables and the shrinkage of fruits.
- Too high rH favors the growth of spoilage organisms.
- Changes in humidity, as well as in temperature, during storage may cause 'sweating' or precipitation of moisture on the food.
- A moist surface favors microbial spoilage. e.g. slime on the moist surface of sausage.

Ventilation

- Ventilation or control of air velocities of the storage room is important in maintaining a uniform relative humidity throughout the room, removing odors, and preventing the development of stale odors and flavors.
- The rate of air circulation affects the rate of drying of foods.
- If adequate ventilation is not provided, food in local areas of high humidity may undergo microbial decomposition.

Composition of storage atmosphere

- The amounts and proportions of gases in the storage atmosphere influence preservation by chilling.
- Although stored plant foods continue to respire, using oxygen and giving off CO_2.
- Attention has been given to 'gas storage' of foods, where the composition of the atmosphere has been controlled by the introduction of O_2, ozone or other gas or the removal of CO_2.
- It has been found that in the presence of optimal concentrations of CO_2 or ozone
  1. a food will remain unspoiled for a longer period
  2. a higher relative humidity can be maintained without harm to the keeping quality of certain foods.
  3. Higher storage temperature can be used without shortening the keeping time of the food than is possible with ordinary chilling storage.
- 2.5% CO_2 is best for eggs, 10% for chilled beef and 100% CO_2 is for bacon.

Irradiation

- The combination of UV radiation with chilling storage helps preserve some foods and may permit the use of higher humidity or storage temperature than is practicable with chilling alone.
- UV lamps have been installed in rooms for the storage of meat and cheese.

Freezing or frozen storage

1. The storage of foods in the frozen condition has been an important preservative method for centuries.
2. Frozen storage of foods, microbial growth is prevented entirely and the action of food enzymes is greatly retarded.
3. The lower the storage temperature, the slower will be any chemical or enzymatic reactions. but most of them will continue slowly.
4. It is a common practice to inactivate enzymes at of vegetables by scalding or blanching before freezing when practicable.

Selection and preparation of foods for freezing

1. The quality of food to be frozen is of prime importance.
2. fruits and vegetables are selected on the basis of their suitability for freezing and their maturity and are washed, trimmed, cut or otherwise pretreated as desired.
3. Most vegetables are scalded or blanched and fruits may be packed in a sirup.
4. Meats and seafood are selected for quality and are handled to minimize enzymatic and microbial changes.
5. Most foods are packaged before freezing, but some foods in small pieces. eg. Strawberries may be frozen before packaging.
6. The scalding or blanching of vegetables is done with hot water or steam. it accomplish the following
   - inactivation of most of the enzymes, which otherwise cause toughness, change in color, mustiness, loss in flavor, softening and loss in nutritive value.
   - reduction in the numbers of microorganisms in foods.
   - enhancement of green color in vegetables such as peas, broccoli and spinach.
   - wilting of leafy vegetables such as spinach making them pack better
   - displacement of air entrapped in the tissues

Freezing of foods

1. The rate of freezing of foods depends on a number of factors, such as the method employed, the temperature, circulation of air or refrigerant, size and shape of package and kind of food.
2. Sharp freezing – usually refers to freezing in air with only natural air circulation or at best with electric fans. The temperature is usually −23.3°C or lower but may vary from −15 to −29°C and freezing may take from 3 to 72 hr. This is sometimes termed as Slow freezing.
3. Quick freezing – in which the food is frozen in a relatively short time. Quick freezing is variously defined but in general implies a freezing time of 30 min or less and usually the freezing of small packages or units of food.
4. Quick freezing is accomplished by three methods.
   a. direct immersion of food or the packaged food in a refrigerant
   b. indirect contact with the refrigerant, where the food or package is in contact with the passage through which the refrigerant at −17.8 to −45.6°C flows.
   c. air-blast freezing, where frigid air is at −17.8 to −34.4°C is blown across the materials being frozen.

Advantages of quick freezing over slow freezing

- Smaller ice crystals are formed
- less mechanical destruction of intact cells.
- Shorter period of solidification
- more prompt prevention of microbial growth
- rapid slowing of action

changes during preparation for freezing

1. The rate and kind of deterioration of foods before freezing will depend on the condition of food at harvesting or slaughter and the methods of handling thereafter.
2. The temperature at which the food is held and other environmental conditions will determine the kinds of microorganisms to grow and the changes to be produced.
3. The condition of the food at the times of freezing will determine the potential quality of frozen food.

Changes during freezing

1. The quick-freezing process rapidly slows chemical and enzymatic reactions in the foods and stops microbial growth.
2. The physical effects of freezing are of great importance. There is an expansion in volume of the frozen food, and ice crystals form and grow in size.
3. These crystals usually are larger with slow freezing and more ice accumulates between tissue cells than with quick freezing and may crush cells.
4. Water is drawn from the cells to form such ice. Ice crystals rupture tissue cells or even microorganisms

Changes during Storage

1. During storage of the food in the frozen condition chemical and enzymatic reactions proceed slowly.
2. Meat, poultry and fish proteins may become irreversibly denatured, the red myoglobin of meat may be oxidized to brown metmyoglobin and the fats of meat and fish may become oxidized and hydrolyzed.
3. The unfrozen, concentrated solution of sugars, salts, etc - may come from portages of fruits or concentrates during storage as a viscous material called the metacryotic liquid.
4. When ice crystals evaporate from an area at the surface, a defect called freezer burn is produced on fruits, vegetables, meat, poultry and fish.
5. The spot usually appears dry, grayish or brownish.

Lethal Effects

1. Many cells are killed by freezing, but this is not a sterilization process.
2. Lethal effects are thought to be the result of denaturation or flocculation of essential cell proteins or enzymes possibly as a result of the increased concentration of solutes in the unfrozen water or perhaps in part of physical damage by ice crystals.
3. Rapid cooling of cells from an optimal temperature to 0°C can also result in death. This destruction is referred to as cold shock.

Sublethal effects

- During microbiological enumeration of frozen foods a reduction in numbers may not always represent true death of population.
- Actually, some of the cells may be in an injured or damaged state which prevents their recovery for enumeration. e
- Cells in this state have been referred to as freeze-injured, frost-injured or metabolically injured.
- Since, these cells can be resorted if repair time is permitted or additional nutritional factors are added to the enumeration of media, they are not really dead.

Response of microorganisms to freezing

The following factors or variables occur during freezing and perhaps dictate why some microorganisms die, some are injured and some are not damaged.

1. The kind of microorganism and its state

- Resistance to freezing varies with the kind of microorganisms, its phase of growth, and whether it is a vegetative cell or spore
- Christopherson (1973) has classified microorganisms on the basis of sensitivity to freezing as.

a) susceptible - vegetative cells of yeast and mold and many gram negative bacteria

b. moderately resistant - Gram positive organisms including staphylococci and enterococci

c. insensitive organisms - predominantly sporeformers bacteria in the log phase of growth would be more easily killed than those in other phases.

2. The freezing rate

There appears to be a critical range of temperatures which result in lethal effects; therefore faster freezing rates would tend to be less destructive since the critical range would be passed through faster.

3. The freezing temperature
- High freezing temperatures are more lethal. More organisms are inactivated at -4 to -10c, than -15c to -30c

4. The time of frozen storage
- The initial killing rate during freezing is rapid, but it is followed by a gradual reduction of microorganisms and it is referred to as storage death.

5. The kind of food.
- The composition of food influences the rate of death of organisms during freezing and storage.
- Sugar, salt, proteins, colloids, fat and other substances may be protective, whereas high moisture and low pH may hasten killing.

6. Influence of defrosting
- The response of microorganisms to the rate of defrosting varies.
- Rapid warming has been found to be harmful to some bacteria.

7. Alternate freezing and thawing
- Alternate freezing and thawing is reported to hasten the killing of microorganisms but apparently does not always to do so

8. Possible events during freezing of the cell.
- As the temp is lowered, more and more water freezes.
- The remaining or unfrozen free water at each temperature therefore becomes more and more concentrated with solutes.
- This can change the pH of cellular matter, concentrate electrolytes, alter colloidal state, denature proteins and increase viscosity.
- Ice crystals can form outside the cell and draw water out of the cell with a resulting dehydration or concentration effect.
- Intracellular crystals may form and grow or crystallize right through the cell, resulting in altered permeability or "holes" in the membrane and cell wall.
- Intracellular ice is thought be more harmful to cells than are extracellular ice crystals.

Food Microbiology

Unit - 3

Food Preservation by drying

Preservation of foods by drying has been practised for centuries. Some foods, e.g. grains are sufficiently dry as harvested or with little drying remain unspoiled for long periods under proper storage conditions.

Most foods, however, contain enough moisture to permit action by their own enzymes and by microorganisms, so that to preserve them by dryness the removal or binding (eg. by solutes) of moisture is necessary.

Drying usually is accomplished by the removal of water, but any method that reduces the amount of available moisture, i.e., lowers the a_w, in a food is a form of drying.

For eg: Dried fish may be heavily salted so that moisture is drawn from the flesh and bound by the solute and hence is unavailable to microorganisms.

Sugar may be added, as in sweetened condensed milk, to reduce the amount of available moisture.

Moisture may be removed from foods by number of methods, from the ancient sun drying method to modern artificial ones.

A Sun dried food has had moisture removed by exposure to the Sun's rays without any artificially produced heat and without controlled temperatures, relative humidities or air velocities.

A dehydrated or desiccated food has been dried by artificially produced heat under controlled conditions of temperature, relative humidity, and air flow.

Condensed usually implies that moisture has been removed from a liquid foods and

evaporated may have a similar meaning or may be used synonymously with the term dehydrated.

Moisture content of various foods before and after drying

Food	Moisture before drying (%)	Moisture after drying (%)
Milk		
Whole	87	5.0
Non fat	90	5.0
Egg		
Whole	74	2.9
White	88	7.3
Yolk	51	1.1
Beef, lean, roasted	60	1.5
Chicken, broiled	61	1.6
Beans, snap, cooked	92	11.5
Corn, sweet, cooked	76	3.2
Potatoes, boiled	80	4.0
Apple juice	86	6.2
Figs, raw	78	3.6
Parsley, raw	84	5.3

Methods of drying

Solar drying

Solar drying is limited to climates with a hot sun and a dry atmosphere and to certain fruits such as raisins, prunes, figs, apricots, nectarines, pears, and peaches.

The fruits are spread out on trays and may be turned during drying.

Fish, rice and other grains may also be sun-dried.

...ng by mechanical dryers

- Most methods of artificial drying involve the passage of heated air with controlled relative humidity over the food to be dried or the passage of the food through such air.
- A number of devices are used for controlled air circulation and for the reuse of air in some processes
- The simplest dryer is the evaporator or kiln, sometimes used in the farm house, where the natural draft from the rising of heated air brings about the drying of the food
- forced-draft drying systems employ currents of heated air that move across the food, usually in tunnels.
- An alternative method is to move the food on conveyor belts or on trays in carts through the heated air.
- Liquid foods, such as milk, juices, and soups, may be evaporated by the use of comparatively low temperatures and a vacuum in a vacuum pan or similar device.
- drum-dried by passage over a heated drum, with or without vacuum; or spray-dried by spraying the liquid into a current of dry, heated air.

Freeze drying

- Freeze drying, or the sublimation of water from a frozen food by means of a vacuum plus heat applied at the drying shelf, is being used for a number of foods, including meats, poultry, seafood, fruits, and vegetables.
- Frozen thin layers of foods of low sugar content may be dried without vacuum by sublimation of moisture during passage of dry carrier gas.

Drying during smoking

- Most of the preservative effect of the smoking of foods is due to the drying of the food during the process.
- Maintain wood smoke as main preservative factor, especially drying at the surface of the food.

Other methods

- Electronic heating has been suggested for the removal of still more moisture from a food already fairly well-dried.
- Foam-mat drying, in which liquid food is whipped to a foam, dried with warm air, and crushed to a powder, is receiving attention to give a porous structure.

Types of dryer used for various foods, food by-products & wastes

Products	Type of dryer
Vegetables, confectionery, fruits, pectin	Compartment, tray and tunnel dryer
Grass, grain, vegetables, fruit, nuts, breakfast cereals	Conveyor band
Grass, grain, apple pomace, lactose, poultry manure, peat, starch	Rotary
Coffee, milk, tea, fruit purees	Spray
Milk, starch, predigested infant foods, soaps, brewery and distillery by-products	Film, drum
Starch, fruit pulp, distillery waste products, crops	Pneumatic
Coffee, essences, meat extracts, malted and other confectioneries	Freeze dryers, & vacuum dryers

Factors in the control of drying

A consideration of the proper control of dehydration includes the following factors

1. The temperature employed
   - This varies with the food and the method of drying
2. The relative humidity of air
   - This too, is varied with the food and the method of drying and also with the stage of drying.
   - Its usually higher at the start of drying than it is later.

The velocity of the air

4. The time of drying

Improper control of these factors may cause case-hardening resulting from more rapid evaporation of moisture from the surface than diffusion from the interior, with a resulting hard, horny, impenetrable surface film that hinders further drying.

Treatments of foods before drying

Many of the pretreatments of foods to be dried are important in their effect on the microbial population.

These pretreatments may include,

1. Selection and sorting for size, maturity and soundness
2. Washing, especially of fruits and vegetables.
3. Peeling of fruits and vegetables by hand, machine, lye bath, or abrasion.
4. Subdivision into halves, slices, shreds, or cubes,
5. Alkali dipping, which is used primarily for fruits such as raisins, grapes, and prunes (for sun drying) and employs hot 0.1 - 1.5% lye or sodium carbonate.
6. blanching or scalding of vegetables and some fruits (apricots & peaches).
7. Sulfuring of light-colored fruits and vegetables.
   Fruits are sulfured by exposure to sulfur dioxide gas produced by the burning of sulfur so that a level of 1,000 to 3,000 ppm, depending on the fruit, will be absorbed.
   vegetables may be sulfured after blanching in a similar manner or by dipping into or spraying with sulfite solution.

Sulfuring helps maintain an attractive light color, conserve vitamin-C, and perhaps vitamin-A, and repel insects: it also kills many of the microorganisms present

Procedures after drying

The procedures after drying vary with the kind of dried food.

Sweating

- Sweating is storage, usually in bins or boxes, for equalization of moisture or readdition of moisture to a desired level.
- It is used primarily with some dried fruits and nuts (walnuts & almonds)

Packaging

- Most foods are packaged soon after drying for protection against moisture, contamination with microorganisms, and infestation with insects,
- although some dried foods (eg. fruits and nuts) may be held as long as a year before packaging.

Pasteurization

- Pasteurization is limited for the most part to dried fruits and kills any pathogens that may be present, as well as destroying spoilage organisms.
- The fruit usually is pasteurized in the package, and the treatment, varying with the fruit, is from 30 to 70 min at 70 - 100% relative humidity at 65.6°C to 85°C

Microbiology of dried foods

a. Before reception at the processing plant

1. The microbiology of foods before their reception at the processing plant is likely to be similar whether the foods are to be dried, chilled, frozen, canned, or otherwise processed.
2. Fruits and vegetables have soil and water organisms on them when harvested, plus their own natural surface flora and spoiled parts contain the microorganisms causing the spoilage.
3. Growth of some of these microorganisms may take place before the foods reach the processing plant if environmental conditions permit.
4. Thus, piled vegetables may heat and support the surface growth of slime-forming, flavor harming, or even rot-producing organisms
5. Meats and poultry are contaminated by soil, intestinal contents, handlers and equipment.
6. Fish are contaminated by water and their own slime, and intestinal contents as well as by handlers and equipment, and growth may take before reaching the plant.
7. Eggs are dirtied by the hen, the nest, and the handler and, unless they are well and promptly handled,
8. Milk is subject to contamination from the time of its secretion by the cow to its reception at the processing plant and may support the growth of some psychrotrophic bacteria.

b. In the plant before drying

1. Growth of microorganisms that has begun on foods before they have reached the drying plant.
2. Equipment and workers may contaminate the food, some of the pretreatments reduce numbers of organisms, and other may increase them, but the chance of contamination of foods are possible after pretreatments.

3. The grading, selection and sorting of foods, especially those such fruits, vegetables, eggs, and milk, will influence the kinds and numbers of microorganisms present.

4. The elimination of spoiled fruits and vegetables or of spoiled parts will reduce numbers of organisms in the product to be dried.

5. The rejection of cracked, dirty, or spoiled eggs serves a similar purpose, as does the rejection of milk does not conform to bacteriological standards of quality.

6. Washing of fruits and vegetables removes soil and other adhering materials and surface microorganisms. Also there is possibility of adding microorganisms, if water quality is poor, and surface moisture favors the growth of microorganisms

7. Peeling of fruits and vegetables, with steam or lye should reduce numbers, sliing or cutting should not increase microbial load unless the equipments are sanitized.

8. Dipping in alkali, as applied to certain fruits before sun drying, may reduce the microbial population.

9. Blanching or scalding vegetables reduces bacterial numbers greatly as much as 99%. After blanching, numbers of bacteria may build up because of contamination from equipment and opportunities for growth.

10. Sulfuring of fruits and vegetables also cause a great reduction in numbers of microorganisms and serves to inhibit growth in the dried product.

C. During the drying process

1. Heat applied during a drying process causes a reduction in total numbers of microorganisms, but the effectiveness varies with the kinds and numbers of organisms originally present and the drying process employed.

2. Usually, all yeasts and most bacteria are destroyed, but spores of bacteria and molds commonly survive, and improper conditions during drying may even permit the growth of microorganisms.

More microorganisms are killed by freezing than by dehydration during the freeze-drying process, because freeze drying damages the metabolism of microbes, which unable to retrieve nutrition for their survival.

d. After drying

1. If the drying process and storage conditions are adequate, there will be no growth by of microorganisms in the dried food.
2. Microorganisms that are resistant to drying will survive best, therefore, the percentages of such organisms will increase.
3. The spores of bacteria, molds, some micrococci and microbacteria are well known for spoilage agents in dried food.
4. Contamination is possible during packaging and other handling subsequent to drying.
5. The sweating of dry fruits to equalize moisture may permit some microbial growth
6. The microbial content and the temperature of water used to rehydrate dried foods will affect the keeping quality of the rehydrated product.
7. Bacteria in freeze dried chicken meat are further reduced in numbers by rehydration with water at 50c and are almost eliminated when the water is at 85 to 100c.

Microbiology of Specific dried foods

a. Dried fruits

1. The number of microorganisms on most fresh fruits range from comparatively few to many, depending on pretreatments, and on most dried fruits may vary from few hundred to thousand.
2. Spores of bacteria and molds are likely to be the most numerous.
3. When part of the fruit has supported growth and sporulation of mold before or after drying, mold spores may be present in large numbers.

b. Dried vegetables

1. Microbial counts on dried vegetables range from negligible numbers to millions per gram.
2. The numbers on the vegetable just before drying may be high because of contamination and growth after blanching
3. Onions and potatoes are improperly loaded in drying trays Cause lactic acid bacteria to grow rapidly. The risk is greater in onions because they are not blanched.
4. Organisms like Lactobacillus, Leuconostoc, Escherichia, Enterobacter, Bacillus, clostridium, Micrococcus, Pseudomonas and Streptococcus usually found on dried vegetables.

c. Dried eggs

1. Dried eggs may contain from a few hundred microorganisms to over 100 million, depending on the eggs broken and methods employed.
2. The contents of fresh eggs of good quality are normally free of microorganisms or include only a few.
3. However, the inclusion of poorly washed eggs, those which have been permitted to sweat, dirty and cracked eggs, and those already invaded by microorganisms may add large numbers of organisms, also contamination and growth may take place during breaking and other handling before drying.
4. A variety of kinds of organisms have been found in dried eggs, including micrococci, streptococci, coliforms, sporeformers and molds.

D. Dried milk

1. The number of microorganisms in dry milk may vary from a few hundred to millions depending on the milk being dried and the drying process.
2. Roller or drum drying kills more organisms than does the spray process.
3. The predominant kinds of organisms in dry milk are thermoduric streptococci, micrococci, and sporeformers.

Intermediate Moisture Foods

1. IMF are shelf-stable products that have water activities of 0.6 – 0.84 aw, with a moisture content ranging from 15% – 40% and are edible without rehydration.
2. These food products are below the minimum aw for bacteria (0.90) but are susceptible to yeast and mold growth.
3. Historically, ancient civilizations would produce IMF using methods such as sun drying, roasting over fire and adding salt to preserve food for winter months or when preparing for travel.
4. A variety of products are classified as IMF such as dried fruits, sugar added commodities, marshmallows and pie fillings.
5. The purpose of IMF foods is to achieve a aw that the food can be stored safely without refrigeration.
6. However, the food is not sterile, staphylococcus aureus is a microorganism of concern as it can grow and produce specific enterotoxins in water activities of 0.83 – 0.86 under aerobic conditions.
7. So, proper handling, storage, hygiene and GMP are necessary to prevent staphylococcus aureus.
8. Molds of Aspergillus and Penicillium species can grow and produce harmful mycotoxins at aw 0.77 – 0.85. Salmonella and Bacillus cereus are the primary pathogens of concern with low moisture foods and IMF's.
9. Most illnesses associated with low-moisture foods or IMF's have been caused by salmonella spp.
10. To reduce the risk of bacterial growth, products are treated with a combination of low pH, addition of sugar, salt and preservatives and a thermal process that can eliminate pathogens and extend shelf-life.
11. In case of yeasts and molds, chemical preservatives such as sorbates and propionates are used to inhibit their growths.

Water Activities of some common IMF products

Range	Food
0.85 - 0.75	Sweet condensed milk, fruit cake, salted fish, molasses, jams, dog food, dried fruit, syrups, soy sauce, jam.
0.75 - 0.65	Dates, figs, nuts, parmesan cheese, dulce de leche
0.60 - 0.65	Honey, chocolate cake, marshmallows, biscuits.

Preservation by food Additives

What is food additive?

A food additive is a substance or mixture of substances, other than the basic food stuff, which is present in food as a result of any aspect of production, processing, storage or packaging.

Food additives which are specifically added to prevent the deterioration or decomposition of a food have been referred to as chemical preservatives. These deteriorations may be caused by microorganisms, by food enzymes, or by purely chemical reactions.

The inhibition of the growth and activity of microorganisms is one of the main purposes of the use of chemical preservatives. Preservatives may inhibit microorganisms by interfering with their cell membranes, their enzyme activity, or their genetic mechanisms.

other preservatives may be used as antioxidants to hinder the oxidation of unsaturated fats, as neutralizers of acidity, as stabilizers to prevent physical changes, as firming agents and as coatings or wrappers to keep out microorganisms, prevent loss of water, or hinder undesirable microbial, enzymatic and chemical reactions.

There are many chemicals that get on or into foods during production, processing or packaging are residues of pesticides, herbicides, and fungicides on fruits and vegetables, residues of detergents used in washing foods and residues of detergents and sanitizers used on utensils and equipment are likely to carry ~~out~~ over into foods.

Antimicrobial Preservative

1. The countries experiencing food shortages and low food quality are the countries with inadequate technology of preservation. The use of a chemical preservative in this situation would have an immense impact.
2. Chemical preservatives are dependable on, either independently or in combination with other forms of preservation, to maintain a food in its original or fabricated state and to prevent excess losses from deterioration.
3. Ideally, therefore, a chemical preservative should have a wide range of antimicrobial activity.
   - should be non-toxic to human beings or animals
   - should be economical
   - should not have an effect on the flavor, taste or aroma of the original food.
   - should not be inactivated by the food or any substance in the food
   - should not encourage the development of resistant strains and
   - should kill rather than inhibit microorganisms.
4. Most of the preservatives are inhibitory at acceptable concentrations, but only ethylene and propylene oxides and diethyl pyrocarbonate are lethal to microorganisms at normal concentrations of use.
5. Needless to say, the ideal chemical preservative has not been found. Many of the compounds most widely used are the oldest preservatives.
6. The new, simple and ideal preservatives being suggested are few and many of those suggested for one reason or another do not develop into a commercially acceptable additive.

Different groups of food Additives

Groups	Examples
Preservatives	chemical preservatives
Colors	natural, Synthetic
Flavors	nature identical extracts
Sweeteners	Saccharin, Aspartame, Polyols
Emulsifiers and Stabilizers	Lecithin
Antioxidants	Vitamin E, BHA, BHT
Flour improvers	Vitamin-C, Cysteine, Chlorine
Humectants and Anticaking agents	Polyhydroxy alcohols, Calcium silicate
Leavening agents	Baking Soda, Ammonium Carbonate
Chelating agents	Polycarboxylic acids
Curing agents	Sodium nitrite, Polyphosphates
Nutrient Supplements	Thiamine, Nicotinic acid, Iron, calcium
Processing aids	Acids, Acidity regulators, Gelling agents, antifoaming agents

Preservatives

Principal preservative	Significance
Sodium chloride	Antimicrobial, dehydrating agent or used as brine
Sugars	Preservation of foods due to the high osmotic pressure
Sulfur dioxide	Prevents the growth of undesirable microbes during wine making, prevents browning of dried and cut fruits
Nitrate & Nitrite	Color stabilizer in the curing of meat and antimicrobial in action.
Sorbic acid	Sodium and potassium salts inhibit the growth of molds and yeast in cheese, bakery products, fruit juices, wines and pickles.

Acetic acid	Vinegar (4% acetic acid) is used to preserve pickled vegetables. Acetates of sodium, potassium and calcium are used to prevent hopiness and growth of molds.
Propionic acid	Sodium and Calcium salts are effective against molds and some bacteria. Controls Bacillus mesentericus causing ropy bread.
Benzoic acid	Active agent against yeast and bacteria, well suited for the preservation of acid foods such as fruit juices, Carbonated beverages, pickles and Sauerkraut.
Parabens	Effective inhibitors of molds and yeast, they are alkyl esters of p-hydroxybenzoic acid; Methyl, ethyl, propyl, and heptyl esters are used.
Epoxides	Antimicrobial cyclic esters, used as preservatives Ethylene oxide and propylene oxide. to reduce load of microbes in spices.
Antibiotics	Antimicrobial agents used in the control of bacteria in fish and poultry products. Chlorotetracycline and oxytetracycline
Diethyl pyrocarbonate	Used as an antimicrobial agent in fruit juices, wines, and Carbonated beverages.

Preservative	Conc. allowed
Benzoic acid	0.1% Covered by GMP
Methyl paraben	0.1% " "
Propyl paraben	0.1% " "
Ethyl paraben	not authorized for use
Sodium nitrate	500 ppm
Sodium nitrite	200 ppm
Sorbates	Covered by GMP's
Acetates	Covered by GMP's with concentration 0.25 to 9.0%
Propylene oxide	300 ppm Cocoa, gums, starch Spices, processed nuts (except peanuts)

Ethylene oxide	Residues not to exceed 50 ppm
Sulfites	Covered by GMP's
Natamycin	200 to 300 ppm as a dip. Spray or solution.

Maximum Levels of Antimicrobials Permitted in foods

Organic Acids and their salts

Lactic, acetic, propionic and citric acids or their salts may be added

Citric acid is used in simps, drinks, jams and jellies as a substitute for fruit flavors and for preservation

Lactic acid and acetic acids are added to brines of various kinds, green olives, etc.

a. Propionates

1. Sodium or calcium propionate is used most extensively in the prevention of mold growth and rope development in baked goods and for mold inhibition in many cheese foods and spreads
2. They have been used in butter, jams, jellies, figs, apple slices and malt extract.
3. They are effective against mold, with little or no inhibition of most yeast and bacteria
4. Their effectiveness decreases with an increase in pH, upto 5 to 6.
5. They appear to be ideal preservatives for bread and baked goods
6. Propionic acid is a short-chain fatty acid, and is found naturally in Swiss cheese, as a developed preservative, at levels up to 1%.

b. Benzoates

1. The sodium salt of benzoic acid has been used extensively as an antimicrobial agent in foods. It has been incorporated into jams, jellies, margarine, Carbonated beverages, fruit salads, pickles, relishes, fruit juices, etc.
2. Sodium benzoate is relatively ineffective at pH values near neutrality, and the effectiveness increases with increase in acidity, Mostly pH between 2.5 to 4.0.
3. Two esters of P-hydroxybenzoic acid, methylparaben and propyl-paraben, are used extensively in foods, and to lesser extent the butyl and ethyl esters. These compounds are similar to benzoic acid in their effectiveness.

The mechanism of action of the benzoates is not clear;

c. Sorbates

1. Sorbic acid, as the calcium, sodium and potassium salt, is used as a direct antimicrobial additive in foods and as a spray, dip or coating on packaging materials.
2. It is widely used in cheeses, cheese product, baked goods, beverages, sirups, fruit juices, jellies, jams, fruit cocktails, dried fruits, pickles and margarine.
3. Sorbic acid and its salts are known to inhibit yeast and molds but are less effative against bacteria
4. They are most effative at low pH values with a maximal level of use at about pH 6.5.
5. These compounds are more effective than sodium benzoate at pH values above 4.0.

d. Acetates

1. Derivatives of acetic acid, eg. monochloroacetic acid, peracetic acid, dehydroacetic acid and sodium diacetate, have been recommended as preservatives, but not all are approved by FDA.
2. Dehydroacetic acid has been used to impregnate wrappers for cheese to inhibit the growth of molds and as a temporary preservative for squash.
3. Acetic acid in the form of vinegar is used in mayonnaise, pickles, catsup, pickled sausages, and Pig's feet.
4. Acetic acid is more effative against yeasts and bacteria than molds and its effativeness increases with a decrease in pH
5. Sodium diacetate has been used in the cheese spreads and malt sirups and as treatment for wrappers used on butter.

e. Nitrites and Nitrates

1. Combinations of these various salts have been used in curing solutions and curing mixtures for meats.
2. Nitrites decompose to nitric acid, which forms nitrosomyoglobin when it reacts with the heme pigments in meats and thereby forms a stable red color.
3. Nitrites can react with secondary and tertiary amines to form nitrosamines, which are known to be carcinogenic.
4. Nitrates probably only act as a reservoir for nitrite, and their use is being restricted.
5. The problem of possible carcinogenic nitrosamines may be greatest in bacon and the extended use of nitrite in foods is controversial.
6. They are currently added in the form of sodium nitrite, potassium nitrite, sodium nitrite and potassium nitrate.
7. Therefore, nitrates have a limited effect on a limited number of organisms and would not be considered a good chemical preservative.

f. Sulfur Dioxide and sulfites.

1. The Egyptians and Romans burned sulfur to form sulfur dioxide as a means of sanitizing their wine-making equipment and storage vessels.
2. Today sulfur dioxide, and sulfites are used in the wine industry to sanitize equipment and to reduce the normal flora of the grape must.
3. In aqueous solutions, sulfur dioxide, and various sulfites, including sodium sulfite, potassium sulfite, sodium bisulfite, potassium bisulfite, sodium metabisulfite and potassium metabisulfite, form sulfurous acid, the active antimicrobial compound. The effectiveness is at low pH values.
4. The fumes of burning sulfur are used to treat most light-colored dehydrated fruits, while dehydrated vegetables are exposed to a spray of neutral bisulfites and sulfites before drying.

Sulfur dioxide has also been used in sirups and fruit juices and wine-making. Some countries permit the use of Sulfites on meats and fish.

6. They are also used to prevent enzymatic and non-enzymatic changes & or discoloration in some foods.

9. Ethylene and Propylene oxide

1. These two gases are sterilants.
2. Ethylene oxide kills all microorganisms; propylene oxide, although it kills many microorganisms, is not as effective
3. The primary uses have been as sterilants for packaging materials, fumigation of watchouses and "Cold sterilization" of numerous plastics, chemicals, pharmaceuticals, syringes, and hospital supplies.
4. They have also been used successfully in dried fruits, dried eggs, gelatin, cereals, dried yeast, and spices.
5. The FDA restricts the use of ethylene oxide to spices and other processed natural seasonings except mixtures containing added salt.
6. Propylene oxide is permitted only as a package fumigant for dried plums or glace fruits and as a fumigant for cocoa, gums, spices, starch, and processed nuts.

10. Sugar and Salt

These compounds lower the a_w and thus have an adverse effect on microorganisms.

Sodium chloride is used in brines and curing solutions or is applied directly to the food.

Enough may be added to slow or prevent the growth of microorganisms or only enough to permit the acid fermentation to take place.

Salt has been reported to have the following effects:

1. It causes high osmotic pressure and hence plasmolysis of cells, the percentage of salt necessary to inhibit growth or harm the cell varying with the microorganism.

2. it dehydrates foods by drawing out and tying up moisture as it dehydrates microbial cells.
3. it ionizes to yield the chloride ion, which is harmful to organisms.
4. it reduces the solubility of oxygen in the moisture
5. it sensitizes the cell against ox
6. it interferes the action of proteolytic enzymes.

The effectiveness of NaCl varies directly with its concentration and the temperature.

Sugars

- Such as glucose or Sucrose, owe their effectiveness as preservatives to their ability to make water unavailable to organisms and to their osmotic effect
- Examples of foods preserved by high sugar concentrations are sweetened, Condensed milk, fruits in Syrups, jellies and Candies.

i) Alcohol

- Ethanol, a coagulant and denaturizer of cell proteins, is most germicidal in concentrations between 70 to 95%.
- flavoring extracts. e.g. vanilla and lemon extracts, are preserved by their content of alcohol.
- The alcoholic content of beer, ale, and unfortified wine is not great enough to prevent their Spoilage by microorganisms but limits the types able to grow.
- methanol is poisonous and should not be added to foods: the traces added to foods by Smoking are not enough to be harmful
- Glycerol is antiseptic in high concentrations because of its dehydrating effect but is unimportant in food preservation
- Propylene glycol has been used as a mold inhibitor and as a Spray to kill airborne microorganisms.

5. Wood Smoke

- The smoking of foods usually has two main purposes: adding desired flavors and preserving.
- Other desirable effects may result, however, e.g. improvement in the color inside of meat, and in the finish, or "glaze", of the outside and a tenderizing action on meats.
- The smoking process helps preservation by impregnating the food near the surface with chemical preservatives from the smoke, by combined action of the heat and these preservatives during smoking, and by the drying effect, especially at the surface.
- Commonly, smoke is obtained from the burning wood, preferably a hard wood such as hickory, other woods like apple, oak, maple, beech, birch, walnut and mahogany. Saw dust is added to the fire to give a heavy smudge.
- Temperature, humidity and duration are controlled and it depends on the type of food.
- For meat from 43 to 71°C, smoking lasts from a few hours to several days
- Woodsmoke contains a large number of volatile compounds that may have bacteriostatic and bactericidal effect.
- Compounds in the smoke include, caprioc, alcohols, ketones, acetaldehyde, resins, guaiacol, methyl and propyl esters, catechol, methyl catechol, and pyrogallol and its methyl ester.
- Wood smoke is more effective against vegetative cells than bacterial spores
- effective against bacteria than mold.
- The application of "liquid smoke", a solution of chemicals similar to those in wood smoke, to the outside of foods has little or no preservatives effect although it contributes to flavor.

Spices and Other Condiments

1. Spices and other condiments, do not have any marked bacteriostatic effect in the concentrations used, but may help other agents in preventing the growth of organisms in foods.
2. Effectiveness of the varieties of spices depending on the source, the freshness and whether they have been stored whole or ground up.
3. Mustard flour and volatile oil of mustard are very effective against Saccharomyces cerevisiae but are not as potent as Cinnamon and Cloves against most bacteria. The essential oils of spices are more inhibitory than the corresponding ground spices.
4. Cinnamon and cloves, containing cinnamic aldehyde and eugenol, are more bacteriostatic than are other spices.
5. Ground pepercorn and allspice are less inhibitory, mustard, mace, nutmeg, ginger still less. Thyme, bay leaves, marjoram, savory, rosemary, blackpepper and others have only weak inhibitory power against most organisms and may stimulate yeasts and molds.
6. Of the oils tested, the volatile oil of mustard is most effective against yeasts; oils of cinnamon and cloves are fairly effective and oils of thyme and bay leaves are least effective.
7. Other plant materials used in seasoning foods, such as horseradish, garlic and onion may be bacteriostatic or germicidal.
   Extracts of these plants, as well as of cabbage and turnip, have been shown to be inhibitory to Bacillus subtilis and Escherichia coli
   Acrolein, in onions and garlic: butyl thiocyanate in horseradish
8. Volatile compounds are lost from the condiment on exposure to the air, with a corresponding loss in bacteriostatic properties.

Colors

- Any natural or synthetic dye, pigment or substance that can impart color when applied or added to a food, which includes stabilizers, color fixatives or color-retention agents are widely used in food industries.

a. Natural Colorants

i. Anthocyanins – glycosidic derivatives, imparts blue, violet and red color to many edible fruits and vegetables.

ii Carotenoids – oil soluble colors seen in plants and animals.

Xanthophylls – yellow Carotenoid pigments

eg: Carotenoids & Xanthophylls are bixin, curcumin, saffron.

Betalaines – red beetroot (Beta vulgaris)

iii. Cochineal and related pigments

– extracted from the dried crushed bodies of the female Dactylopius coccus, just prior to egg-laying time

eg: Carmine is used in the powder form in a variety of foods.

Alkannet, extracted in alcohol from the roots of Alkanna tinctoria is used in ice creams.

iv. Microbial colorants

– Monascus, obtained from Monascus purpureus (fungus) ~~ate~~ which imparts a red color, used in wine making.

– Soluble in oil and heat stable.

v. Biliproteins

– from algae soluble in water or alcohol and are used in chewing gum, identified as red phycoerythrins and the blue phycocyanins.

b. Synthetic colorants

1. Synthetic colors are permitted to be used only in certain foods such as ice creams, biscuits, cakes, sugar-boiled candies, sweets, savories, fruit syrups, fruit squash, soft drinks, jam, RTS beverages etc.
2. Synthetic colors, when used must carry a declaration on the labels and the permissible quantity is 200 mg / Kg.
3. Synthetic colors excel in the coloring power, uniformity, stability, and cost and hence are preferred than naturally available coloring materials.
4. Coal-tar dyes are used in gelatin desserts, candies and bakery products. Red-color is obtained from Ponceau 4R, carmoisine & erythrosine. Yellow color is obtained from tartrazine, sunset yellow, blue from indigo carmine, brilliant blue and green color from fast green.
5. These colors ~~are~~ must be pure and free from harmful substances and must be sold only under the BIS certification.
6. The pink dye Rhodamine B, orange RN II and Blue VRS are carcinogenic and cause lesions in kidney, liver and spleen. Metanil yellow causes degeneration of the reproductive structures and sterility. Hence the dyes are prohibited in use & in the food industry.

Flavors

1. Flavors of most fruits and vegetables are mixtures of aldehydes and esters of organic alcohols and acids.
2. Flavoring additives are ingredients occurring naturally and they can be added to give a characteristic flavor to almost all foods.
3. Flavor enhancers are not flavors but they amplify the flavors of other substances.
4. Natural flavoring substances such as spices, herbs, roots, essences and essential oils are plant derivatives.
5. Widely used flavor enhancers are MSG - (monosodium glutamate) generally recognized as safe, manufactured all over the world. not used in infant foods.
6. Chinese and Japanese cooking for centuries have been using MSG extracted from seaweeds and soyabeans.

Sweeteners

1. Sucrose is the ideal sweetener, tasteless, soluble in water, has a pure taste, rich in calories.
2. The first synthetic sweetening agent used was saccharin. Use of saccharin leaves a bitter and unpleasant after-taste.
3. Cyclamates, are widely used in the manufacture of soft drinks, and other low-calorie liquid foods use of cyclamates have been banned after use of high dosage in rats, which caused bladder cancers.
4. Glycyrrhizic acid obtained from the root of Glycyrrhiza glabra is used in tobacco products, confectionery and beverages.
5. Aspartame is used in soft drinks, gelatin desserts and low-calorie frozen foods. It is produced from two amino-acids. aspartic acid and phenylalanine and is 180 times sweeter than sucrose not recommended for use by pregnant and lactating women.
6. Sucralose is derived from sucrose and closely resembles the table sugar in taste, highly soluble in water, stable at high temperature doesnot absorbed from the digestive tract, and hence it adds no its calories to consumed foods, not increase blood-sugar levels.
7. Neotame is an approved non-nutritive sweetener, about 8-13000 times sweeter than sucrose. Similar to aspartame
8. Other sweeteners generally use are dulcin, neohesperidin, dihydrochalcone, 5-Nitro-2-propoxyaniline, Lubrasuss, alitame.

Emulsifiers and Stabilizers

1. The additives used as emulsifiers and stabilizers are surfactants, amphipathetic molecules which act at the interfaces of the two phases in the food.
   eg: Mono- and diglycerides, and phospholipids like lecithin
2. Stabilizers are macromolecules which form a dispersed matrix or gel into which other smaller molecules can be incorporated
   Eg: guargum, plant polysaccharides, gum arabic, gum karaya, agar, alginates, pectin, carrageenan.
   Chemicals like, Xanthan gum, CMC, hydroxyl propyl methyl cellulose and methyl cellulose.

3. Stabilizers and thickeners are hydrophilic and are dispersed as colloids in solution and help thicken gravies, pie fillings, Cake toppings, chocolate milk drinks, Jellies, puddings etc.

Antioxidants

1. oxidation of fats in foods not only deteriorates the food but also results in unpleasant odors.
2. TO avoid such spoilage of foods, antioxidants are added to food fat and fat containing substances.
3. Some antioxidants used are

BHA - Butylated hydroxyanisole
BHT - Butylated hydroxytoluene
PG - Propyl gallate
TBHQ - ~~Tetra~~ + Tertiary butyl hydroxy quinone

Flour improvers.

1. Chemical agents used are oxidizing agents, which help in bleaching the food product.
2. Benzoyl peroxide is used as flour-bleaching agent; also chlorine dioxide nitrosyl chloride, and nitrogen di and tetraoxides.
3. oxidizing agents used for dough improvement are potassium bromate, potassium iodate, Calcium iodate and calcium peroxide.

Humectants

1. Humectants are moisture-retention agents. improve the rehydration of dehydrated foods
2. Propylene glycol, glycerol, sorbitol and mannitol are examples of humectan

Anticaking agents.

+ Helps to prevent particles from adhering each other and turning into a solid material during damp weather.
2. Calcium silicate, Sodium silicoaluminate, tricalcium phosphate, magnesium silicate, & magnesium carbonate are examples of anticaking agents.

Leavening agents

- Leavening agents produce light and fluffy baked foods
- Yeast has been used as a natural leavening agent. Ammonium salts are added to provided nitrogen for the growth of yeast and phosphate salts (Sodium and Calcium phosphates) are added to maintain pH.
- Chemical leavening agents such as baking soda and ammonium Carbonate are also used
- Baking powder consists of sodium bicarbonate, when heated it produces CO_2 and water.
- Ammonium Carbonate is used as a leavening agent in baking biscuits and crackers. Ammonia escapes when baked at high temperatures.

Chelating agents

- Chelating agents, or sequestrants, are compounds that form complexes with metal ions.
- When metal ions are released due to the hydrolytic or other degradative reactions they are free to participate in reactions that lead to discoloration, oxidative rancidity, turbidity and flavor changes in the food
- Addition of chelating agents results in the complexing of these metal ions, and thereby the stabilization of the food.
- Chelators used in the food industry include sorbic acid, poly-Carboxylic acid (Citric, malic, tartaric, oxalic and Succinic acids), polyphosphates (ATP, pyrophosphates), macromolecules (porphyrins, proteins) and EDTA.

Curing agents

- Curing agents are additives used to preserve meats, to impart a desirable color and flavor, to discourage the growth of microorganisms and to prevent toxin formation.

- Sodium nitrite has been used for centuries as a preservative and color stabilizer in meat and fish products.
- The nitrite, when added to the meat is converted to nitric oxide, which combines with the myoglobin to form nitric oxide myoglobin (nitrosyl myoglobin), a heat stable pigment.
- Nitrite curing inhibits the growth of clostridium and streptococcus.
- Nitrosation may occur during storage and processing and there is evidence to the formation of nitrosamines, hence in recent times the use of nitrite in curing of meat has become controversial.
- Polyphosphates such as sodium tripolyphosphate and sodium hexa-metaphosphate are used in the curing of meat.
- These compounds aid tenderness, juiciness and flavor of the cured meat. They also contribute to the antimicrobial properties of the cured meat.

Nutrient Supplements

- Nutrient Supplements restore values lost in processing or storage, or ensure a higher nutritional value which nature may have provided.
- for eg: to produce refined flour, wheat is milled, resulting in the removal of the brown part of the grain, which is rich in vitamins, and minerals.
- To restore the losses, thiamine, nicotinic acid, iron, and calcium are added to the flour.
- Baby food is fortified to enhance its quality. lysine, methionine and use of iodine in the form of potassium iodide in common salt are examples of nutrient supplements.

Processing aids

- clarifying agents like bentonite, gelatin

Antibiotics

- Most of the better known antibiotics have been tested on raw foods, chiefly proteinacious ones like meats, fish and poultry to increase the shelf life.
- Aureomycin (Chlortetracycline), Terramycin (oxytetracycline) and chloromycetin (chloramphenicol), known to inhibit the protein synthesis in the cell.
- streptomycin, neomycin, polymyxin, nisin, subtilin, bacitracin, and others are not as satisfactory and penicillin is of little use.
- Nisin has been employed in Europe to suppress anaerobes in cheese and cheese products.
- Natamycin is effective against yeasts and molds: it is used or tested in orange juice, fresh fruits, sausage and cheese.
- Application of antibiotics in canned foods have reduced the duration or thermal treatment necessary for low and medium-acid canned foods.
- Subtilin, nisin and tylosin has suggested to use in canned ~~foods~~. Subtilin has no effect on the heat resistance of bacterial ~~spores~~ but inhibits heat-damaged cells during outgrowth.
- Nisin apparently interfering with spore germination and with lysis of the spore coat.
- Tylosin may inhibit the cell growth.
- Food biotechnologists realize the advantages of the preservation of raw foods by a nontoxic antibiotic or the use of one in combination with reduced amounts of heat in the processing of canned foods.
- Antibiotics never be substituted for good hygiene. The effect of an antibiotic on microorganisms is known to vary with the species or strain of the organism.
- There may be effects of the antibiotic on the consumer such as sensitization to it. Changes in the intestinal flora and the development of strains of pathogens in the body resistant to that antibiotic. These effects can be minimized by the use of low level of antibiotic than the amount used for therapy.

- The food and Drug Administration had approved the use of Chlortetracycline and oxytetracycline dip for preserving poultry, Setting up a 7-ppm tolerance in the uncooked, dressed foods.
- This quantity of antibiotic has been shown to double or triple the storage life of the poultry.
- Apparently, approval had been granted because evidence was given to prove that.
  i) use of material affords added protection to consumer,
  ii) basic Sanitation procedures are not replaced because of the method.
  iii) the antibiotic is destroyed during cooking of the poultry, leaving no harmful end products.
- This permission for use by FDA has been revoked. Now its permissible to use these tetracyclines at 5ppm only on fresh fish, Shucked scallops, and unpeeled shrimp.
- The antibiotic may be applied as a dip or an ice.

Developed Preservatives

- Food fermentations may serve either or both of two purposes
  1. to produce new and desired flavors and physical characteristics and hence a different food product
  2. to help preserve the food product.
- These may vary with the food and difficult to evaluate.
- In the world of food fermentation, fermented milk and Sauerkraut are the empirical discoveries and served primarily to keep milk or Cabbage over long periods of storage, but a taste for the fermented products developed, and now they are made as much for their palatability as for their keeping quality.
- The preservatives produced in foods by microbial action are the most part acids (lactic acid) and alcohol. These preservatives may be supplemented with other preservatives like low temp, heat, anaerobic conditions, Sodium Chloride, Sugar or added acid.

- Developed acidity plays a part in the preservation of Sauerkraut, pickles, green olives, fermented milk, cheese, and certain Sausages and in fermented foods.
- The approximate acidity developed in Some of these products, expressed as lactic acid, in Sauerkraut - 1.7 %.
  Salt-stock / dill pickles & green olives - 0.9 %.
  fermented milks - 0.6 to 0.85 %.
- The acidity of cheese usually is expressed in terms of hydrogen-ion concentration; mostly fresh cheeses have a pH of about 5.0 to 5.2 and become more alkaline during curing.
- The alcohol content of beer, ale, fermented fruit juices, and distilled liquors has a preservative effect but was not produced primarily for that purpose.

Food Microbiology – 18BTFT303

Unit-1

General Concepts of Molds

1. Molds are multicellular microorganisms with mycelial (filamentous) morphology. These microbes are also characterized by their display of a variety of colors and are generally recognized by their mildewy or fuzzy cotton like appearence.

2. Molds can develop numerous tiny spores that are found in the air and can be spread by air currents. These spores can produce new mold growth if they are transferred to a location that has conditions conducive to germination.

3. Molds generally withstand greater fluctuation in pH than bacteria and yeasts and can frequently tolerate more temperature fluctuation.

4. Molds grow better at pH 7, a pH range of 2.0 to 8.0 can also be tolerated, even an acid to neutral pH is preferred.

5. Usually molds growth is optimal at a aw of 0.85, but possible growth can be seen at below aw 8.0. at aw of 9.0 or higher, bacteria and yeasts grow more effectively. when aw goes below 9.0, molds grow rapidly
   i.e. food stuffs such as pastries, cheeses, and nuts that are low in moisture content are more likely to spoil from mold growth.

6. Most molds are mesophilic, grow at optimal temperatures around 25 to 30°C, Some grow at 35 to 37°C eg. Aspergillus spp
   Some molds grow at psychrotrophic (refrigeration temp), also at freezing environment −5 to −10°C. eg: Aureobasidium pullulans
   Few are thermophilic, grow at high temperatures
   eg: Myceliophthora thermophila
   Sporotrichum thermophile

7. Molds are aerobic
   i.e. They require oxygen for growth. This is true at least for the molds growing on foods.

8. In general, molds can utilize many kinds of food, ranging from simple to complex.

9. Most of the common molds possess a variety of hydrolytic enzymes, and some are grown for producing microbial enzymes like amylases, pectinases, proteinases and lipases (Hydrolytic enzymes, which break the chemical bond between atoms of large molecules in the presence of water).

10. Compounds inhibitory to other organisms are produced by some molds, such as penicillin from Penicillium chrysogenum and clavacin from Aspergillus clavatus

11. Certain chemical compounds are mycostatic, inhibiting the growth of molds eg: sorbic acid, propionates and acetates, are specifically fungicidal, killing molds.

12. Under favorable conditions, bacteria and yeasts show rapid growth than mold.

Important parts of ~~Spoila~~ Molds

The morphology, i.e., the form and structure of molds, as judged by their macroscopic and microscopic appearance, is used in their identification and classification.

Thallus: A plant body that is not differentiated into stem, and leaves and lacks true roots and vascular system.

Hyphae: The mold thallus consists of a mass of branching, interwined filaments called hyphae (singular: hypha).

Mycelium: The whole mass of hyphae

Sclerotia: Some molds produce sclerotia (singular: sclerotium), which are tightly packed masses of modified hyphae

Septate and nonseptate :

Molds are divided into two groups, septate and nonseptate. Septate with the hyphae cross walls dividing the hypha into cells nonseptate have nuclei scattered throughout their length and are considered multicellular.

Reproductive parts of molds

Reproduction is mainly by spores of Asexual and Sexual Kind.

3 - principal types of asexual spores

1. Conidia (Singular: conidium) - conidiophores (bud / fragment of hyphae)
2. Arthrospores or oidia (Singular: oidium) - fragmentation of hyphae
3. Sporangiospores (in sporangium) (plural sporangia) - at the tip of a fertile hypha, the sporangiophore.
4. Chlamydospore - formed by many species of mold, in mycelium it stores up reserve food, swells and forms a thicker wall. it uses stored food for growth in favorable condition.

Sexual spores.

1. The nonseptate molds (phycomycetes) that produce oospores are termed Oomycetes.
2. In Zygomycetes, zygospores - union of the tips of two hyphae.
3. In Ascomycetes, ascospores - union of two cells from same mycelium

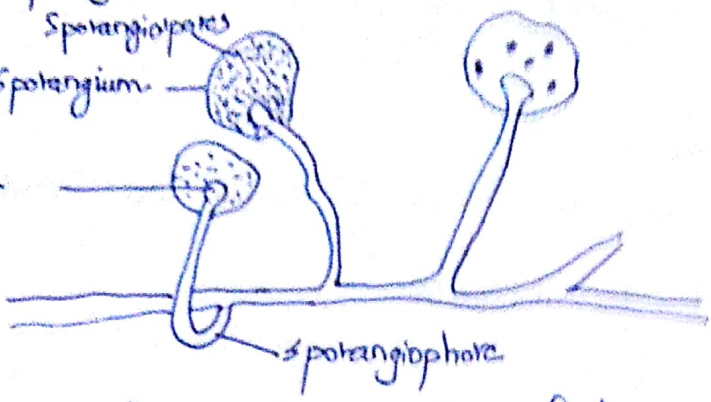
The swollen tip of sporangiophore is columella, which usually projects into sporangium.

Sterigma (plural: sterigmata) or phialide, present at the tip of conidiophore.

Molds of Industrial Importance

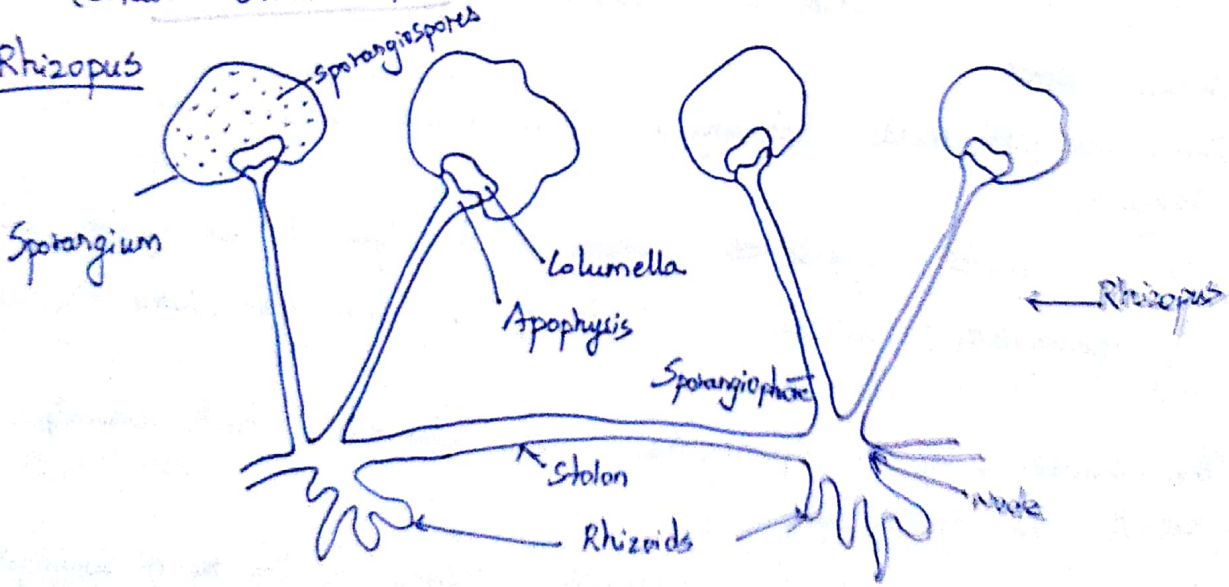
Several molds of industrial importance are outlined by genus, with typical morphological structures

1. Mucor



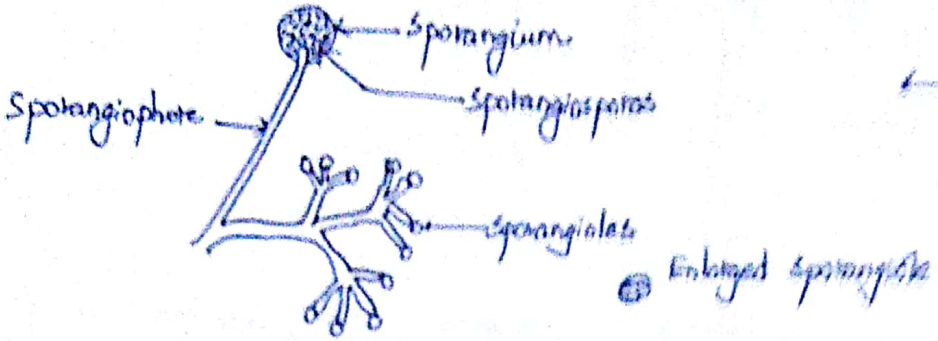
- involved in the spoilage of some foods and the manufacture of others
- widely distributed species are Mucor racemosus, Mucor rouxii, used in the 'Amylo' process for the saccharification of starch
- Helps in ripenning of cheeses (e.g. Gramelast), used in making certain Oriental foods

2. Rhizopus



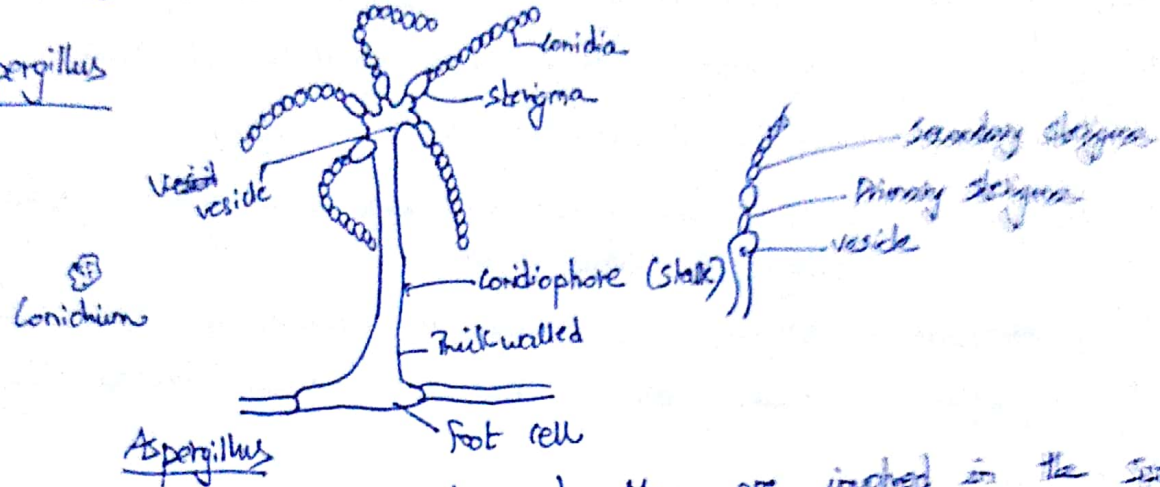
- Rhizopus stolonifer, the so-called bread mold, is very common and is involved in the spoilage of many foods: berries, fruits, vegetables, bread, etc.

Thamnidium



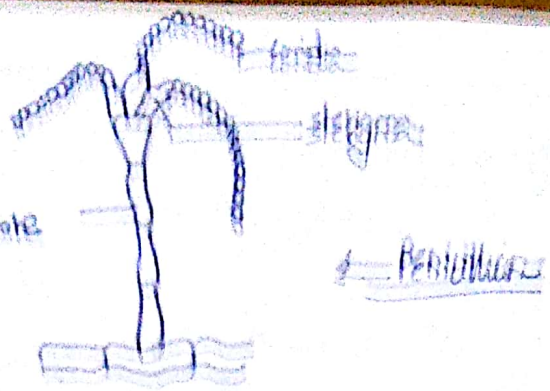
- Thamnidium elegans is found on meat in chilling storage, forming 'whiskers' on the meat

4. Aspergillus



- The Aspergilli are very widespread. Many are involved in the spoilage of foods, and some are useful in the preparation of certain foods.
- A. glaucus and A. repens – involved in food spoilage – grow well in high concentrations of sugar and salt.
- Conidia of this group are shade of green
- Asco spores - yellow to reddish
- A. niger - a leading species, is widespread and important in foods
- These spores are tightly packed, and black, brownish-black, or purple-brown
- Selected strains of niger are used in commercial production of citric acid and gluconic acid and in a variety of enzyme preparations.
- A. flavus - oryzae includes molds important in oriental foods and the production of enzymes. Conidia vary from yellow to green shade.

5. Penicillium



- This genus is widespread in distribution and important in foods
- This genus is divided into large groups on the basis of the branching of the spore-bearing heads.
- P. expansum — blue-green spore — Causes soft rot of fruits
- P. digitatum — olive or yellowish-green conidia — causing soft rot of citrus fruit
- P. italicum — Called "blue mold" with blue-green conidia. Cause rotting of citrus fruits.
- P. Camemberti — grayish mold — use in ripening of cheese eg: Camembert
- P- roqueforti — bluish-green — ripening of blue cheeses. e.g. roquefort

6. Trichothecium

- Trichothecium roseum, is a pink mold which grows on wood, paper, fruits such as apples and peaches, and vegetables such as cucumbers and Cantaloupes.

7. Neurospora (Monilia)

- Mycologists call Neurospora as perfect mold (producing sexual spores)
- Monilia sitophila - most important species in food, sometimes is termed as "red bread mold", because its pink, loose-textured growth often occurs on bread.
- It also grows on Sugarcane bagasse and on various foods.

8. Botrytis

- An important species in foods is B. cinerea. It causes a disease of grapes but may grow saptophytically on many foods

9. Monascus

- Monascus purpureus are thin and spreading, reddish purple color mold
- found on dairy products and on chinese red rice (ang-khak)

General Concepts of yeasts

1. The term 'yeast' is commonly used but hard to define.
2. Fungi which are generally not filamentous but unicellular and ovoid to or spheroid and which are reproduce by budding or fission
3. Yeasts may be useful or harmful in foods. Yeast fermentations are involved in the manufacture of foods such as bread, beer, wines, vinegar and Surface-ripened cheese and yeasts are grown for enzymes and for food.
4. Yeasts are undesirable when they cause spoilage of sauerkraut, fruit juices, syrups, molasses, honey, jellies, meats, wine, beer, and other foods.
5. Yeasts are classified chiefly on their morphological characteristics, although their physiological ones are more important to the food microbiologist.

Morphological characteristics

1. The morphological characteristics of yeasts are determined by microscopic examination.
2. The form of yeasts may be spherical to ovoid, lemon-shaped, pear-shaped, cylindrical, triangular, or even elongated into a false or true mycelium.
3. They also differ in size, Special staining is necessary to demonstrate the nucleus.

Reproduction

1. Most yeasts reproduce asexually by multilateral or polar budding. a protoplasm bulges out the cell wall grows in size and finally walls off as a new yeast cell.
2. Sexual reproduction of "true yeasts" results in the production of ascospores, the yeast cell serving as the ascus. The formation of ascospores follows conjugation of two cells in most species of true yeasts.

3. 'False' yeasts. which produce no ascospores or spores, belong to the fungi imperfecti. Cells of some yeasts become chlamydospores by formation of a thick wall about the cell, for. eg. Candida, Rhodotorula and Cryptococcus.

4. Yeasts are oxidative, fermentative or both. The oxidative yeasts may grow as a film, pellicle, or scum on the surface of a liquid and then are termed film yeasts.

5. Fermentative yeasts usually grow throughout the liquid and produce Carbon di oxide.

Physiological Characteristics.

1. Yeasts grow best with a plentiful supply of available moisture. Yeasts grow in the presence of greater concentrations of solutes such as sugar or salt than most bacteria, it can be concluded that these yeasts require less moisture than the majority of bacteria.

2. Most yeasts require more moisture than molds. Lower limit of aw for ordinary yeasts tested thus far range from 0.88 to 0.94.

   $a_w = 0.94$ – beer yeast
   $a_w = 0.90$ – yeast from condensed milk
   $a_w = 0.90$ – bakers yeast.
   $a_w = 0.62 - 0.65$ – osmophilic yeast (Syrups).

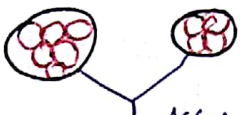
3. Molds grow optimum around 25 to 30°c and maximum about 35 to 47°c. Some kinds can grow at 0°c or less.

4. Most yeasts grow in the pH of 4 to 4-5. Yeasts grow best under aerobic conditions, but the fermentative types can grow anaerobically, although slowly.

Yeasts of industrial importance

1. Genus Schizosaccharomyces

- These yeasts, which reproduce asexually by fission and form 4 to 8 ascospores per ascus after isogamic conjugation, have been found in tropical fruits, molasses, soil, honey and elsewhere.
- A common species is S. pombe.



Ascus with four to eight ascospores

2. Genus Saccharomyces

- Saccharomyces cerevisiae var. ellipsoideus is a high-alcohol-yielding variety used to produce industrial alcohol, wines, and distilled liquors.
- Saccharomyces uvarum, a bottom yeast, is used in making beer.
- Saccharomyces fragilis and S. lactis, because of their ability to ferment lactose, may be important in milk or milk products.
- Saccharomyces rouxii and S. mellis are osmophilic.

3. Genus Zygosaccharomyces

- These yeasts are notable for their ability to grow in high concentration of sugar (hence they are termed osmophilic) and are involved in the spoilage of honey, syrups, and molasses and in the fermentation of soy sauce and some wines.
- Zygosaccharomyces nussbaumeri grows in honey.

4. Genus Torulopsis

- Round or oval fermentative yeasts, cause trouble in breweries and spoil various foods.
- Torulopsis sphaerica ferments lactose and may spoil milk products. Other species can spoil sweetened condensed milk, fruit-juice concentrates, and acid food.

5. Genus Candida

- May form films and can spoil foods high in acid and salt.
- Candida utilis is grown for food and feed.
- Candida krusei has been grown with dairy starter cultures to maintain the activity and increase the longevity of the lactic acid bacteria
- Lipolytic. Candida lipolytica can spoil butter and oleomargarine.

6. Genus Rhodotorula

- These red, pink or yellow yeasts may causes discolorations on foods. eg. colored spots on meats or pink areas in Sauerkraut.

Groups of yeasts

1. film yeasts - Genera Pichia, Hansenula, Debaromyces, Candida, and Trichosporon, grow on the surface of acid products such as Sauerkraut and pickles, and oxidize the organic acids
   - Hansenula and Pichia - oxidize the alcoholic beverages
   - Pichia favourably grows on Jerez and Arbois wine
   - Debaromyces - grow on cheese brines.

   film yeasts produce little or no alcohol from sugars.

2. Apiculate or lemon-shaped yeasts - Saccharomycodes, Hanseriaspota, Nadsonia, and Kloeckera induce off flavors, low yields of alcohol and high volatile acids.

3. Osmophilic yeasts - Saccharomyces rouxii and S. millis grow well in high sugar solutions, cause spoilage of dry fruits, concentrated fruit juices, honey, maple syrup.

4. Salt tolerant yeasts - grow in curing brines, salted meats and fish, soy sauce, miso paste, and tamari sauce.

   Most salt tolerant species are Debaromyces, which grow on curing salt brines, and on meats, and cucumbers in them.

Sewage, Waste Treatment and Disposal, Types of wastes

The food Sanitarian is concerned directly or indirectly with the adequate treatment and disposal of wastes from the industry.

Solid and concentrated wastes ordinarily are kept separate from the watery wastes and may be used directly for food, feed, fertilizer, or other purpose; may be concentrated, dried, or fermented or may be carted away to available land as unusable waste.

Care is taken to keep out of the waste waters as much wasted liquid or solid food material.

It is recommended that sewage of human origin be kept separate from other plant wastes because of the possible presence of human intestinal pathogens and the necessity for a guarantee of their removal or destruction.

Such sewage may be turned into a municipal system, if one is available, for adequate treatment and disposal or may be treated separately at the food plant. Other food plant wastes should not contain human pathogens.

Wastes from food plants ordinarily contain a variety of organic compounds, which range from simple, readily oxidizable kinds to those which are complex and difficult to decompose.

The strength of the sewage or food waste containing organic matter is expressed in terms of biochemical oxygen demand (BOD), which is the quantity of oxygen used by aerobic microorganisms and reducing compounds in the stabilization of decomposable matter during a selected time at a certain temperature.

A period of 5 days at 20°C is generally used, and results are expressed as 5-day BOD.

The BOD is determined by dilution of a measured quantity of waste with water that has been saturated with oxygen and incubation of the mixture at 20°C, along with a control of dilution water alone.

After 5 days, the residual oxygen in both control and test sample is measured by titration.

The difference represents the oxygen-consuming capacity of the waste and is calculated to be expressed as parts per million of oxygen taken up by the waste.

The strength of the waste in terms of pounds of BOD is calculated as follows:

$$\frac{\text{PPM} \cdot \text{5-day BOD} \times \text{gallons of waste} \times 8.34}{1{,}000{,}000} = \text{pounds of BOD}$$

This value can be converted to population equivalent (PE) by assuming that the domestic sewage of one person is equivalent to one-sixth of a pound of BOD per day.

Whenever, appreciable amounts of wastes high in oxidizable organic matter (high BOD) are emptied into natural waters, such as streams, ponds, or lakes. The 7 to 8 ppm of free oxygen normally present in waters is used up soon by oxidation processes carried by aerobic or facultative microorganisms.

When the oxygen drops below 3 ppm, the fish either leave or die and anaerobic condition have been attained, hydrolysis, putrefaction and fermentation by microorganisms will follow, result the body of water will become malodorous and cloudy and hence unsuited for recreational use and unfit for drinking and for use in the food plant

Wastes from a food plant to be emptied into a body of water must either be so greatly diluted by that water or must be treated first to reduce the oxidizable compounds to a harmless level.

Even the effluent from an efficiently operated sewage treatment system will encourage the growth of algae and higher aquatic plants in the water and make it less attractive for recreational purposes.

Chemical treatment

1. In chemical pretreatments, a chemical or mixture of chemicals is added to the sewage or waste so as to cause formation of a flocculent precipitate, which in settling, carries with it much of the suspended and colloidal material, including bacteria.
2. The effluent then is run into a body of water, onto soil, or into a biological treatment system.
3. The chemicals commonly used are soluble aluminium or iron salts, such as alum or ferrous sulfate, plus lime, giving a flocculent precipitate of a aluminium or ferric hydroxide.

Biological treatment and Disposal.

The general biological methods for waste disposal / treatment include

1. Dilution - by running waste wates into a large body of water
2. Irrigation - in which waste waters are sprayed onto fields of open-textured soil.
3. Lagooning - by turning the waste waters into shallow artificial ponds (with or without other treatments)
4. Use of trickling filters - made of crushed rock, coke, filter tile, etc
5. Use of activated sludge method - waste water is inoculated heavily with sludge from a previous run and is actively aerated in tanks.
6. Use of anaerobic tanks - various kinds of anaerobic tanks, where settling, hydrolysis, putrefaction and fermentation take place, usually to be followed by some aerobic treatment.

Types of food wastes

1. Each type of waste has a characteristic BOD that may be high, low or intermediate and that each present its own problems of treatment and disposal.
2. Dairy wastes, for example are usually high in protein, and lactose and contain many microorganisms.

3. Such wastes, if not already acid, will turn acid if kept under anaerobic conditions and then will be more difficult to treat
4. Some wastes may be acid originally, e.g. wastes from fruit canneries,
5. Malthouse, brewery, distillery, sweet-corn cannery and corn-products plant wastes are high in carbohydrates and likely to become acid under anaerobic conditions
6. Wastes high in proteins, e.g. pea- or fish-cannery and packing-plant wastes, are likely to putrefy under anaerobic conditions.
7. Other wastes may contain antiseptic chemicals such as the sulfite in waste sulfite liquors from paper mills, and therefore may be difficult to decompose by means of microorganisms.
8. Ranges of 5-day BOD values reported for wastes from various types of food-processing plants are given in the below table.
9. Most industry-related wastes have been the subject of extensive research on waste utilization.

Range of 5-day BOD values for wastes from various food processing plants

Source of wastes	5-day BOD, PPM	Source of waste	5-day BOD, PPM
Dairy plants	500 – 2000	Pea Cannery	380 – 4700
Meat packing plants	upto 2500	pumpkin Cannery	2800 – 6900
Poultry plants	300 – 7500	spinach Cannery	280 – 730
Sugar processing	500 – 1500	Sauerkraut Cannery	upto 6,300.
Fruit Cannery	200 – 2100		
Tomato Cannery	180 – 4000		
Brewery	420 – 1200		
String bean Cannery	180 – 600		
Lima bean Cannery	190 – 450		
Sweet Corn Cannery	625 – 6000		

Food Fermentations

Fermentation in food processing is the process of converting carbohydrates to alcohol or organic acids using microorganisms - molds, yeasts or bacteria - under anaerobic conditions.

The science of fermentation is known as Zymology or Zymurgy.

Food fermentation not only helps preserve the foods but also results in distinctive new food products. Many fermentations make food porous, fluffy, texturized / imparts flavor.

Bread, beer, wine or distilled liquors by yeast
Vinegar — Yeast and bacteria
fermented milk — bacteria
Cheeses and oriental foods — Molds.

Bread

Microorganisms are useful in two ways in bread making

1. They may produce gas to leaven, or raise, the dough, giving the bread the desired loose, porous texture, and
2. They may produce desirable flavoring substances. They may also function in the conditioning of the dough.

Leavening

1. Dough is usually leavened by bread yeasts, which ferment the sugars in the dough and produce mainly CO_2 and alcohol.
2. Also, instead of bread yeasts, gas-forming microorganisms, such as wild yeasts, coliform bacteria, Saccharolytic clostridium species, heterofermentative lactic acid bacteria.
3. Leavening also may be accomplished by the direct incorporation of gas (CO_2) in the dough.

Leavening by Bread Yeasts

1. There is little or no growth during the first 2 hr after the yeast is added to the dough, but some growth in 2 to 4 hr. if more than 4 hrs. there will be decline in growth in 4 to 6 hr
2. Fermentation by yeast begins as soon as the dough (or sponge) is mixed and continues until the temperature of the oven inactivates the yeast enzymes.
3. During fermentation, "conditioning" of the dough takes place when the flour proteins (gluten) mature, i.e. become elastic and springy and therefore capable of retaining a maximal amount of the CO_2 produced by the yeasts.
4. The conditioning results from action on the gluten by
   a. proteolytic enzymes in the flour from the yeast, from the malt or added otherwise.
   b. the reduction in pH by the acids added and formed.
5. Dough conditioners, sometimes called yeast foods, that are added include ammonium salts to stimulate the yeasts and various salts, eg., $KBrO_3$, KIO_3, CaO_2 and $(NH_4)_2S_2O_8$, to improve dough characteristics.
6. The rate of gas production by the yeasts is increased by adding
   i. more yeast
   ii. sugar or amylase-bearing malt and
   iii. yeast food

   Gas production can be decreased by
   i. addition of salt
   ii. addition of too much yeast food
   iii. use of too high or low temperatures.

Leavening by Other Microorganisms

1. Leavening can be accomplished by gas-forming bacteria other than bread yeasts.
2. Heterofermentative lactic acid bacteria and saccharolytic anaerobes can take part in leavening.
3. Salt-rising-bread is leavened by "salt-rising yeast" as well as microorganisms from the ingredients.

Leavening by Chemicals

1. Leavening of dough may be accomplished by chemical agents instead of by microorganisms.
2. CO_2 gas which may be incorporated directly into the dough, or baking powders, which are combinations of chemical compounds that release gas when mixed into the dough, may be employed for leavening.
3. The addition of ammonium bicarbonate can be used, since the heat of baking will result in the release of CO_2 and NH_3 gas.

Continuous Bread making

1. Continuous bread making process usually involves growth and fermentation by the yeast in part of the ingredients to get a large yield of active yeast or at least the addition of more yeast than usual, before the final dough is formed.
2. Leavening may take place in the pans just before baking.

Flavor production

1. Yeasts are reported to contribute to the flavor of bread though products released during the fermentation of sugars, many workers believe that yeasts add little or no flavor.
2. More than yeasts, bacteria growing in dough can contribute the most to flavor. Alcohol, esters, acids and aldehydes are products that add desirable flavors.
3. In industries, leavening may be allowed for too little time, than in domestic home traditional baking methods, which take long time for leavening and more flavor will be imparted to the bread.
4. Previous culture in dough may receive a good inoculums for desirable flavor producing bacteria for day-to-day bread production. Some special brands of bread made in this way are famous for their characteristic flavors.
5. Most of the flavor in bread may come from ingredients and chemical reaction like Maillard browning during baking. Flavoring substances may include alcohol, diacetyl, aldehydes, acetoin, iso alcohols, lactic, acetic and succinic acids and their esters.

The Baking process

1. Although the interior of the loaf does not quite reach 100°C during baking, the heat serves to kill the yeasts, inactivates enzymes, from flour and malt, expands the gas present, and set the structure of the loaf.
2. Baking, besides producing the appearence of the loaf, also contributes desirable flavors.
3. The heat also drives off most of the alcohol and other volatile substances formed but contributes substances such as furfural, pyruvic acid, other aldehydes.

Rye bread

1. Rye bread may be made with or without a starter or "sour".
2. The older method of preparing sour depended on the bacteria naturally present in a mixture of rye flour and water.
3. The mixture was allowed to ferment for 5 to 10 hr; then more flour and water were added and the fermentation was continued for an additional 5 to 6 hr. Then this was repeated several times.
4. Half of the ~~dough~~ sour thus produced was incorporated in the sponge or dough for the bread, and the rest was carried over to start a new sour.
5. This sour was modified by some bakers by the addition of yeasts and of lactic acid bacteria from cultured buttermilk or Bulgarian buttermilk to a sour that was made a new daily.
6. Moder methods involve adding considerable amounts of cultures of acid-forming bacteria to the dough used as a sour, and controlling the fermentation time 18 to 24 hr and incubation temp 25°C.
7. The starter imparts a desired tangy or sour flavor to the rye bread that is not given by the addition of lactic and acetic acids.

San Francisco Dough Bread

1- The leavening of this type of bread results from the action of Torulopsis holmii, the asporogenous form of Saccharomyces exiguus.

2- The second principal organism involved, responsible for the acid development, has been identified as a heterofermentative Lactobacillus Sanfrancisco.

Wines

The term "wine" applied to the product made by the alcoholic fermentation of grapes or grape juice by yeast and a subsequent aging process.

Wines, however, can be produced by the fermentation of the juices of fruits, berries, rhubarb, dandelions, honey - etc.

Grape wine

1. Grape wines may be red or white
2. Red wines fermented on the skins, contain red pigment from the skins of purple or red varieties of grapes.
3. White wines are made from white grapes or the expressed juice of other grapes, fermented free of the skin.

Preparation of juice.

Grapes are harvested with known variety, reaching desired sugar content

↓

Concentration of sugar may vary, depends on grape variety and it degree of ripeness.

↓

Stemmed and Crushed by machine

↓

Treated with sulfurdioxide or Potassium metabisulfite (75-200 ppm)

↓

which inhibits the undesirable competitors of yeast

Fermentation

Crushed grapes (must) transferred to a tank

↓

2 to 5% of special wine yeast, Saccharomyces cerevisiae var. ellipsoideus added to the must.

↓

The contents of the tank are mixed twice a day

↓

facilitates, aeration and growth of yeast, also stirring make the color to squeeze out from grape skin.

↓

Mixing is discontinued, allowed for anaerobic fermentation (alcoholic)

↓

Maintain temperature, for red wine → 24–27°C, 3 to 5 days
for white wine → 10–21°C, 7 to 14 days

↓

High temp inhibits wine yeasts and permitting Lactobacilli to grow
low temp slows action of wine yeasts, and permits wild yeasts, lactic acid bacteria, and other organisms to grow.

↓

After primary fermentation → fermented juice is drawn and placed in a storage tank under a light pressure of CO_2 for secondary fermentation for 7 to 11 days at 21 to 29°C.

↓

Remaining sugar is fermented, if dry wine is desired.
Clear wine is drawn off or racked.

Storing and Aging

Wine – flash pasteurized before aging to precipitate proteins

↓

Cooled (few days), filtered and transferred into wooden tanks

↓

Wooden tanks (Oak or red wood) / plastic-coated concrete tanks.

↓

Tanks are filled completely and sealed to keep out air.

↓

final aging may be in the bottle

↓

Aging → months / years – results in desirable changes in body and flavor of the wine, aroma develops.

↓

During aging, malolactic fermentation may take place. (fermentation of malic acid of grape juice by lactobacilli)

↓

After aging, wine is filtered, clarified, barreled or bottled, and stored.

↓

Some wines are pasteurized after aging, usually in the bottle.

↓

The final alcohol content may vary between 6 to 9% by W or 8 to 13% by V.

Volatile Acidity of Wines

High content of volatile acid in wines indicates faulty fermentation

In US, the legal limit for volatile acid content in wine is 0.14 g / 100 ml, expressed as acetic acid for red wine
0.12 g / 100 ml, " " for white wine

Microbiology

1. The grapes when Crushed have a variety of microorganisms on their surfaces, including yeasts and bacteria.
2. Not only on the surface, flora of the grape present, but also an array of Contaminants from the soil.
3. To Suppress these organisms the wine maker adds sulfurdioxide or sulfite or less commonly pasteurizes the must.
4. In anaerobic conditions, fermentation liberates Co_2 and ethyl alcohol. both of which help inhibit organisms other than the wine yeast.
5. The Surface Co_2 above the wine in Secondary fermentation prevents the growth of aerobic Contaminants, Such as acetic acid bacteria

Kinds of wine

① Still wines: They retain none of the Co_2 produced during fermentation
② Sparkling wines: which Contain Considerable amounts of Co_2, Sometimes artificially Carbonated.
③ Dry wines: Contain little or no unfermented sugar
④ Sweet wines: which have Sugar left or added
⑤ fortified wines: Distillate of wines called wine spirits or brandy has been added, Contain about 19 to 21 % of alcohol
⑥ Table wines: Low Content of alcohol, little or no Sugar
⑦ Dessert wines: fortified Sweet wines

Wine defects and microbial Spoilage

1. Like beer, wine has defects from nonmicrobial Causes and Spoilage Caused by microorganisms.
2. Defects include those due to metals or their salts, enzymes, and agents employed in clearing the wine.
3. Iron, for eg. may produce a Sediment known variously as gray, black, blue, or ferric ~~cause~~ Cause, and in white wine may be responsible for a white precipitate of iron phosphate termed white Cause

4. Tin and copper and their salts have been blamed for cloudiness. White wines may be turned brown and red wines may have their color precipitated by peroxidase, an oxidizing enzyme of certain molds. Gelatin, used in clarifying wines, may cause cloudiness.

5. Microorganisms causing wine spoilage are chiefly wild yeasts, molds, and bacteria of the genera,
Acetobacter, Lactobacillus, Leuconostoc and Micrococcus / pediococcus.

Factors affecting the growth of microorganisms

1. Acidity or pH

- The lower the pH, the less likely there is to be spoilage. The minimal pH permitting the growth of microorganisms varies with the organisms, type of wine, and alcoholic content.

2. Sugar Content

- Dry wines (0.1% sugar), with their low sugar content, are rarely spoiled by bacteria, but 0.5 to 1.0% or more sugar will favor spoilage.

3. Concentration of alcohol

- Tolerance of alcohol varies with spoilage organism.
- Acetic bacteria spoiling musts and wines are inhibited by over 14 to 15% of alcohol.
- deacidifying coli are stopped by 12%, Leuconostoc spp by 14%, heterofermentative lactobacilli by 18%, homofermentative by 10%.

4. Concentration of accessory growth substances

- Acetobacter species can make their own vitamins, but lactic acid bacteria must have their vitamins provided / added.
- Chief source is the wine yeast, which releases accessory growth factors.
- The more of these substances present, greater the likeli-hood of spoilage by lactic acid bacteria.

5. Concentration of tannins.

- Tannins added with gelatin for clarification retard bacteria, but usually not enough are added to be of much practical importance as inhibitors.

6. Amount of Sulfurdioxide present
- The more sulfurdioxide added, greater the retardation of the spoilage microorganisms.
- 75 to 200 ppm, is adequate
- Effectiveness depends upon the kind of organism to be suppressed and increases with a lowering of pH and sugar content.

7. Temperature of Storage
- Spoilage usually most rapid at 20 to 35°C and slows as the temperature is dropped toward freezing.

8. Availability of air
- Absence of air prevents the growth of aerobic organisms, such as molds, film yeasts and Acetobacter, but the lactic acid bacteria grow well anaerobically.

Spoilage by Aerobic Microorganisms

1. film yeasts, which can oxidize alcohol and organic acids, may grow on the surface of must and wines exposed to air, producing a heavy pellicle called "wine flowers" They should cause no trouble if the must is mixed periodically and if the air is kept away from the wine.
2. In the presence of air, the aerobic acetic acid bacteria, usually Acetobacter aceti or Gluconobacter oxydans, oxidize alcohol in must or wine to acetic acid, an undesirable process called acetification. They may oxidize glucose in the must to gluconic acid and may give a "mousy" or "sweet-sour" taste to the must.

Spoilage by facultative Microorganisms

1. The most commonly occurring is tourne (turned or soured) spoilage, in which acid is formed from sugars, glucose and fructose in the wine, chiefly by heterofermentative Lactobacillus species, such as L. brevis, L. hilgardii, L. trichodes and L. buchneri
2. The growth of Lactobacilli produces silky cloudiness, increases lactic and acetic acid, yields CO_2. Sometimes gives "mousy" or other disagreeable flavors and damages the color of the wine.

3. When the fermentation of fructose results in the bitter product mannitol, the fermentation sometimes is termed "mannitic", bitterness (amertume) also may result from the fermentation of the glycerol in the wine.
4. Graininess, resulting from any cause. Such as from the liberation of CO_2 by the heterofermentative lactics, is called "pousse".
5. The homofermentative L. plantarum forms mostly lactic acid from sugars in table wines, increasing the fixed acidity and giving a "mousy" flavor.
6. Sliminess or ropiness of young white wines, accompanied by cloudiness and increased volatile acidity has been blamed for Leuconostoc spp. L. mesenteroids, & L. dextranicum.

Other wines

1. Wines can be made from most kinds of fruits, including apples (hard cider), peaches, apricots, plums, pears (perry), cherries, berries and many others.
2. Berries and most other fruits (except wine grapes) contain insufficient sugar to make a good wine and must be "ameliorated" by the addition of sugar before the fermentation.
3. The products may be dry, sweet, fortified, sparkling or carbonated wines for consumption as such or for distillation to produce brandies. may also be made from dried fruits such as raisins, dates, figs & prunes
4. Any edible product that contains sufficient moisture, sugar, and other foods for yeasts can be used to make wine
5. Honey wine, or mead, is made from diluted honey to which minerals and nitrogenous food for the yeasts have been added.
6. Dandelion wine is homemade product made by alcoholic fermentation of a water extract of flowers of the dandelion to which sugars flavoring substances and yeast have been added

Distilled Liquors

1. Distilled liquors or spirits are produced by distillation of an alcoholically fermented product.
2. Rum is the distillate from alcoholically fermented sugarcane juice, syrup or molasses.
3. Whiskeys are distilled from saccharified and fermented grain mashes eg: rye whisky from rye mash, bourbon or corn whiskeys from corn mash, wheat whiskey from wheat mash, etc.
4. Rums and whiskeys are made from mashes fermented by special distillers' yeasts, strains of Saccharomyces cerevisiae var. ellipsoideus which give high yields of alcohol.
5. Brandy means the distillate from grape wine, unless a qualifying word is added. e.g. apple brandy (apple jack), peach brandy, and apricot brandy.
6. There should be no problems of spoilage of distilled liquors by microorganisms.

Malt beverages

① Beer and ale are the principal malt beverages.

② Made of malt, hops, yeast, water and malt adjuncts.

Malt - Prpated from barley grains - germinated and dried and had sprouts or germs removed.

Hops - dried flowers of the hop plant

Malt adjuncts - starch or sugar containing materials.

- Corn, corn products, rice, wheat, barley, sorghum grain, Soybeans Cassava, potatoes.
- sugars and syrups.

Brewing of beer.

① Malting.

Barley grains soaked / steeped at 10 to 15.6°C

↓

germinated at 16 to 21°C for 5 to 7 days and kiln dried

↓

Sprouts & germs removed

↓

Malt, source of amylases and proteinases, crushed before use.

② Mashing

Main purpose of Mashing is

- to make soluble as much as possible of valuable portions of malt and malt adjuncts.
- to cause hydrolysis of starches and other polysaccharides, proteins, & products of their hydrolysis.

Mashing

Mixing ground malt with water at 38 to 50°C

↓

Add, cooked starch malt adjuncts in water at 100°C, after boiling or cooking under steam pressure

↓

Temperature rises to 65 - 70°C

↓

Saccharification occurs (production of sugars from starch)

↓

Temperature is increased to 75°C

↓

Inactivate the enzymes

↓

Insoluble material settles down / clear liquid is called wort

↓

Special 'lauter' tub is used for the filtration

↓

Rinsing from the filtering material added to wort

↓

Hops are added

Boiling the wort with Hops

Liquid containing wort and Hops are boiled for 2.5 hrs

↓

filtered → hop solids and precipitated proteins are removed

↓

precipitate is washed with hot water

↓

washings are collected in original filtrate

↓

Mash / wort is ready for fermentation

Advantages of boiling

- to concentrate it
- to sterlize it
- to inactivate enzymes
- to extract soluble substances from hops
- to coagulate & precipitate proteins
- to caramelize the sugar
- to contribute antiseptic substances.

Fermentation

Bottom Yeast S. Carlsbergenesis used for inoculation of the cooled wort.

↓

1 lb (543.6 g) per barrel of beer. (159 lit)

↓

temp 3.3 to 14°C

↓

Complete within 8 to 14 days, mostly 8 to 10 days

↓

yeast converts sugar in the wort to alcohol and CO_2, glycerol, acetic acid.

↓

End. bottom yeast breaks, floculate and settle

Aging / maturing

young beer / green beer

↓

Stored in vats at 0°C from several weeks to several months

↓

Precipitation of proteins, yeasts, resin, and other undesirable substances.

↓

Beer becomes clear. Ester compounds add taste & aroma.

finishing.

After aging, beer is carbonated to CO_2 0.45 - 0.52%.

↓

cooled, filtered and packaged in bottles, cans, or barrels

↓

The alcohol content is about 3.8% by weight

↓

Beer cans/bottles are pasteurized at about 60 - 61°C

Microbiology

1. The procedure during the brewing process have a great influence on the ability of Morganisms to survive or grow.
2. The first two steps, malting and mashing, are highly probable for occuring Organisms.
3. Boiling the wort and hops for 2.5 hrs, provide sufficient heat to destroy all but most resistant bacterial spores, Clostridium and Bacillus, may be destroyed by the combined action of heat and hops antiseptics.
4. The wort is unfavorable to some organisms because of its low pH (3.7 to 4.5).

Beer defects and diseases

1. The term defects will be applied here to undesirable characteristics with causes that are not microbial such as
   a. turbidity due to unstable protein, protein-tannin complexes, starch and resin.
   b. off-flavors caused by poor ingredients or contact with metals.
   c. poor physical characteristics.

2. The beer infections or beer diseases caused by microorganisms. The mash in the brewhouse may undergo butyric acid fermentation by Clostridium spp or lactic acid fermentation by lactics, if the mash is held too long at temperatures favoring these bacteria. Off-flavors so produced may carry over into the beer.
3. Yeast adding into the wort, be pure and it's not contaminated with other organisms. Yeast and bacteria produce turbidity when they grow in beer and induce cloudiness in beer.
4. The bacteria causing beer diseases are mostly from the genera Pediococcus, Lactobacillus, Flavobacterium and Acetobacter.
5. Sarcina sickness, characterized by sourness, turbidity, and ropiness of beer is caused by Pediococcus cerevisiae.
6. Lactobacillus pastorianus and L. diasticus cause sourness and a silky turbidity. These bacteria produce lactic, acetic, and formic acids and alcohol and CO_2 and alcohol.
7. Species of Acetobacter and Gluconobacter, which are tolerant of acid and hop antiseptics, can cause sourness of wort or beer under aerobic conditions.
8. All the yeasts and bacteria that cause infections or diseases in wort and beer are killed by boiling the wort and hops and must enter thereafter from equipment, the air, the water, or the pitching yeast and that aseptic and sanitary precautions will help prevent these troubles.

Other Malt beverages and Beer types

Variations in malt beverages or beer types are usually related to

1. Alcohol content
2. Concentration of malt and hops used
3. Length of aging
4. Initial total solids and
5. Temperature of fermentation

a. Malt liquor: may have a higher alcohol content than regular beer

b. Bock beer: very dark beer with a high alcohol content, addition of higher alcohol concentrations of malt and hops followed by longer aging.

c. Pilsener: Lager-type beer, light in colour, containing little remaining fermentable carbohydrate.

d. Low-Calorie: light or no carbohydrate
These beers are made from prehydrolyzed wort. fungal enzymes like glucoamylases and amylases are used to hydrolyze the dextrin to maltose and glucose.

e. Ale: made with top yeast, instead of bottom yeast. The primary fermentation takes place at 12.2 to 24.4°C, a higher temp than beer, and 5 to 7 days of fermentation. Usually, pale in color and tart in taste.

f. Weiss, porter and stout beer.
- Ales, top yeasts are employed. Weiss beer is a light, tart ale made chiefly from wheat. Porter and stout are dark, heavy and sweet ales.

g. Sake: Yellow rice beer, wine of Japan; with an alcohol content of 14 to 17%. Aspergillus oryzae, inoculated in a soaked or steamed rice. This Koji contains amylases cause hydrolysis of rice starch to sugars. The liquor filtered from the fermented mass after 10 to 14 days is the sake

h. Sonti: Rice beer or wine of India. The mold Rhizopus sonti and yeasts are active in fermentation.

i. Pulque: Latin-American beer like beverage made by fermentation of about 6% alcohol from the juice of agave or century plant.

j. Ginger beer: Mildly alcoholic, acid beverage made from sugar solution flavored with ginger.
Saccharomyces pyriformis and Lactobacillus vermiformis are used for fermentation.