KARPAGAM ACADEMY OF HIGHER EDUCATION

(Established Under Section 3 of UGC Act 1956)

Coimbatore – 641 021.

(For the candidates admitted from 2017 onwards)

DEPARTMENT OF MICROBIOLOGY

CLASS: II B.Sc (MB) **BATCH – 2017 -2020**

SUBJECT NAME: FOOD AND DIARY MICROBIOLOGY PRACTICAL

SUB.CODE:17MBU312

SEMESTER: III **4H – 4C**

SYLLABUS

Instruction Hours / week:L: 4 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 03 Hours

Unit: 1 –

Foods as a substrate for microorganisms Natural flora and source of contamination of foods in general. Intrinsic and extrinsic factors that affect growth and survival of microbes in foods. Microbial spoilage of various foods – Spoilage of vegetables, fruits, meat, eggs, milk and butter, bread, canned Foods

Unit: 2 –

Principles and methods of food preservation and sterilization Principles of food preservation. Physical methods of food preservation: temperature (low, high, canning, and drying), irradiation, hydrostatic pressure, high voltage pulse, microwave processing and aseptic packaging. Chemical methods of food preservation: salt, sugar, organic acids, SO2, nitrite and nitrates, antibiotics and bacteriocins, sterilization of dry heat, moist heat, chemical, physical and radition.

Unit: 3 –

Fermented foods Fermented dairy products: yogurt, acidophilus milk, kumiss, kefir, dahi and cheese. Other fermented foods: idly, sauerkraut, soy sauce and tampeh. Probiotics: Health benefits, types of microorganisms used, probiotic foods available in market.

Unit: 4 –

Food borne diseases Causative agents, foods involved, symptoms and preventive measures of the following diseases Food intoxications: *Staphylococcus aureus*, *Clostridium botulinum* and mycotoxins. Food infections: *Bacillus cereus*, *Vibrio parahaemolyticus*, *Escherichia coli*, Salmonellosis, Shigellosis, *Yersinia enterocolitica*, *Listeria monocytogenes* and *Campylobacter jejuni* , fungal diseases, toxins

Unit: 5 –

Detection of food borne pathogens, food sanitation and control Cultural and rapid detection methods of food borne pathogens in foods and introduction to predictive microbiology. HACCP, FSSAI Indices of food sanitary quality and sanitizers.

Suggested readings

1. Jay JM, Loessner MJ and Golden DA. (2005). Modern Food Microbiology. 7th edition, CBS Publishers and Distributors, Delhi, India.
2. Frazier WC and Westhoff DC. (1992). Food Microbiology. 3 rd edition. Tata McGraw-Hill Publishing Company Ltd, New Delhi, India.
3. Adams MR and Moss MO. (1995). Food Microbiology. 4th edition, New Age International (P) Limited Publishers, New Delhi, India.
4. Gould GW. (1995). New Methods of Food Preservation. Blackie Academic and Professional, London.
5. Banwart JM. (1987). Basic Food Microbiology. 1 st edition. CBS Publishers and Distributors, Delhi, India.
6. Davidson PM and Brannen AL. (1993). Antimicrobials in Foods. Marcel Dekker, New York.
7. Dillion VM and Board RG. (1996). Natural Antimicrobial Systems and Food Preservation. CAB International, Wallingford, Oxon.
8. Lund BM, Baird Parker AC, and Gould GW. (2000). The Microbiological Safety and Quality of Foods. Vol. 1-2, ASPEN Publication, Gaithersberg, MD.

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DEPARTMENT OF MICROBIOLOGY

SUBJECT NAME: FOOD AND DAIRY MICROBIOLOGY
SEMESTER: III
SUB.CODE:17MBU302 **CLASS: II B.Sc (MB)**

LECTURE PLAN
DEPARTMENT OF MICROBIOLOGY

S.No	Lecture Duration Period	Topics to be Covered	Support Material/Page Nos
		UNIT-I	
1	1	Natural flora and source of contamination of foods	T1 13-20 R1 35-39
2	1	Intrinsic factors that affects growth and survival of microbes in food	T3 23-26
3	1	Extrinsic factors that affects growth and survival of microbes in food	R1 77-78
4	1	Microbial spoilage of vegetables and fruits	T2 194-206
5	1	Spoilage of meat and eggs	T1 201-219
6	1	Spoilage of milk and butter	T1121-130
7	1	Spoilage of bread	T1 236-245
8	1	Spoilage of canned foods	R2 306-318
9	1	Recapitulation and discussion of question	
	Total No of Hours Planned For Unit 1=09		
		UNIT-II	
1	1	Principles of food preservatives-physical methods temperature	T2 101-130
2	1	Preservation by irradiation, hydrostatic pressure, high Voltage pulse	T1 290-300
3	1	Preservation by microwave processing and aseptic package	T2 140-142
4	1	Chemical methods salt, sugar and organic acids	T1 250-263
5	1	So2, Nitrite and Nitrates	T3 102-107

6	1	Preservation by antibiotic, bacteriocins	T2 154-170
7	1	Sterilization by heat, moist heat,	R1 451-455
8	1	Sterilization by chemical, physical and radiation.	R1 466-488, W1
9	1	Recapitulation and discussion of question	
	Total No of Hours Planned For Unit II=09		
		UNIT-III	
1	1	Fermented dairy products: yogurt, acidophilus milk	R1 191-194
2	1	Fermented products kumis, kefir	W2, J1
3	1	Fermented products dhai, cheese	W3,R1 205-225
4	1	Fermented Idly, sauerkraut	W4,T1 205-210
S5	1	Fermented soy sauce and tampeh	J2,T3 362-365
6	1	Probiotic health benefits	J3
7	1	Types of microorganisms used	J4
8	1	Probiotics foods available in market	W5
9	1	Recapitulation and discussion of question	
	Total No of Hours Planned For Uni III=09		
		UNIT-IV	
1	1	Causative agents foods involved symptoms of *Staphylococcus aureus*,	R1 344-350
2	1	Causative agents foods involved symptoms of *C. botulinum*	T1 572-580
3	1	Mycotoxins	T1 709-722
4	1	Food infections: *Bacillus cereus, Vibrio parahaemolyticus*	T3 185-189
5	1	*E.coli*, Salmonellosis and Shigellosis	R1 361-367 R1 371-374 T1 567-569
6	1	*Yersinia enterocolitica* and *Listeria monocytogenes*	T3 634-645 T3 224-229
7	1	Food infection *Campylobacter ijejuni*	T1 668-671
8	1	Fungal diseases- Toxin	T3 281-297

9	1	Recapitulation and discussion of question	
	Total No of Hours Planned For Unit IV=09		
		UNIT-V	
1	1	Culture methods of food pathogens	T3 374-394
2	1	Rapid detection methods of food pathogens	R1 558-586
3	1	Introduction to predictive microbiology	T3 500-529
4	1	HACCP	T2 487-490
5	1	FSSAI	T3 425-432
6	1	Indices of food sanitary	T2 500-504
7	1	Quality of food products	W6
8	1	Quality of sanitizers used and types	W7
9	1	Recapitulation and discussion of question	
10	1	Old question paper discussion (Last Five years)	
11	1	Old question paper discussion (Last Five years)	
12	1	Old question paper discussion (Last Five years)	
	Total No of Hours Planned for unit V=12		

SUGGESTED READINGS:

1. Jay JM, Loessner MJ and Golden DA. (2005). Modern Food Microbiology. 7th edition, CBS Publishers and Distributors, Delhi, India.
2. Frazier WC and Westhoff DC. (1992). Food Microbiology. 3rd edition. Tata McGraw-Hill Publishing Company Ltd, New Delhi, India.
3. Adams MR and Moss MO. (1995). Food Microbiology. 4th edition, New Age International (P) Limited Publishers, New Delhi, India.

References:

1. Bibek Ray (2004) Fundamental Food Microbiology. 3rd edition, CRC Press,Boca Raton, London.

Journals:

1. Semih Ot1es and Oz1em Cagindi "Kefir: A Probiotic Dairy-Composition, Nutritional and Therapeutic Aspects" Pakistan Journal of Nutrition 2 (2): 54-59, 2003.
2. Luth B.S. "Industrial production of soy sauce" Journal of Industrial Microbiology 14 :467-471,1995.

3. Ivonne Figueroa-González, Alma Cruz-Guerrero1 and Guillermo Quijano "The Benefits of Probiotics on Human Health" Journal of Microbial & Biochemical Technology" 72: 4172-4190.
4. Sabina Fijan "Microorganisms with Claimed Probiotic Properties: An Overview of Recent Literature" 11 : 4745-4767, 2014.

Websites:

1. WWW.sterile.in.org
2. WWW.users.on.net
3. WWW.consumers affairs.nic
4. WWW.generalmicroscience.com
5. WWW.livestrong.com
6. WWW.quality.com
7. WWW.santizers.in.ace

UNIT-I
SYLLABUS

Natural flora and source of contamination of foods in general. Intrinsic and extrinsic factors that affect growth and survival of microbes in foods. Microbial spoilage of various foods- Spoilage of vegetables, fruits, meat, eggs, milk and butter, bread, canned foods.

Natural flora in Foods

Molds

Mold growth on foods, with its fuzzy or cottony appearance, sometimes colored, is familiar to everyone, and usually food with a moldy or "mildewed" food is considered unfit to eat. Special molds are useful in the manufacture of certain foods or ingredients of foods. Thus, some kinds of cheese are mold-ripened, e.g., blue, Roquefort, Camembert, Brie, Gammelost, etc., and molds are used in making Oriental foods, e.g., soy sauce, miso, sonti, and other discussed later. Molds have been grown as food or feed and are employed to produce products used in foods, such as amylase for bread making or citric acid used in soft drinks.

General characteristics of molds

The term "mold" is a common one applied to certain multicellular filamentous fungi whose growth on foods usually is readily recognized by its fuzzy or cottony appearance. Colored spores are typical of mature mold of some kinds and give color to part or all of the growth. The thallus, or vegetative body, is characteristic of thallophytes, which lack true roots, stems, and leaves.

Morphological Characteristics

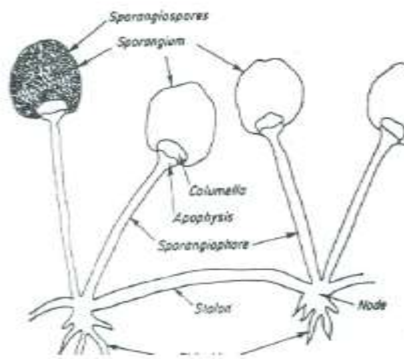
Hyphae and Mycelium: The mold thallus consists of a mass of branching, intertwined filaments called hyphae (singular hypha), and the whole mass of these hyphae is known as the mycelium. Molds are divided into two groups: septate, i.e., with cross walls dividing the hypha into cells; and noncoenocytic, septate with the hyphae apparently consisting of cylinders without cross walls. The non-septate hyphae have nuclei scattered throughout their length and are considered multicellular. Special, mycelial structures or parts aid in the identification of molds. Examples are the rhizoids, or "holdfasts," of *Rhizopus* and *Absidia*, the foot cell in *Aspergillus*, and the dichotomous, or Y-shaped, branching in *Geotrichum*.

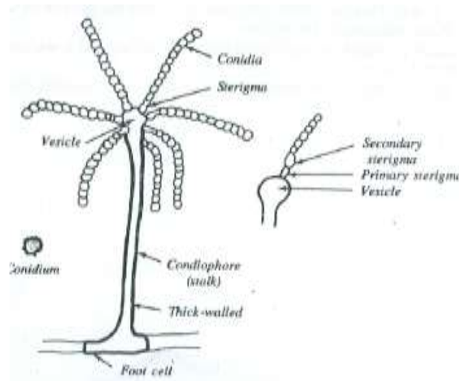
Reproductive Parts or Structures

Reproduction of molds is chiefly by means of asexual spores. Some molds also form sexual spores. Such molds are termed “perfect’’ and are classified as either Oomycetes or Zygomycetes if non-septate, or Ascomycetes or Basidiomycetes if septate, in contrast to "imperfect" molds, the Fungi Imperfecti (typically septate), which have only asexual spores.

Asexual Spores

The asexual spores of molds are produced in large numbers and are small, light, and resistant to drying. They are readily spread through the air to alight and start new mold thallus where conditions are favorable. The three principal types of asexual spores are (1) conidia (singular conidium), (2) arthrospores or oidia (singular oidium), and (3) sporangiospores. Conidia are cut off, or bud, from special fertile hyphae called conidiophores and usually are in the open, i.e., not enclosed in any container, in contrast to the sporangiospores, which are in sporangium (plural sporangia), or sac, at the tip of a fertile hypha, the sporangiophore. Arthrospores are formed by fragmentation of a hypha, so that the cells of the hypha become arthrospores. A fourth kind of asexual spore, the chlamydospore, is formed by many species of molds when a cell here and there in the mycelium stores up reserve food, swell, and forms a thicker wall than that of surrounding cells.





Sexual Spores: The molds which can produce sexual spores are classified on the basis of the manner of formation of these spores and the type produced. The non-septate molds (Phycomycetes) that produce.

1. *Oospores* are termed Oomycetes. These molds are mostly aquatic; however, included in this group are several important plant pathogens. The oospores are formed by the union of a small male gamete and a large female gamete.
2. *Zygospores*: Zygomycetes form zygospores by the union of the tips of two hyphae which often appear similar and which may come from the same mycelium or from different mycelia. Both Oospores and zygospores are covered by a tough wall and can survive drying for long periods.
3. *Ascospores*: The Ascomycetes (septate) form sexual spores known as ascopores, which are formed after the union of two cells from the same mycelium or from two separate mycelia. The ascospores, resulting from cell division after conjugation, are in an ascus, or sac, with usual eight spores per ascus.
4. *Basidiospores*: The Basidiomycetes, which include most mushrooms, plant rusts, smuts, etc.,form a fourth type of sexual spore, the basidiospore.

Physiological characteristics

Moisture Requirements In general most molds require less available moisture than do most yeasts and bacteria. Approximate limiting total moisture content of a given food for mold growth can be estimated, and therefore it has been claimed that below 14 to 15 percent total moisture in flour or some dried fruits will prevent or greatly delay mold growth.

Classification and identification of molds

Molds are plants of the kingdom Myceteae. They have no roots, stems, or leaves and are devoid of chlorophyll. They belong to the Eumycetes, or true fungi, and are subdivided further to subdivisions, classes, orders, families, and genera.

The following criteria are used chiefly for differentiation and identification of molds:

1 Hyphae septate or non-septate
2 Mycelium clear or dark (smoky)
3 Mycelium colored or colorless
4 Whether sexual spores are produced and the type: oospores, zygospores, or ascospores
5 Characteristics of the spore head.
a) Sporangia: size, color, shape, and location

b) Spore heads bearing conidia: single conidia, chains, budding conidia, or masses; shape and arrangement of sterigmata or phialides; gumming together of conidia.
6 Appearance of sporangiophores or conidiophores: simple or branched, and if branched the type of branching; size and shape of columella at tip of sporangiophore; whether conidiophores are single or in bundles.
7 Microscopic appearances of the asexual spores, especially of conidia: shape, size, color; smooth or rough; one-, two-, or many-celled.
8 Presence of special structures (or spores): stolons, rhizoids, foot cells, apo-physis, chlamydospores, sclerotia, etc.

Molds of Industrial Importance

Mucor:*Mucor* are involved in the spoilage of some foods and the manufacture of others. Widely distributed species is *M. racemosus*; *M. rouxii* is used in the "Amylo" process for the saccharification of starch, and mucors help ripen some cheese, (e.g., Gammelost) and are used in making certain Oriental foods.
Zygorrhynchus: These soil molds are similar to *Mucor*except that the zygo-spore suspensors are markedly unequal in size.
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.
Absidia: Similar to *Rhizopus*, except that sporangia are small and pear-shaped.
Thamnidium: *Thamnidiumelegans* is found on meat in chilling storage, causing "whiskers" on the meat.
Aspergillus: The aspergillus is very widespread. Many are involved in the spoilage of foods, and some are useful in the preparation of certain foods.
Penicillium: P. expansum, the blue-green-spored mold, causes soft rots of fruits. Other important species are *P. digitatum*, with olive, or yellowish-green conidia, causing a soft rot of citrus fruits; *P. italicum*, called the “blue contact mold” with blue green conidia, also rotting citrus fruit; *P.camemberti*, with grayish conidia, useful in the ripening of Camembert cheese; and *P. roqueforti*, with bluish-green conidia, aiding in the ripening of blue cheeses, e.g., Roquefort.
Trichothecium: The common species, *T. roseum*, is a pink mold which grows on wood, paper, fruits such as apples and peaches, and vegetables such as cucumbers and cantaloupes.

Yeasts and yeast like fungi

Like mold, the term "yeast" is commonly used but hard to define. It refers to those fungi which are generally not filamentous but unicellular and ovoid or spheroid and which reproduce by budding or fission.
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. Yeasts are undesirable when they cause spoilage of sauerkraut, fruit juices, syrups; molasses, honey, jellies, meats, wine, beer, and other foods.

Bacteria

Morphological characteristics important in food bacteriology

One of the first steps in the identification of bacteria in a food is microscopic examination to ascertain the shape, size, aggregation, structure, and staining reactions of the bacteria present. The following characteristics may be of special significance.

Encapsulation

The presence of capsules or slime may account for sliminess or ropiness of a food. In addition, capsules serve to increase the resistance of bacteria to adverse conditions, such as heat or chemicals. To the organism they may serve as a source of reserved nutrients. Most capsules are polysaccharides of dextrin, dextran, or levan.

Formation of Endospores

Bacteria of the genera Bacillus, Clostridium, Desulfotomaculum, Sporolactobacillus (rods), and Sporosarcina (cocci) share the ability to form endospores. Bacillus - aerobic and some facultative anaerobic and Clostridium - anaerobic. Endospores are formed at an intracellular site, are very refractile, and are resistant to heat, ultraviolet light, and desiccation.

Formation of Cell Aggregates

It is characteristic of some bacteria to form long chains and of others to clump under certain conditions. It is more difficult to kill all bacteria in intertwined chains or sizable clumps than to destroy separate cells.

Cultural characteristics important in food bacteriology

Bacterial growth in and on foods often is extensive. Pigmented bacteria cause discolorations on the surfaces of foods; films may cover the surfaces of liquids; growth may make surfaces slimy; or growth throughout the liquids may result in undesirable cloudiness or sediment.

Physiological characteristics important in food bacteriology

These changes include hydrolysis of complex carbohydrates to simple ones; hydrolysis of proteins to polypeptides, amino acids, and ammonia or amines; and hydrolysis of fats to glycerol and fatty acids. O-R reactions, which are utilized by the bacteria to obtain energy from foods (carbohydrates, other carbon compounds, simple nitrogen-carbon compounds, etc.), yield such products as organic acids, alcohols, aldehydes, ketones, and gases.

Genera of bacteria important in food bacteriology

Genus *Acetobacter*

These bacteria oxidize ethyl alcohol to acetic acid. They are rod-shaped and motile and are found on fruits, vegetables, souring fruits, and alcoholic beverages. They are a definite spoilage problem in alcoholic beverages.

Genus *Aeromonas*

These are gram-negative rods with an optimum temperature for growth of 22 to 28 °C. They are facultative anaerobes and can be psychrophilic. They are frequently isolated from aquatic environments. A. hydrophila can be a human pathogen; it is also pathogenic to fish, frogs, and other mammals.

Genus *Alcaligenes*

As the name suggests, an alkaline reaction usually is produced in the medium of growth. *A. viscolactis* causes ropiness in milk, and *A. metalcaligenes* gives a slimy growth on cottage cheese. These organisms come from manure, feeds, soil, water, and dust. This genus also contains organisms which were formerly classified in the genus *Achromobacter*.

Genus *Alteromonas*

Several former species of *Pseudomonas* are now classified as *Alteromonas*. They are marine organisms that are potentially important in sea foods.

Genus *Bacillus*

The endospores of species of this aerobic to facultative genus usually do not swell the rods in which they are formed. Different species may be mesophilic or thermophilic, actively proteolytic, moderately proteolytic, or non proteolytic, gas-forming or not, and lipolytic or not. In general the spores of the mesophiles, e.g., *B. subtilis*, are less heat-resistant than spores of the thermophiles. Spores of the obligate thermophiles, e.g., *B. stearothermophilus*, are more resistant than those of facultative thermophiles, e.g.,

B. coagulans. The actively proteolytic species usually may also sweet-curdle milk; B. cereus is such a species. The two chief acid- and gas-forming species, *B. polymyxa* and *B. macerans*, sometimes are termed "aerobacilli."

Genus *Brevibacterium*

*B. linens*are related to *Arthrobacterglobiformis* and may be synonymous.

Genus*Brochotrix*

These are gram-positive rods which can form long filamentous like chains that may fold into knotted masses. The optimum temperature for growth is 20 to 25°C, but growth can occur over a temperature range of 0 to 45°C depending on the strain.

Genus *Campylobacter*

These bacteria were originally classified in the genus *Vibrio*. Several strains of *C. fetus* subsp. *jejuni* have been associated with gastroenteritis in humans.

Genus *Clostridium*

The endospores of species of this genus of anaerobic to microaerophilic bacteria usually swell the end or middle of the rods in which they are formed. Different species may be mesophilic or thermophilic and proteolytic or non-proteolytic. *Clostridium thermosaccharoolyticum* is an example of a saccharolytic obligate thermophile; this organism causes gaseous spoilage of canned vegetables. Putrefaction of foods often is caused by mesophilic, proteolytic species, such as *C. lentoputrescens* and *C. putrefaciens*.

Genus *Corynebacterium*

The diphtheria organism, *C. diptheriae*, may be transported by foods. *C. bovis*, with the slender, barred, or clubbed rods characteristic of the genus, is commensally on the cow's udder, can be found in aseptically drawn milk, and may be a cause of bovine mastitis.

Genus *Erwinia*

The species of this genus are plant pathogens that cause necrosis, galls, wilts, or soft rots in plants and therefore damage the plants and vegetable and fruit products from them. *E.carotovora* is associated with the market disease called "bacterial soft rot." *E. carotovora* subsp. *carotovora*causes rotting in a large number of plants. *E. carotovora subsp. atroseptica*produces a black rot in potatoes. *E. carotovora* subsp. *betavasculorum* causes soft rot in sugar beets.

Genus *Escherichia*

Found in feces, a predominant gram-negative rod isolated from the intestinal tract of warm-blooded animals and widely distributed in nature. One of the "*coliform*groups," the genus is divided into many biotypes and serotypes, some of which can be pathogenic to humans.

Genus *Flavobacterium*

The yellow to orange-pigmented species of this genus may cause discolorations on the surface of meats and be involved in the spoilage of shellfish, poultry, eggs, butter, and milk. Some of the organisms are psychrotrophic and have been found growing on thawing vegetables.

Genus *Klebsiella*

Many are capsulated. Commonly associated with the respiratory and intestinal tracts of humans. *K. pneumoniae* is the causative organism for a bacterial pneumonia in humans.

Genus *Lactobacillus*

The lactobacilli are rods, usually long and slender, that form chains in most species. They are microaerophilic, (some strict anaerobes are known), are catalase-negative and gram-positive, and ferment sugars to yield lactic acid as the main product.

Source of Contamination of foods

Contamination of Foods:

The internal tissues of healthy plants (fruits and vegetables) and animals (meat) are essentially sterile. Yet raw and processed (except sterile) foods contain different types of molds, yeasts, bacteria, and viruses. Microorganisms get into foods from both natural (including internal) sources and from external sources to which a food comes into contact from the time of production until the time of consumption.

Sources of contamination:

A. Plants (Fruits and Vegetables)

The inside tissue of foods from plant sources are essentially sterile, except for a few porous vegetables (e.g., radishes and onions) and leafy vegetables (e.g., cabbage and Brussels sprouts). Some plants produce natural antimicrobial metabolites that can limit the presence of microorganisms. Fruits and vegetables harbor microorganisms on the surface; their type and level vary with soil condition, type of fertilizers and water used, and air quality. Molds, yeasts, lactic acid bacteria, and bacteria from genera Pseudomonas, Alcaligenes, Micrococcus, Erwinia, Bacillus, Clostridium, and Enterobacter can be expected from this source. Pathogens, especially of enteric types, can be present if the soil is contaminated with untreated sewage. Diseases of the plants, damage of the surface (before, during, and after harvest), long delay between harvesting and washing, and unfavorable storage and transport conditions after harvesting and before processing can greatly increase microbial numbers as well as predominant types. Improper storage conditions following processing can also increase their numbers.

B. Animals, Birds, Fish, and Shellfish

Food animals and birds normally carry many types of indigenous microorganisms in the digestive, respiratory, and urinogenital tracts, the teat canal in the udder, as well as in the skin, hooves, hair, and feathers.Many, as carriers, can harbor pathogens such as *Salmonella* pathogenic *Escherichia coli*, *Campylobacter jejuni*, *Yersinia enterocolitica*, and *Listeria monocytogenes* without showing symptoms. Laying birds have been carrying *Salmonella Enteritidis* in the ovaries and contaminating the yolk during ovulation.Fish and shellfish also carry normal microflora in the scales, skin, and digestivetracts. Water quality, feeding habits, and diseases can change the normal microbial types and level. Pathogens such as *Vibrio parahaemolyticus*, and *V. cholerae* are of major concern from these sources.In addition to enteric pathogens from fecal materials, meat from food animals and birds can be contaminated with several spoilage and pathogenic microorganisms from skin, hair, and feathers, namely *Staphylococcus aureus*, *Micrococcus* spp., *Propionibacterium* spp., *Corynebacterium* spp., and molds and yeasts.

C. Air

Microorganisms are present in dust and moisture droplets in the air. They do not grow in dust, but are transient and variable, depending on the environment. Their level is controlled by the degree of humidity, size and level of dust particles, temperature and air velocity, and resistance of microorganisms to drying. Generally, dry air with low dust content and higher temperature has a low microbial level. Spores of *Bacillus* spp., *Clostridium* spp., and molds, and cells of some Gram positive bacteria (e.g., *Micrococcus* spp. and *Sarcina* spp.), as well as yeasts, can be predominantly present in air. If the surroundings contain a source of pathogens(e.g., animal and poultry farms or a sewage-treatment plant), different types of bacteria, including pathogens and viruses(including bacteriophages), can be transmitted via the air. Microbial contamination of food from the air can be reduced by removing the potential sources, controlling dust particles in the air (using filtered air), using positive air pressure, reducing humidity level, and installing UV light.

D. Soil

Soil, especially the type used to grow agricultural produce and raise animals and birds, contains several varieties of microorganisms. Because microorganisms can multiply in soil, their numbers can be very high (billions/g). Many types of molds, yeasts, and bacterial genera (e.g., *Enterobacter, Pseudomonas, Proteus, Micrococcus, Enterococcus, Bacillus, and Clostridium*) can enter foods from the soil. Soil contaminated with fecal materials can be the source of enteric pathogenic bacteria and viruses in food. Sediments where fish and marine foods are harvested can also be a source of microorganisms, including pathogens, in those foods. Different types of parasites can also get in food from soil. Removal of soil (and sediments) by washing and avoiding soil contamination can reduce microorganisms in foods from this source.

E. Sewage

Sewage, especially when used as fertilizer in crops, can contaminate food with microorganisms, the most significant of which are different enteropathogenic bacteria and viruses. This can be a major concern with organically grown food and many imported fruits and vegetables, in which untreated sewage and manure might be used as fertilizer. Pathogenic parasites can also get in food from sewage. To reduce incidence of microbial contamination of foods from sewage, it is better not to use sewage as fertilizer. If used, it should be efficiently treated to kill the pathogens. Also, effective washing of foods following harvesting is important.

F. Water

Water is used to produce, process, and, under certain conditions, store foods. It is used for irrigation of crops, drinking by food animals and birds, raising fishery and marine products, washing foods, processing (pasteurization, canning, and cooling of heated foods) and storage of foods (e.g., fish on ice), washing and sanitation of equipment, and processing and transportation facilities. Water is also used as an ingredient in many processed foods. Thus, water quality can greatly influence microbial quality of foods. Contamination of foods with pathogenic bacteria, viruses, and parasites from water has been recorded.

Potable water does not contain coliforms and pathogens (mainly enteric types), it can contain other bacteria capable of causing food spoilage, such as *Pseudomonas, Alcaligenes*, and *Flavobacterium.* Improperly treated water can contain pathogenic and spoilage microorganisms. To overcome the problems, many food processors use water, especially as an ingredient, that has a higher microbial quality than that of potable water.

G. Humans

Between production and consumption, foods come in contact with different people handling the foods. They include not only people working in farms and food processing plants, but also those handling foods at restaurants, catering services, retail stores, and at home. Human carriers have been the source of pathogenic microorganisms in foods that later caused foodborne diseases, especially with ready to eat foods. Improperly cleaned hands, lack of aesthetic sense and personal hygiene, and dirty clothes and hair can be major sources of microbial contamination in foods. The presence of minor cuts and infection in hands and face and mild generalized diseases (e.g., flu, strep throat, or hepatitis A in an early stage) can amplify the situation. In addition to spoilage bacteria, pathogens such as *Staphylococcus. aureus, Salmonella serovars, Shigella* spp., pathogenic *E. coli*, and *hepatitis A* can be introduced into foods from human sources. Proper training of personnel in personal hygiene, regular checking of health, and maintaining efficient sanitary and aesthetic standards are necessary to reduce contamination from this source.

H. Food Ingredients

In prepared foods, many ingredients or additives are included in different quantities. Many of these ingredients can be the source of both spoilage and pathogenic microorganisms. Various spices generally have very high populations of mold and bacterial spores. Starch, sugar, and flour might have spores of thermophilic bacteria. Pathogens have been isolated from dried coconut, egg, and chocolate. The ingredients should be produced under sanitary conditions and given

Equipment

A wide variety of equipment is used in harvesting, slaughtering, transporting, processing, and storing foods. Many types of microorganisms from air, raw foods, water, and personnel can get into the equipment and contaminate foods. Depending on the environment (moisture, nutrients, and temperature) and time, microorganisms can multiply and, even from a low initial population, reach a high level and contaminate large volumes of foods. Also, when processing equipment is used continuously for a long period of time, microorganisms initially present can multiply and act as a continuous source of contamination in the product produced subsequently.

Small equipment, such as cutting boards, knives, spoons, and similar articles, because of improper cleaning, can be sources of cross contamination. *Salmonella*, *Listeria*, *Escherichia*, *Enterococcus*, *Micrococcus*, *Pseudomonas*, *Lactobacillus*, *Leuconostoc*, *Clostridium*, *Bacillus* spp., yeasts and molds can get in food from equipment . Proper cleaning and sanitation of equipment are important to reduce microbial levels in food.

J. Miscellaneous

Foods might be contaminated with microorganisms from several other sources,namely packaging and wrapping materials, containers, flies, vermin, birds, house pets, and rodents. Many types of packaging materials are used in food. Flies, vermin, birds, and rodents in food processing and food preparation and storage facilities should be viewed with concern as they can carry pathogenic microorganisms. House pets can also harbor pathogens.

FACTORS AFFECTING THE GROWTH AND SURVIVAL OF MICROORGANISMS IN FOODS

INTRINSIC PARAMETERS

The parameters of plant and animal tissues that are inherent part of the tissues are referredto as intrinsic parameter. These parameters are as follows,

1. pH

pH: It is the negative logarithm of the hydrogen ion activity.

$$PH = -\log(a_H) = \log \frac{1}{(a_H)}$$

$$= \log \frac{1}{\left[H^{-1}\right]}$$

pH = Hydrogen ion activity

+ H= Hydrogen ion concentration.

Every micro organism has a minimal, a maximal and an optimal pH for growth. Bacteria grow fastest in the pH range 6.0 – 8.0, yeasts 4.5 – 6.0 and filamentous fungi 3.5-4.0. Usually between pH 5.0 & 6.0.

Inherent acidity: Some foods have a low pH because of inherent property of the food.

Ex: Fruits & vegetables.

Biological acidity: Some foods develop acidity from the accumulation of acid daring fermentation. Ex: curd, sauerkraut, pickles etc. Molds can grow over a wide range of pH vales than the yeast and bacteria.

Film yeasts grow well on acid foods such as sauerkraut and pickles. Most yeast does not grow well in alkaline substrates. Bacteria which are acid formers are favored by moderate acidity. Active proteolytic bacteria can grow in media with a high pH (alkaline.) Ex: Egg white. The compounds that resist changes in pH are important not only for their buffering capacity but also for their ability to be especially effective within a certain pH range.

Vegetable juices have low buffering power, permitting an appreciable decrease in pH with the production of small amount of acid by lactic acid bacteria during the early part of sauerkraut and pickle fermentations. This enables the lactic to suppress the undesirable pectin –hydrolyzing and proteolytic competing organisms. Low buffering power makes for a more rapidly appearing succession of micro-organisms during fermentation than high buffering power. Ex: Milk – High in protein content, act as good buffer. Lactic acid converted to pyruvic acid by glycolytic pathway. Acid again converts to lactic acid by lactic dehydrogenase enzyme. After 5- 10 minutes, there will be decreased in pH. Hence the lactic acid bacteria survive and activity slows dawn. Once the acidity increase, yeasts and molds will take upper hand and all the products used by these organisms. The quantity of acid decreases and pH increases to neutral.

Proteolytic bacteria acts on caesin and these proteins are broken down and give bad smell accompanied by removal of NH_3. pH increases and neutral due to deamination. Then lipolytic organisms which utilize the fat present and utilize the short chain fatty acids through hydrolysis which gives still bad smell. Egg white where the pH increases to around 9.2 as CO_2 is lost from the egg after laying. Fish spoil more rapidly than meat under chill conditions. The pH of post – rigor mammalian muscle, round 5.6 and it is lower than that of fish (6.2-6.5) and this contributes to the longer storage life of meat.

The ability of low pH to restrict microbial growth has been employed since the earliest times in the presentation of foods with acetic and lactic acids. Fruits are acidic than vegetables. pH of milk – neutral. Fruits generally undergo mold and yeast spoilage than vegetables.

Redox potential (Eh): - Oxidation – reduction potential

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

1. Characteristic O-R potential of the original food.
2. The poising capacity i.e., the resistance to change in potential of the food.
3. The oxygen tension of the atmosphere about the food.
4. The access which the atmosphere has to the food.

Head space in an “evacuated” can of food contains low oxygen tension compared to air.

Micro organisms are classified as aerobic, anaerobic, and facultative based on the requirement of O2.

- Molds – aerobic, yeasts – Aerobic and facultative.
- Bacteria – Aerobic, anaerobic and facultative.
- High O - R potential favors aerobes and facultative organisms.
- Low O-R potential favors anaerobic and facultative organisms.However some aerobes grow at low O-R potential O-R potential of a system is usually written
- Eh are measured and expressed in terms of millivolts (mv).

Highly oxidised substrate would have a positive Eh and a reduced substrate have a negative Eh. Aerobic microorganisms require positive Eh. Ex: *Bacillus, Micrococcus, Pseudomonas, Acinetobacters*. Anaerobic micro organisms required negative Eh. Ex: *Clostridium.* Most fresh plant and animal foods have a low and well poised O – R potential in their interior because plants contain reducing substances

like ascorbic acid and reducing sugars where as animal tissues contain –SH (Sulfhydryl) and other reducing groups. As long as the plant or animal cells respire and remain active, they have low level of O-R potential.
Meat could support the aerobic growth of shine forming or souring bacteria at the same time that anaerobic putrefaction was proceeding in the interior. Heating and processing may alter the reducing and oxidizing substances of food. Ex: Fruit juices lost reducing substances by their removal during extraction and filtration by their removal during extraction and filtration and therefore have become more favorable for the growth of yeasts.

Nutrient content

Food is required for energy and growth of micro organisms. Carbohydrates especially the sugars are commonly used as an energy source. Complex carbohydrates such as cellulose can be utilized by few organisms and starch can be hydrolyzed by limited number of organisms. Many organisms cannot use the disaccharide lactose (Milk sugar) and therefore do not grow well in milk. Maltose is not attacked by some yeast. Some micro organisms hydrolyze pectin of the fruits and vegetables. Limited number of micro organisms can obtain their energy from fats by producing lipases. Fats are hydrolyzed to glycerol and fatty acids. Aerobic micro organisms are more commonly involved in the decomposition of fats than are anaerobic ones and the lipolytic organisms usually are also proteolytic. Hydrolysis products of proteins, peptides and amino acids serve as an energy source for many proteolytic organisms when a better energy source is lacking. Meats are decomposed by proteolytic sps Ex: *Pseudomonas* sps. Concentration of food in solution increases the osmotic effect and amount of available moisture. Molds & yeasts can grow in the highest concentrations of sugars. Bacteria can grow best in low concentration of sugars.
Microorganisms differ in their ability to use various nitrogenous compounds as a source of nitrogen for growth. Many organisms are unable to hydrolyze proteins and hence cannot get nitrogen from them. Peptides, amino acids, urea, ammonia and other simpler nitrogenous compounds may be available to some organisms but not to others. These compounds may be used under some environmental conditions but not under other conditions.Ex: Some lactic acid bacteria grow best with polypeptides as nitrogen foods cannot attack casein. Some microorganisms use fermentable carbohydrates and results in acid production which suppresses the proteolytic bacteria and hence it is called sparing action on the nitrogen compounds.
Many kinds of molds are proteolytic but very few types of yeast are actively proteolytic. Proteolytic bacteria grow best at pH values near neutrality and are inhibited by acidity. Carbon for growth may come partly from CO_2 and also from organic compounds. Minerals required by microorganisms are always present in low level. Sometimes an essential mineral may be unavailable, lacking or present in insufficient amounts.
Ex: Milk contains insufficient iron for pigmentation of the spores of *Penicillium roqueforti*. Accessory food substances or vitamins needed by the organisms.

Antimicrobial barriers and constituents (or) Inhibitory substances and biological structure

Inhibitory substances: These originally present in the food or added purposely to prevent growth of micro organisms.

- Freshly drawn milk – Lactenins, anticoliform factors.
- Egg white – Lysozyme
- Cran berries – Benzoic acid
- Short chain fatly acids on animal skin cabbage and other brassicas, garlic, onions and leeks.

- Allicin – Garlic, onion, leeks.
- Phytoalexins are produced by many plants in respone to microbial invasion.
- Antifungal compound phaseolin produced in green beans
- Eugenol – Allspice (pimento), cloves, cinnamon
- Thymol – thyme and oregano
- Cinnamic aldehyde – cinnamon and Cassia
- Inclusion of cinnamon in raisin bread retards mould spoilage.
- Humulones contained in the hop resin and isomers produced during processing, impart the characteristic bitterness of beer.
- Oleuropein – The bitter principle of green olives have antimicrobial properties.
- Lysozyme present in milk, egg is most active against gram positive bacteria.
- Egg – Ovotransferrin, avidin ovolflaroprotein.
- Milk – Lactoferrin
- Ovoflavo protein and avidin in egg white which sequester biotin and riboflavin restricting the growth of those bacteria.

Biological structures of food on the protection of foods against spoilage have been observed.
Ex: 1) Inner parts of healthy tissues of living plants and animals are sterile or low in microbial content.
2) Protective covering on the food like shell on egg, skin on poultry, shell on nuts, rind or skin on fruits and vegetables, artificial coating like plastic or wax.
3) Layers of fat over meat may protect the part of the flesh or scales may protect the outer part of the fish.

Water activity

Micro organisms have an absolute demand for water. Without water, no growth can occur. The exact amount of water needed for growth of micro organisms varies. This water requirementis best expressed in terms of available water or water activity (aw).

Factors that may affect water activity (aw). Requirements of micro organisms include thefollowing.

1. The kind of solute employed to reduce aw. Potassium chloride is usually less toxic than NaCl. and less inhibitory than sodium sulphate.
2. The nutritive valve of the culture medium. The better the medium for growth, the lower the limiting aw.
3. Temperature: Most organisms have the greatest tolerance to low aw at about optimal temperatures.
4. Oxygen supply: Growth of aerobes takes place at lower aw in the presence of air than in itsabsence.
5. pH: Most organisms are more tolerant of low aw at pH valves near neutrality than in acid oralkaline media.
6. Inhibitors: The presence of inhibitors narrows the range of aw for growth of micro organisms.

Methods for the control of aware

1. Equilibrium with controlling solutions
2. Determination of the water – sorption isotherm for the food.
3. Addition of solutes.

0.85 – 0.93 Dried beef, raw ham, aged cheddar cheese,sweetened condensed milk, dry or fermentedsausage.0.60 – 0.85. Dried fruit, flour, cereals, jams & jellies, nuts. Below 0.60 Chocolate, confectionary, Honey, Biscuits,Crackers, Potato chips, dried eggs, milk and vegetables.

Methods for measuring or establishing aw valves of food:

1. Freezing point determinations by Clausius – Clay person equation.
2. Manometric techniques

3. Electrical devices.
Favorable aw for bacteria growth in foods is 0.995 to 0.998. They grow best in low concentration of sugar or salt. 3-4% sugar and 1-2% salt may inhibit some bacteria.
Molds have optimum aw of 0.98 – 0.99; Mold spores germinate at min aw of 0.62.
Some general conclusions related to water requirement of micro organisms are
1. Each organism has its own characteristic optimal aw.
2. Bacteria require more moisture than yeasts and yeasts more than molds.
Minimum aw required for bacteria – 0.91
Minimum aw required for yeasts – 0.88
Minimum aw required for molds – 0.80
Minimum aw required for Halophilic bacteria – 0.75
Minimum aw required for Xerophilic fungi – 0.65
Minimum aw required for Osmophilic yeasts – 0.60
3. Micro organisms that can grow in high concentrations of solutes e.g. sugar and salt have low water activity (aw). Osmophilic yeasts grow best in high concentrations of sugar.

EXTRINSIC PARAMETERS (ENVIRONMENTAL LIMITATIONS)

Relative humidity (RH)

Relative humidity and water activity are interrelated. When food commodities having low water activity are stored in an atmosphere of high RH, water will transfer from the gas phase to the food. It may take a very long time for the bulk of the commodity to increase in water activity. Once micro organisms have started to grow and become physiologically active they usually produce water as an end product of respiration.Ex: Grain silos or in tanks in which concentrates and syrups is stored. Storage of fresh fruits and vegetables requires very careful control of relative humidity. If RH is too low; many vegetables will lose water and become flaccid. If it is too high, then condensation may occur and microbial spoilage may be initiated.

Temperature

Microbial growth can occur over a temperature range from about -8°C up to 100°C atatmospheric pressure.
Thermophiles have optimum: 55-75°C
Mesophile have optimum: 30 -40°C
Psychrophiles (Obligate psychrophiles): 12 – 15°C
Psychotroph (facultative): 25-30°C
Micro organisms can be classified into several physiological groups based on their cardinal temperatures. Low temperature affects the uptake and supply of nutrients to enzyme systems within the cell. Many microorganisms responds to growth at lower temperature by increasing the amount of unsaturated fatty acids in their membrane lipids and that psychrotrophs generally have higher level of unsaturation in a fatty acid decreases its melting point so that membranes containing higher levels of unsaturated fatly acid will remain fluid and hence functional at lower temperatures.As the temperature increases above the optimum, the growth rate declines as a result of denaturation of proteins.

Gaseous atmosphere

Oxygen comprises 21% of the earth's atmosphere and is the most important gas in contact with food under normal circumstances. The inhibitory effect of CO_2 on microbial growth is applied in modified atmosphere packing of food and is an advantage in carbonated mineral waters and soft drinks. Moulds and bacteria are sensitive to CO_2 condensation. Some yeast such as *Bettanomyces* sp.has tolerance to high CO_2 levels. Growth inhibition is usually greater under aerobic conditions than anaerobic and the inhibitory effect increases with decrease of temperature, presumably due to the increased solubility of CO_2 at lower temperatures CO_2dissolves in water to produce carbonic acid which decreases pH and partially dissociates into bicarbonate anions and protons. CO_2 also affects solute transport, inhibition of key enzymes involving carboxylation, decarboxylation reactions in which CO_2 is a reactant and reaction with protein amino groups causing change in their properties and activity.

Food spoilage

Food spoilage can be defined as a disagreeable change in a food's normal state. Such changes can be detected by smell, taste, touch, or sight. These changes are due to a number of reasons -- air and oxygen, moisture, light, microbial growth, and temperature.

Cause of spoilage:

Spoilage may be due to one or more of the following:

1. Growth and activity of microorganisms

2. Insects

3. Action of the enzymes of the plant or animal food.

4. Purely chemical reactions i.e., those not catalysed by enzymes of the tissues or of microorganisms

5. Physical changes such as those caused by freezing, burning, drying, pressure etc.

Classification of foods by ease of spoilage:

1. **Non perishable foods:**

These foods which do not spoil unless handled carelessly include such products as sugar,flour and dry beans.

2. **Semi perishable foods:**

If these foods are properly handled and stored, they will remain unspoiled for a long period. Ex: Potatoes, apples etc.

3**. Perishable foods:**

It includes most important daily foods that spoil quickly.Ex: Meats, fish, poultry, milk, eggs, fruits and vegetables.

Microbial Spoilage of Foods

Most foods serve as good growth medium for many different microorganisms. Considering the variety of foods and the methods used for processing, it is apparent that practically all kinds of microorganisms are potential contaminants. Given a chance to grow, the microorganisms will cause changes in appearance, flavor, odour and other qualities of foods. These degradation processes includes:

Putrefaction: Protein foods + proteolytic microorganisms amino acids +amines+ ammonia+ H_2S.

Fermentation: Carbohydrate foods +saccharolytic microorganisms organic acids + alcohol + gases.

Rancidity: Fatty foods + lipolytic microorganisms fatty acids + glycerol.

Microorganisms cause spoilage not only by degradation of foods, but also by synthesis of various products like pigments and polysaccharides leading to discolorations and formation of slimes.

Spoilage of fruits and vegetables

Vegetables

The main sources of microorganisms in vegetables are soil, water, air, and other environmental sources, and can include some plant pathogens. Fresh vegetables are fairly rich in carbohydrates (5% or more), low in proteins (about 1 to 2%), and, except for tomatoes, have high pH. Microorganisms grow more rapidly in damaged or cut vegetables. The presence of air, high humidity, and higher temperature during storage increases the chances of spoilage. The common spoilage defects are caused by molds belonging to genera *Penicillium, Phytophthora, Alternaria, Botrytis,* and *Aspergillus*. Among the bacterial genera, species from *Pseudomonas, Erwinia, Bacillus,* and *Clostridium* are important.Microbial vegetable spoilage is generally described by the common term rot, along with the changes in the appearance, such as black rot, gray rot, pink rot, soft rot, stem-end rot. Refrigeration, vacuum or modified atmosphere packaging, freezing, drying, beat treatment, and chemical preservatives are used to reduce microbial spoilage of vegetables.

Fruits

Fresh fruits have high carbohydrate content (10% or more), very low protein (≤10%), but have pH 4.5 or below. Thus microbial spoilage of fruits and fruit products is confined to molds, yeasts, and aciduric bacteria like lactic acid bacteria, *Acetobacter*, *Gluconobacter*. Like fresh vegetables, fresh fruits are susceptible to rot by different types of molds from genera *Penicillium, Aspergillus, Alternaria, Botrytis, Rhizopus*, and others. According to the changes in appearance, the mold spoilages are designated as black rot, gray rot, soft rot, brown rot. Yeasts *Saccharomyces*, *Candida, Torulopsis*, and *Hansenula* cause fermentation of some fruits such as apples, strawberries, citrus fruits, and dates. Bacterial spoilage associated with the souring of berries and figs has been attributed to the growth of lactic acid and acetic acid bacteria. To reduce spoilage, fruits and fruit products are preserved by refrigeration, freezing, drying, vacuum packaging and heat treatment.

Fermented Vegetable and Fruit Products

Fermented vegetables like pickles/cucumber and sauerkraut are produced in large volumes. In salt stock pickles containing about 15% salt, yeasts and halophilic bacteria can grow, especially if the acidity is not sufficient. Dill pickles with low salt (<5%) can have a bloating defect from CO2 production by yeasts (*Candida*, *Torulopsis*, and *Saccharomyces* spp), Heterofermentative lactic acid bacteria, and coliforms. Sweet and sour pickles preserved with sugar and vinegar can be spoiled by yeasts and lactic acid bacteria, if the acid level is not sufficient. Sauerkraut can be spoiled from the growth of yeasts and molds if the air is not excluded during fermentation of cabbage. Also, coliforms and other Gram-negative bacteria can multiply to produce undesirable flavor and texture and color defects. Olives are fermented for a long time and are susceptible to many types of spoilage defects such as gassiness (bloating) due to CO2 production by heterofermentative lactic acid bacteria, coliforms, and yeasts.

Spoilage of Meat products

Meats are the perishable of all important foods because of abundance of nutrients and moisture content. Fresh meats from food animals and birds contain a large group of potential spoilage bacteria that include species of *Pseudomonas*, *Acinetobacter*, *Moraxella*, *Shewanella*, *Alcaligenes*, *Escherichia*, *Enterobacter*, *Serratia*, *Hafnia*, *Proteus*, *Brochothrix*, *Micrococcus*, *Enterococcus*, *Lactobacillus*, *Leuconostoc*, *Carnobacterium*, and *Clostridium*, as well as yeasts and molds. The kind and amount of spoilage of meat depends upon the availability of nutrients, presence of oxygen, temperature of storage, pH, the storage time of the product, and the generation time of the spoilage microorganisms under a given environment. Post-rigor meats are rich in non-protein nitrogenous compounds, peptides and proteins, but low in carbohydrates, with a pH of about 5.5 and $A_w > 0.97$.

In order to prevent microbial spoilage, fresh meats are stored at refrigerated temperature (≤ 5°C). Thus normally psychrotrophic bacteria will be the most predominant types in raw meat spoilage. Under aerobic storage at low temperature, growth of psychrotrophic aerobes and facultative anaerobes is favored e.g, *Pseudomonas* spp. In meats with high pH and/or low glucose content, *Acinetobacter* and *Moraxella*, which preferentially metabolize amino acids instead of glucose, can grow rapidly and produce undesirable odors.

In vacuum-packaged meats, psychrotrophic facultative anaerobes and obligate anaerobes can grow and result in different types of spoilage. *Lactobacillus curvatus* and *Lb. sake* metabolize glucose to produce lactic acid and the amino acids leucine and valine to volatile fatty acids like isovaleric and isobutyric acids which impart a cheesy flavor in meat. Heterofermentative *Leuconostoc carnosum* and *Leuconostoc gelidum* produce CO2, and small quantity of lactic acid, causing accumulation of gas and liquid in the package. Facultative anaerobic *Enterobacter*, *Serratia*, *Proteus*, and *Hafnia* species metabolize amino acids while growing in meat to produce amines, ammonia, methylsulfides, and mercaptans, and cause putrefaction. Some strains also produce H2S in small amounts to cause greening of the meat. *Shewanella putrefaciens*, which can grow under both aerobic and anaerobic conditions, metabolizes amino acids (particularly cysteine) to produce methyl sulfides and H2S in large quantities. Along with offensive odors they adversely affect the normal color of meats. H2S oxidizes myoglobin to a form of metmyoglobin, causing a green discoloration.

Ready-to-Eat Meat Products

Ready-to-Eat Meat Products includes high heat-processed and low heat-processed uncured and cured meat products. High heat-processed cured and uncured meats are given heat treatment to make them commercially sterile. Thus they may only have some thermophilic spores surviving, which will not germinate unless the products are temperature abused. Low heat-processed uncured meats, such as roasts, are given heat treatment ranging from 140 to 150°F internal temperature (60 to 65°C) for 1h or more depending upon the size of the meat. Under this condition, only the spores of Bacillus and Clostridium spp. and some extremely thermoduric species like Lactobacillus viridescens, some Enterococcus, Micrococcus can survive. Many other types of microorganisms can enter into the products from equipment, personnel, and air as post-heat contaminants. Also, spices and other ingredients added to the products can add to the microbial contamination of the products. Psychrotrophic facultative anaerobic and obligate anaerobic bacteria have been implicated in the spoilage of these products. Gas production and purge accumulation by psychrotrophic Clostridium spp., along with off flavor and color changing from brown to pink to red have been detected. The vacuum-packaged and gas-packaged products, during storage, can be spoiled by psychrotrophic *Lactobacillus* and *Leuconostoc* spp. In some products, growth of *Serratia* liquifaciens causes amino acid breakdown, leading to production of ammonia-like flavor. In case of unpackaged cooked products putrefaction results from the growth and protein degradation by the proteolytic Gram-positive bacteria. If the products are stored for a long time, yeasts and molds can also grow, causing off-flavour, discoloration, and sliminess. Due to the growth of H2O2-producing lactic acid bacteria, the products may have green to gray discoloration.

Spoilage of Eggs and Egg Products

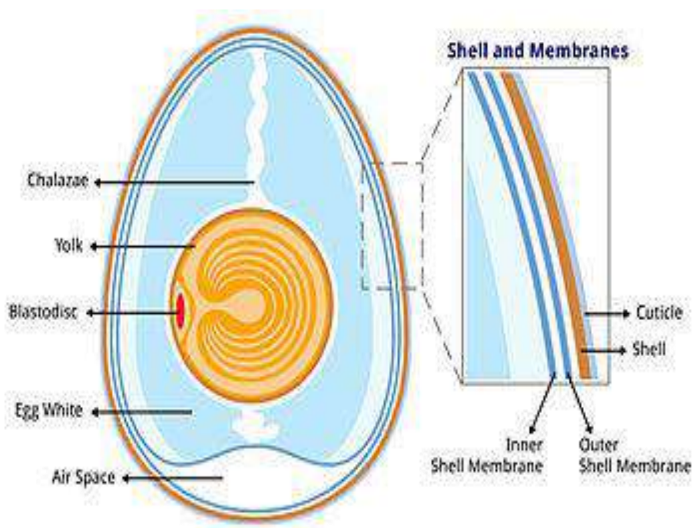
Eggs are a very good source of inexpensive, high quality protein. More than half the protein of an egg is found in the egg white along with vitamin B2 and lower amounts of fat and cholesterol than the yolk. The whites are rich sources of selenium, vitamin D, B6, B12 and minerals such as zinc, iron and copper.

Composition

- 49% water
- 16% protein
- 0.1% carbohydrate
- 1% ash
- Egg yolk pH is about 6.8

Spoilage

Cuticles reduce microorganisms entry due to their waxy structure
Shell, outer and inner membranes also provide resistance to microorganisms Penetration
The pores in the egg shell and inner membrane do not prevent entrance of microorganisms
Washing eggs- take off the curticle
High humidity and storage -increase pore size- favors entrance
Cold temp- decraese the penetration



Contamination

Poultry intestine, nest, hens, feet, fecal matter, wash water, soil, container, hands
Fecal- Salmonella enteritidis, Enterococcus

The most common spoilage- gram (-) motile rods

- Pseudomonas, Proteus, Alcaligenes, Arthrobacter, Bacillus, Citrobacter, Cytophage, Enterobacter, E.Coli, Flavobacterium, Hafnia, Micrococcus and Serratia
- Green rot- greening of albumin
- Pseudomonas fluorescens
- Black rots- discoloration of yolk due to H2S production by Proteus vulgaris
- Pink rots- Pseudomonas
- Custard rots- Proteus vulgaris, P. İntermedium
- Ret rot- Serratia mercescens
- Colorless rot- Acinetobacter, Pseudomonas, coliforms and other

Mold spoilage

Penicillium, Alternaria, cladosporium and Mucor can produce mold rot in eggs
Grow in air sac-use Oxygen
Grow on the shell or under the shell

Yellow, blue or green spots – Penicillium Dark-green or black spots by Cladosporium
Pink spots-Sporothricum Egg products
Pasteurized eggs have short shelf-life
At room temp- off-flavor (putrid) produced by spoiled bacteria, sourness or fishy flavor (trimethyl amin)

Spoilage of milk and milk products

Raw Milk

Raw milk contains many types of microorganisms coming from different sources. The average composition of cow's milk is 3.2% protein, 4.8% carbohydrates, 3.9% lipids, and 0.9% minerals. Besides casein and lactalbumin, it has free amino acids that provide a good N-source. As the main carbohydrate is lactose, those microorganisms with lactose-hydrolyzing enzymes (lactase or β-galactosidase) have an advantage over those unable to metabolize lactose. Milk fat can be hydrolyzed by microbial lipases, with the release of small molecular volatile fatty acids (butyric, capric, and caproic acids).

Microbial spoilage of raw milk can potentially occur from the metabolism of lactose, proteinaceous compound, fatty acids (unsaturated), and the hydrolysis of triglycerides. If the milk is refrigerated immediately following milking and stored for days, the spoilage will be predominantly caused by the Gram-negative psychrotrophic rods, such as *Pseudomonas*, *Alcaligenes*, *Flavobacterium spp*., and some coliforms. *Pseudomonas* and related species, being lactose-negative, will metabolize proteinaceous compounds to change the normal flavor of milk to bitter, fruity, or unclean. The growth of lactose-positive coliforms will produce lactic, acetic, and formic acids, $C0_2$, and H_2 leading to curdling and souring of milk. Some *Alcaligenes spp* and coliforms can also cause ropiness (sliminess) due to production of viscous polysaccharides. However, if the raw milk is not refrigerated soon, growth of mesophiles predominates e.g, *Lactococcus*, *Lactobacillus*, *Enterococcus*, *Bacillus*, and coliforms, along with *Pseudomonas*, *Proteus*, and others causing changes like souring and curdling of milk. Yeast and mold growth, under normal conditions, is generally not expected.

Pasteurized Milk

Pasteurized milk contains various thermoduric bacteria like *Micrococcus*, *Enterococcus*, *Lactobacillus*, *Streptococcus*, *Corynebacterium*, and spores of *Bacillus* and *Clostridium* which survive pasteurization process. In addition, coliforms, *Pseudomonas*, *Alcaligenes, and Flavobacterium* etc can enter as post-pasteurization contaminants. Thus, pasteurized milk has a limited shelf life under refrigerated storage mainly due to growth of these psychrotrophic contaminants. The spoilage pattern of pasteurized milk is the same as described for raw milk. Flavor defects from their growth are detectable when the population reaches $\geq 10^6$ cells/ml. Growth of psychrotrophic *Bacillus spp*., such as *Bacillus cereus*, has been implicated in the spoilage of pasteurized refrigerated milk, especially when the levels of post-pasteurization contaminants are low. Production of rennin-like enzymes by the psychrotrophs can cause sweet curdling of milk at higher pH than required for acid curdling.

Ultrahigh temperature-treated milk (150°C for a few seconds) is an essentially commercially sterile product that can only contain viable spores of some thermophilic bacteria. The milk is not susceptible to spoilage at ambient storage temperature, but can be spoiled if exposed to high temperatures as such with canned foods.

Concentrated Liquid Products

Evaporated milk, condensed milk, and sweetened condensed milk are principal types of concentrated dairy products that are susceptible to limited microbial spoilage during storage. All these products are given sufficient heat treatments to kill vegetative microorganisms as well as spores of molds and some bacteria.

Evaporated milk is condensed whole milk with 7.5% milk fat and 25% total solids. It is packaged in hermetically sealed cans and heated to obtain commercial sterility. Under proper processing conditions, only thermophilic spores of spoilage bacteria *Bacillus* species, such as *B. coagulans*, can cause coagulation of milk. Condensed milk is generally condensed and has about 10 to 12% fat and 36% total solids. The milk is initially given a low heat treatment, close to pasteurization temperature, and then subjected to evaporation under partial vacuum (at about 50°C). Thus only thermoduric microorganisms can grow and cause spoilage. Other microorganisms can also get into the product during the condensing process. Sweetened condensed milk contains about 8.5% fat, 28% total solids, and 42% sucrose. The milk is initially heated to a high temperature (80 to 100°C) and then condensed at about 60°C under vacuum and put into containers. It is susceptible to spoilage from the growth of osmophilic yeasts like *Torula spp*, causing gas formation. If the containers have enough head space and oxygen, molds (e.g., *Penicillium* and *Aspergillus*) can grow on the surface which gains entry into the product by recontamination after heat treatment.

Butter

Butter contains 80% milk fat and can be salted or unsalted. The microbiological quality of butter depends upon the quality of cream and the sanitary conditions used in the processing. Growth of bacteria (*Pseudomonas* spp.), yeasts (*Candida* spp.), and molds (*Geotrichum*) on the surface have been implicated in flavor defects (putrid, rancid, or fishy) and surface discoloration. In unsalted butter, coliforms, *Enterococcus*, and *Pseudomonas* can grow favorably in water-phase and produce flavor defects.

Spoilage of Bread

Bread is a major product prepared using flours. Dough is prepared from flours which undergo fermentation for which desirable microorganisms must grow. If this fermentation exceeds the required limits, it causes souring. Excessive growth of proteolytic bacteria reduces the gas holding capacity which is otherwise required for dough rising. Spoilage of bread is usually of two types viz. moldiness and ropiness. During bread making, it is baked at very high temperature, thereby there are less chances of survival of microorganisms. Thus the contamination usually occurs when cooling is done as well as during packing, handling and from the environment. The molds which are prevalent are *Rhizopus stolonifer*(referred as bread mold), *Penicillium expansum*, *Aspergillus niger*. *Mucor* and *Geotrichum* also develop.

Ropiness in bread is usually due to bacterial growth and is considered more prevalent in home made breads. The chief causative organism is *Bacillus subtilis* or *B. licheniformis*. These are spore forming bacteria with their spores surviving baking temperatures. These spores can germinate into vegetative cells, once they get suitable conditions as heat treatment activates them. In ropiness, the hydrolysis of bread flour protein (gluten) takes place by proteinases. Starch is also hydrolysed by amylases, which encourage ropiness. The manifestation of ropiness is development of yellow to brown color and soft and sticky surface. It is also accompanied by odor.

Another type of spoilage of bread is chalky bread which is caused by growth of yeast like fungi *Endomycosis fibuligera* and *Trichosporon variable*.This spoilage is characterized by development of white chalk like spots.

An unusual spoilage of bread is Red or Bloody bread, which is due to the growth of bacteria *Serratia marcescens*. This organism produces brilliant red color on starchy foods giving blood like appearance. *Neurospora* and *Geotrichum* may also be involved in imparting pigmentation during spoilage of bread.

Some spoilage of bread are summarized below:

Green spored mold- *Penicillium expansum*

- Bread mold- *Rhizopus stolonifer*.
- White cottony mycelium and black spots

Red bread mold- *Neurosporasitophila*

- Ropiness of home-made breads- *Bacillus subtilis* (*Bacillus mesentericus*).
- Ropyness due to hydrolysis of flour protein by proteinase of the *Bacillus* and capsulation of bacillus

Chalky bread

•Chalky bread—chalk like white spots due to yeast like fungi ----*Endomycopsis fibuligera* and *Trichonosporam*

Spoilage of canned foods

Canned foods are heat treated to kill microorganisms present and the extent of heat treatment is predominantly dependent on the pH of a food. High pH (> 4.6/ low acid) foods are heated to destroy most heat-resistant spores of pathogenic bacteria, *Clostridium botulinum*, to ensure that a product is free of any pathogen. However, spores of some spoilage bacteria, which have greater heat resistance, can survive. Such products are called commercially sterile foods. The other food group designated as low pH or high acid food with pH 4.6 and below, is given heat treatment to kill all vegetative cells and some spores. Although low pH will inhibit germination and growth of *C. botulinum*, spores of some aciduric thermophilic spoilage bacteria can germinate and grow when the products are stored at higher temperatures, even for a short time, which facilitates germination. Some spores of thermoduric mesophilic spoilage bacteria (including pathogenic) can also survive, heating in these products, but they are inhibited by the low pH.

Canned food spoilage is due both to nonmicrobial (chemical and enzymatic reactions) and microbial reasons. Production of hydrogen (hydrogen swell), $C0_2$, browning, corrosion of cans due to chemical reactions and liquification, gelation, discoloration of products due to enzymaticreactions are some examples of nonmicrobial spoilage. Microbial spoilage is due to three main reasons:

1. inadequate cooling after heating or high-temperature storage, allowing germination and growth of thermophilic spore formers;
2. inadequate heating, resulting in survival and growth of mesophilic microorganisms; and
3. leakage (microscopic) in the cans, allowing microbial contamination from outside following heat treatment and their growth.

Thermophilic Spore formers

Thermophilic spore formers can cause three types of spoilage of low-acid foods such as corn, beans, peas etc when the cans are temperature abused at 43°C and above, even for short duration.

1. Flat Sour Spoilage

In this type of spoilage, the cans do not swell but the products become acidic due to growth of facultative anaerobic Bacillus stearothermophilus. The organism ferments carbohydrates to produce acids without gas.

2. Thermophilic Anaerobe (TA) Spoilage

This type of spoilage occurs due to the growth of anaerobic Clostridium thermosaccharolyticum which leads to the production of large quantities of H2 and CO2 gas and swelling of cans.

3. Sulfide Stinker Spoilage

Gram-negative anaerobic sporeformer Desulfotomaculum nigrificans is responsible for this type of spoilage. The spoilage is characterized by flat container but darkened products with the odor of rotten eggs due to H2S produced by the bacterium.

Spoilage Due to Insufficient Heating

Insufficient heat treatment results in the survival of mainly spores of Clostridium and some Bacillus spp. Following processing, they can germinate and grow to cause spoilage. The most important concern is the growth of C. botulinum and production of toxins. Spoilage can be either from the breakdown of carbohydrates or proteins. Several Clostridium spp., ferment carbohydrates to produce volatile acids and H2 and CO2 gas, causing swelling of cans. Proteolytic species, metabolize proteins and produce foul-smelling H2S, mercaptans, indole, ammonia, as well as CO2 and H2 (causing swelling of cans).

Spoilage Due to Container Leakage

Leakage of containers during transport will allow different types of microorganisms to get inside the can. They can grow in the food and cause different types of spoilage depending upon the microbial types. Contamination with pathogens will make the product unsafe.

POSSIBLE QUESTIONS

UNIT-I

PART-A (20 MARKS)

(Q.NO 1 TO 20 Online Examination)

Two marks

1. Define water activity?
2. What are intrinsic factors?
3. What are extrinsic factors?
4. What types of spoilage in canned foods
5. Write four preservation methods of egg?
6. What are the spoilage conditions of milk?
7. Which are the microorganisms responsible for the spoilage of bread?
8. Types of spoilage in vegetables
9. Types of spoilage in fruits
10. What is curing

Eight marks

1. Explain briefly about the sources of contamination of food
2. Explain the parameters affecting the microbial growth on food
3. Comment on the importance of extrinsic factors which affects the food.
4. List out and explain the genera of bacteria important in food
5. Explain the parameters affecting the microbial growth on food.
6. Comment on the importance of intrinsic factors which affects the food

UNIT-II
SYLLABUS

Principles of food preservation. Physical methods of food preservation: temperature (low, high, canning,and drying), irradiation, hydrostatic pressure, high voltage pulse, microwave processing and aseptic packaging. Chemical methods of food preservation: salt, sugar, organic acids, SO2, nitrite and nitrates,antibiotics and bacteriocins, sterilization of dry heat, moist heat, chemical, physical and radition.

Food Preservation

Food preservation is the name for a number of processes that help to preserve food, involves preventing the growth of microorganisms, as well as preventing the oxidation of fats that cause rancidity. Food preservation may also include processes that inhibit enzymatic browning reaction in apples after they are cut during food preparation.

Principles of food preservation

1) Prevention or delay of microbial decomposition
a. By keeping out microorganisms (asepsis)
b. By removal of microorganisms, e.g., by filtration, etc.
c. By hindering the growth and activity of microorganisms, e.g., by low temperature, drying, anaerobic conditions, or chemicals.
d. By killing the microorganisms, e.g., by heat or radiation.
2) Prevention or delay of self-decomposition of the food.
a. By destruction or inactivation of food enzymes, e.g., by blanching
b. By prevention or delay of purely chemical reactions, e.g., prevention of oxidation by means of an antioxidant
c. Prevention of damage because of insects, animals, mechanical caused, etc..

Physical methods of food preservation

- Low temperature
- High temperature
- Canning
- Drying
- Irradiation
- Hydrostatic pressure
- High voltage pulse
- Microwave processing
- Aspectic pacakaging

Preservation of food by low temperature

Low-temperature preservation of food is to prevent or reduce growth of microorganisms. Low temperature also reduces or prevents catalytic activity of microbial enzymes, especially heat-stable proteinases and lipases. Germination of spores is also reduced, but spores are not killed at low temperature . Low-temperature storage, especially freezing, is also lethal to microbial cells, and under specific conditions, 90% or more of the population can die during low-temperature preservation. The metabolic activities, enzymatic reactions, and growth rates of microorganisms are maximum at the optimum growth temperature. As the temperature is lowered, microbial activities associated with growth slow down. Normally, the generation time, is doubled for every 10C reduction in temperature. Thus, a species dividing every 60 min in a food at 22 C will take 120 min to divide if the temperature is reduced to 12C. The lag and exponential(Log) phases and the germination time (of spores) for some psychrotrophs (mesophilic types) become longer as the temperature is reduced to 0C or even to –1C. The term psychrophile is applied to organisms that grow over the range of subzero to 20°C, with an optimum range of 10-15°C. The term psychrotroph is an organism that can grow at temperatures between 0°C and 7°C and produce visible colonies (or turbidity) within 7-10 days. Some psychrotrophs in fact, mesophiles. The microorganisms that cause the spoilage of meats, poultry, and vegetables in the 0-5°C range would be expected to be psychrotrophs.

Methods:

A. Common or cellar storage:

The temperature in common or cellar storage usually lower than 15°C. Root crops, potatoes, cabbage, celery, apples stored for limited periods. Fruits and vegetables by their own enzymes and by microorganisms is not prevented but is slower than at atmospheric temperatures.

B. Ice Chilling

This is used in retail stores where the foods are kept over ice; the surface in contact with the ice can reach between 0 and 1°C. Fresh fish, seafood, meats, cut fruits, vegetable salads (in bags), are stored by this method. Temperature fluctuation (due to the size of the container or melting of ice), duration of storage (fresh or several days), and cross-contamination can cause microbiological problems, especially from foodborne pathogens.

C. Refrigeration

Refrigeration temperature at 4 to 5°C. For perishable products, 4.4 °C is considered a desirable refrigeration temperature. Commercial food processors may use as low as 1°C for refrigeration of perishable foods (such as fresh meat and fish). For optimum refrigeration in commercial facilities along with low temperature the relative humidity and proper spacing of the products are also controlled. Raw and processed foods of plant and animal origin, as well as many prepared and ready-to-eat foods, are preserved by refrigeration.

For refrigerated products , the products are nonsterile, even a very low initial microbial population (e.g., £10 cells or spores per 10 g), capable of growing (or germinating) under the storage condition, can multiply to reach hazard (for pathogen) or spoilage levels, thereby reducing the safety and stability of the product. Any fluctuation in temperature or other abuse (e.g., a leak in a vacuum or modified atmosphere package, or oxygen permeation through the packaging materials) can greatly accelerate their growth.

D. Freezing

Freezer temperatures are those at or below -18°C., a temperature at which most of the free water in a food remains in a frozen state. Dry ice (–78°C) and liquid nitrogen (–196 °C) can also be used for freezing . Raw produce (vegetables, fruits), meat, fish, processed products,and cooked products (ready-to-eat after thawing and warming) are preserved by freezing. The two basic ways to achieve the freezing of foods are quick and slow freezing. Quick or fast freezing is the process by which the temperature of foods is lowered to about -20°C within 30 minutes.Slow freezing refers to the process whereby the desired temperature is achieved within 3-72 hours. This is essentially the type of freezing utilized in the home freezer. Quick freezing possesses more advantages than slow freezing, from the standpoint of overall product quality. Quick freezing possesses more advantages
than slow freezing, from the standpoint of overall product quality.

Effect of Freezing on Microorganisms

I. There is a sudden mortality immediately on freezing, varying with species.

II. The proportion of cells surviving immediately after freezing die gradually when stored in the frozen state.
III. Freezing, the free water forms ice crystals.
IV. Freezing results in an increase in the viscosity of cellular matter, a direct consequence of water being concentrated in the form of ice crystals.
V. Freezing results in a loss of cytoplasmic gases such as O2 and CO2. A loss of O2 to aerobic cells suppresses respiratory reactions.
VI. Freezing causes changes in pH of cellular matter.
VII. Freezing effects concentration of cellular electrolytes.
VIII. Freezing causes a general alteration of the colloidal state of cellular protoplasm such as proteins.
IX. Freezing causes some denaturation of cellular proteins.
X. Freezing induces temperature shock in some microorganisms. This is true more for thermophiles and mesophiles than for psychrophiles.
XI. Freezing causes metabolic injury to some microbial cells.

Preservation of food by High temperature

The use of high temperatures to preserve food is based on their destructive effects on microorganisms. Depending on the temperature and time of heating, microbial cells and spores can be heat-shocked, sublethally injured, or dead. Heat-shocked cells achieve some resistance to subsequent heating and sublethally injured cells and spores retain the ability to repair and multiply. Heat injury, bacterial cells show loss of permeability and increased sensitivity to some compounds to which they are normally resistant. Sublethally injured cells seem to suffer injury in the cell membrane, cell wall, DNA, ribosomal RNA and some important enzymes (denaturation). Death occurs from damages in some vital functional and structural components. Death of bacterial spores results from the inability of a spore either to germinate or to outgrow.

Heat treatments employed in processing foods:

1- Low-Heat Processing or Pasteurization

The temperature used for low-heat processing or pasteurization is below 100ºC. Pasteurization by use of heat implies either the destruction of all disease-producing organisms (for example, pasteurization of milk) or the destruction or reduction in the number of spoilage organisms in certain foods, as in the pasteurization of vinegar. The pasteurization of milk is achieved by heating as follows:

63°C for 30 minutes (Low Temperature, Long Time [LTLT])

72°C for 15 seconds (High Temperature, Short Time [HTST])

These treatments are equivalent and are sufficient to destroy the most heat resistant of the nonspore-forming pathogenic organisms Mycobacterium tuberculosis and Coxiella burnetii.

Milk pasteurization temperatures are sufficient to destroy, in addition, all yeasts, molds, gram negative bacteria, and many gram positives. The two groups of organisms that survive milk pasteurization are placed into one of two groups: thermodurics and thermophiles. Thermoduric organisms are those that can survive exposure to relatively high temperatures but do not necessarily grow at these temperatures. Ex: The non spore forming organisms belong to the genera Streptococcus and Lactobacillus.

Thermophilic organisms are those that not only survive relatively high temperatures but require high temperatures for their growth and metabolic activities. Ex: The genera Bacillus and Clostridium

2- High-Heat-Processed Foods

The process involves heating foods at or above 100ºC for a desired period of time. The temperature and time of heating are selected on the basis of product characteristics and the specific microorganisms to be destroyed. Low-acid or high-pH (pH > 4.6) products are given treatment to destroy Cl. botulinum spores (the most resistant spores of a pathogen). However, the products can have viable spores of thermophilic spoilage bacteria (e.g., Bacillus stearothermophilus, B. coagulans, Cl. thermosaccharolyticum, and Desulfotomaculum nigrificans. As long as the products are stored at or below 30ºC, these spores will not germinate. If the products are temperature abused to 40ºC and above even for a short time, the spores will germinate. Subsequent storage at or below 30ºC will not prevent outgrowth and multiplication of these thermophiles to cause food spoilage.For high-acid or low-pH (pH≤ 4.6) products, such as tomato products, fruit products, and acidified foods, a much lower heat treatment is used. Because Cl. botulinum spores cannot germinate or grow at this low pH. The spore formers that can germinate and grow in low pH products (e.g., B. coagulans) and the aciduric nonspore forming bacteria (e.g., Lactobacillus and Leuconostoc spp.), yeasts, and molds that can grow at low pH are relatively heat sensitive. These products are generally heated at 100ºC for a desirable period of time.

Canned foods are sometimes called "commercially sterile" to indicate that no viable organisms can be detected by the usual cultural methods or that the number of survivors is so low as to be of no significance under the conditions of canning and storage. Also, microorganisms may be present in canned foods that cannot grow in the product by reason of undesirable pH, oxidation-reduction potential (Eh), or temperature of storage.The processing of milk and milk products can be achieved by the use of ultrahigh temperatures (UHT). The UHT treatment include very high temperatures (in the range 140-150 ºC) and short time (a few seconds) necessary to achieve commercial sterility . UHT-processed milks have higher consumer acceptability than the conventionally heated pasteurized products, and because they are commercially sterile, they may be stored at room temperatures for up to 8 weeks without flavor changes.

FACTORS AFFECTING HEAT RESISTANCE IN MICROORGANISMS

Equal numbers of bacteria placed in physiologic saline and nutrient broth at the same pH are not destroyed with the same ease by heat. Some 12 factors or parameters of microorganisms and their environment have been studied for their effects on heat destruction, and are presented below.

1-Water

The heat resistance of microbial cells increases with decreasing humidity, moisture, or water activity (aw). Dried microbial cells placed into test tubes and then heated in a water bath are more heat resistant than moist cells of the same type.

2- Fat

In the presence of fats, there is a general increase in the heat resistance of some microorganisms. This is sometimes referred to as fat protection and is presumed to increase heat resistance by directly affecting cell moisture.

3-**Salts**

The effect of salt on the heat resistance of microorganisms is variable and dependent on the kind of salt, concentration and other factors. Some salts have a protective effect on microorganisms, and others tend to make cells more heat sensitive. It has been suggested that some salts may decrease water activity and thereby increase heat resistance by a mechanism similar to that of drying, whereas others may increase water activity (e.g., Ca^{2+} and Mg^{2+}) and consequently, increase sensitivity to heat. It has been shown that supplementation of the growth medium of *Bacillus megaterium* spores with $CaCl_2$ yields spores with increased heat resistance, whereas increased phosphate content decreases heat resistance.

4-Carbohydrates

The presence of sugars causes an increase in the heat resistance of microorganisms suspended. This effect is at least in part due to the decrease in water activity caused by high concentrations of sugars.

5-Proteins

Proteins in the heating have a protective effect on microorganisms. Consequently, high-protein-content foods must be heat processed to a greater degree than low-protein-content foods in order to achieve the same end results.

6-pH

Microorganisms are most resistant to heat at their optimum pH of growth, which is generally about 7.0. As the pH is lowered or raised from this optimum value, there is a consequent increase in heat sensitivity. Advantage is taken of this fact in
the heat processing of high-acid foods, where less heat is applied to achieve sterilization compared to foods at or near neutrality.

7-Numbers of Organisms

The larger number of organisms, the higher degree of heat resistance (Table 2). It has been suggested that the mechanism of heat protection by large microbial populations is due to the production of protective substances excreted by the cells. Because proteins are known to offer some protection against heat, many of the extracellular compounds in a culture would be expected to be protein in nature and, consequently, capable of affording some protection.

8-Age of Organisms

Bacterial cells tend to be most resistant to heat while in the stationary phase of growth and less resistant during the logarithmic phase. Heat resistance has been reported to be high also at the beginning of the lag phase but decreases to a minimum as the cells enter the log phase. Old bacterial spores are reported to be more heat resistant than young spores.

9-Growth Temperature

The heat resistance of microorganisms tends to increase as the temperature of incubation increases, and this is especially true for sporeformers. Ex: cultures of microorganisms grown at 44°C was found to be approximately three times more resistant than cultures grown at 35°C .

10-Inhibitory Compounds

A decrease in heat resistance of most microorganisms occurs when heating takes place in the presence of heat-resistant antibiotics, SO_2, and other microbial inhibitors. The use of heat plus antibiotics and heat plus nitrite has been found
to be more effective in controlling the spoilage of foods than either alone. The practical effect of adding inhibitors to foods prior to heat treatment is to reduce the amount of heat that would be necessary if used alone .

11-Time and Temperature

The longer the time of heating, the greater the killing effect of heat. The higher the temperature, the greater the killing effect of heat. As temperature increases, time necessary to achieve the same effect decreases. Also important is the size of the heating vessel or container and its composition (glass, metal, plastic). It takes longer to effect pasteurization or sterilization in large containers than in smaller ones, and containers with walls that do not conduct heat as readily as others.

12-Effect of Ultrasonics

The exposure of bacterial endospores to ultrasonic treatments just before or during heating results in a lowering of spore heat resistance.

Thermal Destruction of Microorganisms:

-Thermal Death Time (TDT)

Thermal Death Time (TDT) is the time necessary to kill a specific number of
microbial cells or spores at a specific temperature. By this method , the temperature is kept constant and the time necessary to kill all cells is determined.

-Thermal Death Point (TDP):
Temperature required to kill agiven number of microorganisms in afixed time, usually 10 minutes. Here temperature is unknown.

Decimal Reduction Time (*D* Value)
The *D* value is the time in minutes required to destroy 90% or 1 log of microorganisms.
Ex: The 12*D* concept is used in heat processing of high-pH foods (pH > 4.6, lowacid foods such as corn, beans, and meat) to destroy the most heat-resistant spores of the pathogenic bacteria *Clostridium botulinum*. It means that the products are given heat treatment to reduce the population of *Cl. botulinum* spores by 12 log
cycles. The 12*D* value at *D*121.1ºC is ca. 2.8 or ca. 3.0 min.

-*Z* Value
The *Z* value, which indicates the temperature (ºC or ºF) required to change the *D* value (or TDT) to transverse by 1 log. A value of *Z* = 10 in ºC implies that if the *D* value of bacterial spores at 100ºC is 50 min, at 110ºC it will be 5 min, and at 120ºC it will be 0.5 min.
In developing heat-processing conditions of a food, *D* and *Z* values are used to obtain desirable destruction of microorganisms (cells and spores).

- *F* Value
The *F* value is used to express the time (min) necessary to completely destroy a specific number of microbial spores or vegetative cells at a temperature (121.1ºC for spores and 60ºC for vegetative cells.

CANNING
Canning is a method of preserving food by first sealing it in air-tight jars, cansor pouches, and then heating it to a temperature that destroys contaminating microorganisms that can either be of health or spoilage concern because of the danger posed by several spore-forming thermo-resistant microorganisms, such as *Clostridium botulinum* (the causative agent of botulism).
The process of canning is sometimes called sterilization because the heat treatment of the food eliminates all microorganisms that can spoil the food and those that are harmful to humans, including directly pathogenic bacteria and those that produce lethal toxins.

Fresh foods spoil or lose their quality for several reasons:
- growth of undesirable microorganisms-bacteria, molds,and yeasts,
- activity of food enzymes,
- reactions with oxygen,
- moisture loss

Methods for canning preservation

- Preservation by heat
- Pressure canning
- Water bath canning

Preservation by heat

- Destroys microorganisms
- Inactivates enzymes
- Seals container to prevent
- Recontamination

Pressure canning

Foods with low acidity need sterilization by canning under conditions of both high temperature (116-130°C) and pressure.

WATER BATH CANNING

The only foods that may be safely canned in a boiling water bath (without high pressure) are highly acidic foods with a pH below 4.6

CANNING TIME&TEMPERATURE DEPENDS ON;

- The physical state of the food Acid, salt, sugar, starch, fat
- Size of Pieces

Consistency

- Convection heating in liquids
- Conduction heating in solids
- Combination of both
- Fullness of pack
- Container size and material
- Initial temperature of food
- The heat resistance of microorganisms or enzymes likely to be present in the food

Effects of canning on foods

COLOUR

- The time–temperature combinations used in canning have effect on naturally occurring pigments in foods.
- In fruits and vegetables, chlorophyll is converted to pheophytin, carotenoids are isomerised from 5, 6-epoxides to less intensely coloured 5, 6-epoxides, and anthocyanins are degraded to brown pigments.
- Discolouration of canned foods during storage occurs,for example,when iron or tin react with anthocyanins to form a purple pigment,or whencolourless leucoanthocyanins form pink anthocyanin complexes in some varieties of pears and quinces.

Texture or viscosity

- In canned meats, changes in texture are caused by coagulation and a loss of water holding capacity of proteins, which produces shrinkage and stiffening of muscle tissues.
- The texture of solid fruit and vegetable pieces is softer than the unprocessed food due to solubilisation of pectic materials and a loss of cell turgor but is considerably firmer than canned products.

Nutritional value

- Canning causes the hydrolysis of carbohydrates and lipids, but these nutrients remain available and the nutritional value of the food is not affected.
- Proteins are coagulated and, in canned meats, losses of amino acids are 10–20%.
- Reductions in lysine content are proportional to the severity of heating but rarely exceed 25%.

- The loss of tryptophan and, to a lesser extent, methionine, reduces the biological value of the proteins by 6–9%.
- Vitamin losses (Table 12.9) are mostly confined to thiamin (50–75%) and pantothenic acid (20–35%).
- In canned fruits and vegetables, significant losses may occur in all water soluble vitamins, particularly ascorbic acid

CANS ARE WIDELY USED TO PACK FOOD

- Predominantly, the cans are internally coated with a polymeric coating to prevent corrosion or food spoilage
- The most widely used lacquer types for food cans, where the food is retorted in the can to ensure preservationare:
  - epoxyphenolic
  - organosol

Preservation of Foods by Drying

The preservation of foods by drying is based on the fact that microorganisms and enzymes need water in order to be active. In preserving foods by this method, one seeks to lower the moisture content to a point where the activities of food-spoilage and food-poisoning microorganisms are inhibited. Some microorganisms are destroyed in the process of drying, this process is not lethal to microorganisms, and many types may be recovered from dried foods, especially if poor-quality foods are used for drying and if proper practices are not followed in the drying steps.

Dried or low moisture (LM) foods are those that generally do not contain more than 25% moisture and have a water activity (*a*w) between 0.00 and 0.60. Bacteria require relatively high levels of moisture for their growth, with yeasts requiring less and molds still less. Because most bacteria require aw values above 0.90 for growth, they play no role in the spoilage of dried foods. The most troublesome group of microorganisms in dried foods are osmophiles and xerophiles yeasts and molds.

Intermediate Moisture Food

Intermediate moisture foods (IMF) that have aw values of 0.60 to 0.85 (with moisture contents of 15 to 50%). They can be eaten without rehydration, but are shelf-stable for a relatively long period of time without refrigeration and considered microbiologically safe. Some of the traditional IMFs includes salami,dry sausages, dried fruits, jams and jellies, and honey. Microorganisms can survive in the products, but because of low aw, bacteria cannot grow. However, yeasts and molds can grow in some. To inhibit their growth, specific preservatives, such as sorbate and propionate, are added.

Mechanisms of Drying Effect on Microorganisms:

Microorganisms need water for transport of nutrients, nutrient metabolism, and removal of cellular wastes. In a food, the total water (moisture) is present as free water and bound water; the latter remains bound to hydrophilic colloids and solutes and is not available for biological functions. Thus, only the free water (which is related to aw)is important for microbial growth. Microorganisms also retain a slightly lower aw inside the cells than the external environment to maintain turgor pressure, and this is important for cell growth. If the free water in the environment is reduced, the free water from the cells flows outside in an effort to establish equilibrium. The loss of water causes an osmotic shock and plasmolysis, during which the cells do not grow.

Methods of Drying:

A. Natural Dehydration

Natural dehydration is a low-cost method in which water is removed by the heat of the sun. It is used to dry grains as well as to dry some fruits , vegetables, fish, meat, milk, and curd (from milk), especially in warmer countries. The process is slow; depending on the conditions used, spoilage and pathogenic bacteria as well as yeasts and molds (including toxigenic types) can grow during drying.

B. Mechanical Drying

Mechanical drying is a controlled process, and drying is achieved in a few seconds to a few hours. Some of the methods used are:

1- **Tunnel drying** (in which a food travels through a tunnel against flow of hot air that removes the water).

2- **Drum drying** (in which a liquid is dried by applying a thin layer on thesurface of a roller drum heated from inside).

3- **Spray drying** (in which a liquid is sprayed in small droplets, which then come in contact with hot air that dries the droplets instantly).

Milk is dried as either whole milk or nonfat skim milk. The dehydration may be accomplished by either the drum or spray method. Eggs may be dried as whole egg powder, yolks, or egg white. Spray drying is the method most commonly employed. Liquids may be partially concentrated before drying by evaporation, reverse osmosis, freeze-concentration, and addition of solutes. Depending on the temperature and time of exposure, some microbial cells can die during drying, whereas other cells can be sublethally injured. Also, during storage, depending on the storage conditions, microbial cells can die rapidly at the initial stage and then at a slow rate. Spores generally survive and remain viable during storage in a dried food.

C. Freeze-Drying

The acceptance quality of food is least affected by freeze-drying, as compared with both natural and mechanical drying. However, freeze-drying is a relatively costly process. It can be used for both solid and liquid foods. The process initially involves freezing the food, rapidly at a low temperature, and then exposing the frozen food to a relatively high vacuum environment. The water molecules are removed from the food by sublimation (from solid state to vapor state) without affecting its shape or size. The method has been used to produce freeze-dried vegetables, fruits, fruit juices, coffee, tea, and meat and fish products. Microbial cells are exposed to two stresses — freezing and drying that reduce some viability as well as induce sublethal injury. During storage, especially at a high storage temperature and in the presence of oxygen, cells die rapidly initially and then more slowly. Spores are not affected by the process.

D. Foam-Drying

The foam-drying method consists of whipping a product to produce a stable foam to increase the surface area. The foam is then dried by warm air. Liquid products, such as egg white, fruit purees, and tomato paste, are dried in this manner. The method itself has very little lethal effect on microbial cells and spores. However, a concentration method before foaming, the pH of the products,and low *aw* cause both lethal and reversible damages to microbial cells.

E. Smoking

Many meat and fish products are exposed to low heat and smoke for cooking and depositing smoke on the surface at the same time. The heating process removes water from the products, thereby lowering their *aw*. Many low-heat-processed meat products (dry and semidry sausages) and smoked fishes are produced this way. Heat kills many microorganisms. The growth of the survivors is controlled by low *aw* as well as the many types of antimicrobial substances present in the smoke.

Irradiation

• Food irradiation facilities that are built and maintained to accepted standards are no more hazardous than hospitals that carry out numerous X-rays each day and as such do not pose a significant exposure risk.

• Under the standard covering the irradiation of food in Australia and New Zealand, this energy can be in the form of Cobalt 60 sourced gamma rays, machine generated Xrays, or an electrically generated electron beam.

Irradiation can kill harmful bacteria and other organisms in meat, poultry, and seafood, disinfest spices, extend shelf-life of fresh fruits and vegetables, and control sprouting of tubers and bulbs such as potatoes and onions.

• It is a safe process that has been approved by the U.S. Food and Drug Administration (FDA) and over 50 other national food control authorities for many types of foods

Type of food	Effect of Irradiation
Meat, poultry	Destroys pathogenic fish organisms, such as Salmonella, Clostridium botulinum , and Trichinae
Perishable foods	Delays spoilage; retards mold growth; reduces number of microorganisms
Grain, fruit	Controls insect vegetables, infestation dehydrated fruit, spices and seasonings

Onions, carrots, potatoes, garlic, ginger	Inhibits sprouting
Bananas , mangos , papayas, guavas, other non-citrus fruits	Delays ripening avocados, natural juices
Grain, fruit	Reduces rehydration time

Applications of irradiation

- Radiation pasteurisation (sanitary treatment)
- Radiation sterilisation
- Replacing chemical fumigation of food
- Sprout inhibition
- Enhancing food quality
- Eliminating certain parasitic hazards in food.

Radiation sterilisation

- Sterilisation by irradiation can be applied to foods
- a relatively high dose of irradiation (above 10 kGy), together with a mild heat treatment and proper packaging, can kill all microorganisms and allow foods to be kept for long periods at room temperature.
- This process is analogous to canning, which uses heat treatment to achieve the same preservation status.
- Meat, poultry, some types of fish and shellfish, some vegetables and entire meals are suitable for radiation sterilization
- Radiation sterilization has been used in the U.S. to sterilize food for NASA's astronauts and for some patients with impaired immune systems.
- Radiation sterilization of food/meals could help outdoor enthusiasts (campers, mountain climbers, sailors, etc.) carry safe, nutritious and ready to eat food that requires no refrigerated storage.

Replacing chemical fumigation of food

- Irradiation can kill insects and microorganisms in cereals, legumes, spices and dried vegetable seasonings, as well as other stored foods.
- Irradiation could be used in place of chemical fumigation with ethylene dibromide (EDB, now banned in the U.S. and most other countries), ethylene oxide (banned in the European Union and Japan) and methyl bromide (MB).

Sprout inhibition

- Very-low-dose irradiation treatment inhibits the sprouting of vegetables such as potatoes, onions and garlic.
- Irradiation can replace the chemicals currently used for this purpose.
- The US and many other nations have approved this use of irradiation for several types of roots, tubers, and bulbs.
- Currently, irradiation is used extensively to control sprouting of garlic and potatoes in China and Japan, respectively

Enhancing food quality

• Low-dose irradiation also delays ripening and therefore extends the shelf-life of some fruits, including bananas, mangoes, papayas, guavas and tomatoes.
• Medium doses can be used to control mould growth on strawberries, raspberries and blueberries, thereby extending their shelflife.
• Cap opening of mushrooms can also be delayed by relatively low dose irradiation and cool storage.
• Irradiation can produce desirable physical changes in some foods.
• Bread made from irradiated wheat has greater loaf volume when certain dough formulations are used,
• Irradiated dehydrated vegetables reconstitute more quickly than non-irradiated Vegetables.
• When fruits such as grapes are irradiated they yield more juice than non-irradiated ones.

Eliminating parasite hazards in foods

• A low dose of radiation can eliminate the hazards of humans contracting trichinosis and toxoplasmosis from consumption of fresh foods such as pork without significantly affecting the flavour or texture of the meat.
• Irradiation treatment works by impairing the development of these parasites (Trichinellaspiralis Toxoplasma gondii) so that they cannot mature, complete theirlife cycles or cause human diseases.

Hydrostatic pressure (HP)

Hydrostatic pressure (HP) processing is a method of preserving and sterilizing food, in which a product is processed under very high pressure, leading to the inactivation of certain microorganisms and enzymes in the food.

Process

In hydrostatic pressure food products are sealed and placed into a steel compartment containing a liquid, often water, and pumps are used to create pressure. The pumps may apply pressure constantly or intermittently. The application of hydrostatic pressures (HP) on a food product will kill many microorganisms, but the spores are not destroyed. Some bacterial spores may need to be separately treated with acid to prevent their reproduction. hydrostatic pressures works especially well on acidic foods, such as yogurts and fruits, because pressure-tolerant spores are not able to live in environments with low pH levels. The treatment works equally well for both solid and liquid products.

During hydrostatic pressures the food's proteins are denatured, hydrogen bonds are fortified, and non-covalent bonds in the food are disrupted, while the product's main structure remains intact.Because hydrostatic pressures is not heat-based, covalent bonds are not affected, causing no change in the food's taste.This retention of intramolecular bonds means that HP does not destroy vitamins, maintaining the nutritional value of the food. Hydrostatic pressure can affect muscle tissues by increasing the rate of lipid oxidation, which in turn leads to poor flavor and decreased health benefits. Additionally, there are some compounds present in foods that are subject to change during the treatment process. For example, carbohydrates are gelatinized by an increase in pressure instead of increasing the temperature during the treatment process.

Because hydrostatic pressure is able to act quickly and evenly on food, neither the size of a product's container.There are several side effects of the process, including a slight increase in a product's sweetness, but hydrostatic pressure does not greatly affect the nutritional value, taste, texture, and appearance. As a result, high pressure treatment of foods is regarded as a "natural" preservation method, as it does not use chemical preservatives.

Spoilage microogoranisms and some enzymes can be deactivated by HP, which can extend the shelf life while preserving the sensory and nutritional characteristics of the product. Pathogenic microorganisms such as *Listeria*, *E. coli*, *Salmonella*, and *Vibrio* are also sensitive to pressures of 400-1000 MPa used during HP.

Thus, HP can pasteurize food products with decreased processing time, reduced energy usage, and less waste. The treatment occurs at low temperatures and does not include the use of food additives..HP is now being used to preserve fruit and vegetable smoothies and other products such as meat for sale in the UK. An early use of hydrostatic pressure in the United States was to treat guacamole. It did not change the guacamole's taste, texture, or color, but the shelf life of the product increased to thirty days, from three days without the treatment.However, some treated foods still require cold storage because hydrostatic pressure does not stop all enzyme activity caused by proteins,some of which affects shelf life. In recent years, HPP has also been used in the processing of raw pet food. Most commercial frozen and freeze-dried raw diets now go through post-packaging HPP treatment to destroy potential bacteria and viruses contaminants, with salmonella being one of the biggest concerns.

Aseptic packaging

In traditional canning methods, nonsterile food is placed in nonsterile containers, followed bycontainer closure and sterilization. In aseptic packaging, sterile food under aseptic conditions is placed in sterile containers, and the packages are sealed under aseptic conditions as well. Although the methodology of aseptic packaging was patented in the early 1960s, the technology was little used until 1981, when the Food and Drug Administration approved the use of hydrogen peroxide for the sterilization of flexible multilayered packaging materials used in aseptic processing systems. In general, any food that can be pumped through a heat exchanger can be aseptically packaged. The widest application has been to liquids such as fruit juices, and a wide variety of single-serve products of this type has resulted. The technology for foods that contain particulates has been more difficult to develop, with microbiological considerations only one of the many problems to overcome.In determining the sterilization process for foods pumped through heat exchangers, the fastest-moving components (those with the minimum holding time) are used, and where liquids and particulates are mixed, the latter will be the slower moving. Heat-penetration rates are not similar for liquids and solids, making it more difficult to establish minimum process requirements that will effectively destroy both organisms and food enzymes.

Some of the advantages of aseptic packaging are as follows:

1. Products such as fruit juices are more flavorful and lack the metallic taste of those processed in metal containers.
2. Flexible multilayered cartons can be used instead of glass or metal containers.
3. The time a product is subjected to high temperatures is minimized when ultrahigh temperatures are used.
4. The technology allows the use of membrane filtration of certain liquids.
5. Various container headspace gases such as nitrogen may be used.

Among the disadvantages are that packages may not be equivalent to glass or metal containers in preventing the permeation of oxygen, and the output is lower than that for solid containers.A wide variety of aseptic packaging techniques now exists, with more under development. Sterilization of packages is achieved in various ways, one of which involves the continuous feeding of rolls of packaging material into a machine where hot hydrogen peroxide is used to effect sterilization, followed by the forming, filling with food, and sealing of the containers. Sterility of the filling operation may be maintained by a positive pressure of air or gas such as nitrogen. Aseptically packaged fruit juices are shelf stable at ambient temperatures for 6–12 months or longer.The spoilage of aseptically packaged foods differs from foods in metal containers. Whereas hydrogen swells occur in high-acid foods in the latter containers, aseptic packaging materials are nonmetallic. Seam leakage may be expected to be absent in aseptically packaged foods, but the permeation of oxygen by the nonmetal and nonglass containers may allow for other types of spoilage in low-acid foods.

Chemical preservation

Chemical preservatives are added to kill or inhibit microorganisms in food. The may be incorporated into the foods or only their surface or the wrappers used for them may be treated, or they may be used as gas or vapors around the food. Some chemicals may be effective on selected group of microorganisms while others on a wide variety of them. Chemical preservatives may beharmless if they are added during the storage period and are removed before the food is consumed. But if they are consumed as such, they may be poisonous to man or animal, as well as to microorganisms.

Salts

These compounds tend to tie up moisture 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 many be added to slow down or prevent the growth of microorganisms or only enough to permit an acid fermentation to take place. Salt has been reported to have the following effects:

- 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.
- It dehydrates food by drawing out and tying up moisture as it dehydrates microbial cells.
- It ionizes to yield the chlorine ion, which is harmful to organisms.
- It reduces the solubility of oxygen in the moisture.
- It sensitizes the cell against carbon dioxide
- It interfers with the action of proteolytic enzymes.

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

Sugars

Sugars, such as glucose or sucrose 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.

Organic acids and their salts:

Several organic acids and their salts are common preservatives as they have marked microbiostatic and microbicidal action.

Benzoic acid and benzoate are used for the preservation of vegetables. Sodium benzoate is used in the preservation of jellies, jams, fruit juice and other acid foods.

Salicylic acid and salicylates are used as preservatives of fruits and vegetables in place of benzoate. However, it is considered to be deleterious to health of consumer.

Sorbic acid is recommended for foods susceptible to spoilage fungi, e.g., it inhibits mold growth in bread. Wrapping material for cheese may be treated with it. It is also used in sweet pickles and for control of lactic fermentations of olives and cucumbers.

Foods prepared by fermentation processes, e.g. milk products etc. are preserved mainly by lactic, acetic and propionic acids.

Flavoring extracts of vanilla, lemons are preserved in 50-70% alcohol as it coagulates cell proteins.

Inorganic acids and their salts:

Most common among the inorganic acids and their salts are, sodium chloride, hypochlorites, sulphurous acids and sulphites, sulphurdioxide, nitrate and nitrite.

a. Sodium chloride

Sodium chloride produces high osmotic pressure and therefore causes destruction of many microorganisms by plasmolysis. It causes dehydration of food as well as microorganisms, releases disinfecting chlorine ion by ionization, reduces solubility of oxygen in the moisture, sensitizes microbial cells against carbon dioxide and interferes with the action of proteolytic enzymes. These are the reasons why this common salt is used widely for preservation either directly or curing solutions.

b. Hypochlorites

The hypochlorous acid liberated by these salts is an effective germicide. It is oxidative in its action. The commonly used forms are sodium and calcium hypochlorites. Drinking water or water used for washing foods may be dissolved with hypochlorites.

c. Sulphurous acids and Sulphites

Sulphurous acids and sulphites are added to wines as preservatives. Sulphurous acid is used especially in the preservation of dry fruits. It helps in retention of original colour of the preserve and inhibition of molds more than either yeasts or bacteria. Potassium metabisulphite is used in canning.

d. Sulphur dioxide

Sulphur dioxide has a bleaching effect desired in some fruits, and also suppresses the growth of yeast and molds. It is used as a gas to treat drying fruits and is also used in molasses.

e. Nitrates and Nitrites

Nitrates and nitrites produce an inhibitory effect on bacterial growth and are used usually together in meat and fish preservation and for retention of red-colour of the meat. Nitrate is changed to nitrous acid which reacts with myoglobin to give nitric oxide myoglobin. It is the latter which gives a bright red colour to the meat making it more attractive in appearance. However, both nitrite and nitrate are poisonous, if present in potable water or food products in more than minimal amounts. It is why the generous use of these chemicals as preservative in meat and fish products has been questioned.

Antibiotics:

Aureomycin (chlorotetracycline) is the most commonly used antibiotic for the preservation of animal products under chilling conditions. It is extensively used for the preservation of poultry, meat and fish. The antibiotic is applied to the surface of the fresh meat by dipping it in a solution of the antibiotic or it may be fed to the animal, by mixing it with feed or water, for one to several days before slaughter. Fish are treated by adding the antibiotic in the ice or water in which they are to be transported.

The indiscriminate use of antibiotics as preservatives, however, should be prevented or the antibiotics used should be such that it is demobilized on cooking so that the internal flora of man using such food is not constantly exposed to the effect of the antibiotic. It is important for otherwise the use would lead to the development of the antibiotic resistant strains of microorganisms in the body. Aside from this, some individuals sensitive to antibiotics become exposed constantly to allergy.

Biological method

Souring (fermentation) lactic and acetic acid e.g. cheese and cultured milk.

Radiations

Low-frequency, long-wavelength, low energy radiation ranges from radio waves to infrared. Conversely, the high-frequency, shorter-wavelength radiations have high quantum energies and actually excite or destroy organic compounds and microorganisms without heating the product. Microbial destruction without the generation of high temperatures suggested the term "cold sterilization." Radiations of higher frequencies have high energy contents and are capable of actually breaking individual molecules into ions, hence the term ionizing irradiation.

Gamma rays and high-energy electron beams

Gamma rays and high-energy electron beams have been used for the preservation of fresh perishable canned and packaged foods. They have good penetration and are effective to a depth of about 15 cm in most foods. Food preservation by such radiation dosage is called "cold-sterilization" as it produces only a few degrees rise in temperature of the product.

Ultraviolet rays

Ultraviolet rays are short waves and are used to sterilize the surface of foods. These rays have been successfully used for the treatment of water for beverages, aging meat's packaging, and treatment of knives for slicing bread, for sterilizing utensils, for prevention of spoilage by organisms on the surface of preserved pickles, cheese and prevention of air contamination. Cold-storage rooms of meat-processing plants are sometimes equipped with germicidal lamps which reduce the surface contamination and permit longer periods of spoilage-free storage.

Radiation pasteurization or sterilization

It represents a term which describes the killing of over 98% but not 100% of the microorganisms by intermediate dosage of radiation. This method increases the storage life of some meats, sea-foods, certain fruits and vegetables when stored at low temperature. Radiation pasteurization provides the possibility of an entirely new approach to food preservation and could bring about a radical change in industrial methods of food processing.

However, the effect of radiation on colour, flavor nutritional quality of food, odor and texture needs to be more carefully understood. Similarly, chemical changes in food products brought about by radiations may cause bad effects on animal and human subjects and need to be more adequately investigated.

Other methods

There are many different methods for drying, each with their own advantages for particular applications. These include,

- Convection drying
- Bed dryers
- Drum drying
- Freeze Drying
- Microwave-vacuum drying
- Shelf dryers
- Spray drying
- Infrared radiation drying
- Sunlight
- Commercial food dehydrators and Household oven.

POSSIBLE QUESTIONS

UNIT-I

PART-A (20 MARKS)

(Q.NO 1 TO 20 Online Examination)

Two marks

1. Write any four points of preservation?
2. Define preservation
3. Effectiveness of salt on food preservation?
4. What is the drawback of nitrites?
5. What is cold sterilization?
6. Effectiveness of UV radiations?
7. Define canning?
8. Effectiveness of So2 on food preservation?
9. Effectiveness of sugar on food preservation?
10. What are types of dry heat methods as preservation

Eight marks

1. Write short notes on the methods and principles of food preservation.
2. Write in brief about chemical preservation process
3. Give short notes on the advantages of temperature as a preservation method.
4. Write in brief about preservation of food using radiation.
5. Write a detailed note on the preservation of food by chemicals.
6. Write a detailed note on the preservation of food by high temperature.
7. State the importance of canning in food preservation and its types.
8. Write in detail about the criteria of aseptic packaging
9. Write a detailed note on the preservation of food by salt and sugar
10. Write a detailed note on the preservation of food by organic acids and So_2

UNIT-III
SYLLABUS

Fermented dairy products: yogurt, acidophilus milk, kumiss, kefir, dahi and cheese. Other fermented foods: Idly, sauerkraut, soy sauce and tampeh. Probiotics: Health benefits, types of microorganisms used, probiotic foods available in market.

Cultured/fermented dairy products

Yoghurt

Yoghurt is a fermented milk product that evolved by allowing naturally-contaminated milk to sour at a warm temperature. Yoghurt can be either unsweetened or sweetened, set, or stirred. Curd is the name given to a yoghurt-type product made from buffalo milk.

The principles of preservation for yoghurt are:

· Pasteurization of the raw milk to destroy contaminating microorganisms and enzymes.
· An increase in acidity due to the production of lactic acid from lactose. This inhibits the growth of food-poisoning bacteria.

· Storage at a low temperature to inhibit the growth of microorganisms.

Production stages for set yoghurt

Ingredients	*Process*	*Equipment*	*Section reference*
Milk and starter culture (2 per cent)	Preheat to 70°C for 15-20 minutes	Heat source	36.0
		Thermometer	63.0
		Boiling pan	48.0
	Cool to 30-40°C	Thermometer	63.0
	Addition of starter culture	Measuring and weighing equipment	64.1 and 64.2
	Pour into bottles/pots	Funnel or Liquid filler	28.1
		Sealing machine	47.1
		or Capping machine	47.2
	Incubate at 43-45°C	Commercial incubator	39.0
		Thermometer	63.0
	Store at 4°C	Refrigerated storage	

Heating

In the manufacture of yoghurt, milk is normally heated to 70°C for 15-20 minutes, using an open boiling pan, or alternatively a steam jacketed pan.

Addition of starter culture

The milk is cooled to between 30 40°C and inoculated with a mixed culture of Lactobacillus bulgaricus and Streptococcus thermophilus (usually in a ratio of 1:1). If a commercial starter-culture is used, the directions for use will be given. However, if a culture from a previous batch is used, then it is usual to add 2-3 tablespoons per litre of prepared milk.

Yoghurt of the stirred variety can be fermented in the mixing container. To make set yoghurt the inoculated milk should be poured into the individual pots before fermentation.

Incubation

The micro-organisms that produce yoghurt are most active within a temperature range of 32-47°C. Ambient temperatures are therefore not adequate and a heated incubator is needed. Small commercially-available yoghurt-makers consist of an electrically-heated base and a set of plastic or glass containers. Most yoghurt-makers make four or five individual half litre cups at a time. There are other simple and inexpensive ways of incubating yoghurt such as an insulated box, keeping the jars/pots surrounded by warm water, or by using thermos flasks (the latter is only suitable for stirred yoghurt). Incubation takes approximately five hours.

When fermentation is complete, stirred yoghurt is cooled and flavoured or sweetened prior to packaging. In set yoghurt all ingredients are added before fermentation.

Packaging and storage

Yoghurt or curd is commonly packaged in plastic pots fitted with a plastic lid, or heat-sealed with foil, although traditionally, curd is packaged in clay pots. Such pots are made from local materials and can be re-used or later used for cooking. The shelf-life of yoghurt is usually 3-8 days when stored at temperatures below 10°C.

Cheese

Cheese is made from milk by the combined action of lactic acid bacteria and the enzyme rennin (known as rennet). Just as cream is a concentrated form of milk fat, cheese is a concentrated form of milk-protein. The differences in cheeses that are produced in different regions result from variations in the composition and type of milk, variations in the process, and the bacteria used. The different cheese varieties can be classified as either hard or soft.

Collecting milk for cheese-making

Hard cheeses such as Cheddar and Edam have most of the whey drained out and are pressed. Soft cheeses such as paneer contain some of the whey and are not pressed. Many indigenous cheeses are soft types.

The hardness, flavour, and other qualities of a cheese can be varied by changes to the process conditions, to suit local tastes. However, the principal steps of a cheese-making process are basically the same.

The principles of preservation are:

· The raw milk is pasteurized to destroy most enzymes and contaminating bacteria
· fermentation by lactic-acid bacteria increases the acidity which inhibits the growth of food-poisoning and spoilage bacteria

· The moisture content is lowered and salt is added to inhibit bacterial and mould growth.

The table, right, outlines the stages of production and the equipment needed to produce Edam cheese.

Pre-heating

The pasteurized milk is heated to a temperature at which the starter-culture can work.

Addition of starter culture

Starter-culture is added to the milk at the rate of approximately 2 per cent of the weight of milk. The vessel used should be either aluminium or stainless steel.

Addition of rennet

The rennet should be 1 per cent of the weight of milk. The rennet alters the milk proteins and allows them to form the characteristic curd.

Incubation

The milk is allowed to stand until it sets to a firm curd.

Treatment of the curd

The curd is cut into cubes which facilitate the elimination of whey from the gel. The curd is then cooked at 40°C for a period of twenty minutes which has the action of firming the curd. After cooling, the whey is drained off. The curd is pressed to ensure that most of the whey has been removed, and is then cut to fit the cheese-moulds, and finally pressed with weights.

Ripening

This is the final stage in the cheese-making process. It is a process which allows the development of gas in some cheeses and the development of flavour. The longer the ripening process the stronger the flavour. Ripening usually takes place in ripening rooms, where the temperature and humidity must be controlled for the optimum development of the cheese.

Production stages for Edam-type cheese

Ingredients	Process	Equipment	Section reference
Pasteurized milk	Preheat to 35-40°C	Cheese vat	10.0
		or boiling pan	48 0
		Thermometer	63.0
		Heat source	36 0
Starter culture	Addition of starter culture	Measuring and weighing equipment	64.1 and 64.2
Rennet	Add rennet at 30°C	Measuring and weighing equipment	64.1 and 64.2
		Thermometer	63.0
	Incubate		
	Cut the curd	Curd cutters	16.1
	Heat to 40°C for 20 minutes	Heat source	36.0
		Thermometer	63.0
	Drain	Filter cloth	08.0
	Cut to fit a cheese-mould	Knife	17.1
	Put into a cheese-mould	Cheese-moulds	09.1
	Press with	Cheese-press weights	09.2
	Cool and dry at 10-12°C	Thermometer	63.0
Salt	Salting in 20 per cent salt solution at 12°C for 12-16 hours	Brine meter	64.6
		Thermometer	63.0
	Ripen for 6-8 weeks at 16°C	Thermometer (optional)	63.0.
	Washing		
	Drying for 30 minutes		
	Wax with paraffin wax store at 9°C	Refrigerated storage	15.0

Packaging and storage

The packaging requirements differ according to the type of cheese produced. Hard cheese, for example, has an outer protective rind which protects the cheese from air, microorganisms, light, moisture-loss or pick-up, and odour pickup. Cheese should be allowed to 'breathe', otherwise it will sweat. Suitable wrapping materials are therefore cheesecloth or grease-proof paper. Cheese should be stored at a relatively low temperature between 4 and 10°C to achieve a shelf-life of several weeks/months. Soft cheeses are often stored in pots or other containers, often in brine, to help increase their shelf-life of several days/weeks.

Butter

Butter is a semi-solid mass which contains approximately 80-85 per cent milk-fat and 15-20 per cent water. It is yellow/white in colour, with a bland flavour and a slightly salty taste. It is a valuable product that has a high demand for domestic use in some countries and as an ingredient in other food processing (e.g. for confectionery and bakery uses).

The principles of preservation are:

· To destroy enzymes and micro-organisms by pasteurizing the milk
· To prevent microbial growth during storage by reducing the water content, by storing the product at a low temperature, and optionally by adding a small amount of salt during processing.

Ingredients	*Process*	*Equipment*	*Section reference*
Cream or soured cream	Store at 4°C	Milk churns	62.0
		Refrigerated storage	15.0
		Thermometer	63.0
	Churning	Butter churns	13.0
	Draining (pour off buttermilk)		
	Washing		
	Draining (pour off washwater)		
Permitted colours and salt (optional)	Kneading/working	Butter pats	04.0
	Form into blocks	Butter pats	04.0
	Packaging	Paper/plastic/ foil wrapping Wrapping machines	47.3
	Storage at 4°C	Refrigerated storage	15.0

Churning
Churning disrupts the emulsion of fat and water and as a result the milk-fat separates out into granules. This process takes place in a butter churn.
Churning cream
Churning is continued until fat granules are present and at this stage the mixture is drained to remove liquid that has separated from the granules. This liquid is known as buttermilk and can be used as either a beverage or as an ingredient in animal feed.

Washing

Clean water equivalent in weight to the buttermilk is added to the churn in order to wash the butter granules. The wash water is drained away. Churning is continued for a short time to compact the butter, and once this has been achieved it is removed from the churn.

Forming and packaging

Butter is kneaded to achieve a smooth and pliable texture. This can be done using simple hand-tools such as butter pats. Alternatively for higher production rates a specially-designed kneader can be used. Once the butter has a uniform and smooth texture it is formed into blocks with butter pats and packed in either greaseproof paper or foil wrappers.
Working butter with butter pats

Storage

Due to its high fat composition, butter must be stored at temperatures below 10°C otherwise the fat becomes rancid and imparts undesirable 'off' flavours. The water droplets in butter (20 per cent) can also allow bacteria to grow if it is not kept under cool conditions.

Kumiss

Kumiss called fermented milk drink, traditionally made from mare's milk, by its fermentation. For him Mare's milk - a fermented milk drink made from mare's milk
manufacture two kinds of fermentation: lactic acid and alcohol using yeast, Bulgarian and acidophilus lactic acid bacillus. The drink has a whitish, it is peculiar or foam. Kumys refreshing taste, sweet and sour. It is often used for medicinal purposes.

Manufacturing technology allows you to cook different mare fortress. In some types of beverage alcohol content is so high that it can cause intoxication, and lead the man to use it in the excitement-intoxicated state. For a small proportion of alcohol in a drink koumiss has a calming and relaxing effect, until sleepiness.

Kumiss prepared even the nomadic tribes of Mongolia and Central Asia. It is known that the drink existed in the Eneolithic, ie more than 5000 years ago. Proof of this are found in the valley Susamyr, where, besides the evidence of domestication of horses, the researchers found bags of goat skin with traces of horse milk. It is possible that it was fermented in the same way as the mare.

The first written mention of the drink was written by the ancient Greek historian Herodotus, who lived in the 5th century. BC. In describing the life of the Scythians, he tells about their favorite drink, which is made from fermented mare's milk by churning it in wooden tubs. Also, the historian noted that the Scythians so carefully guarded secret of the beverage that dazzled each slave, found out about the process of preparing a beverage.

Later mention of koumiss found in ancient chronicles (egHypatian) and in the notes of foreign missionaries and travelers. Thus, in the 13th century. French monk Guillaume de Rubruk, describing his journey to the "Tatars" describes in detail not only the effect of koumiss and taste, but also a way to cook it. Description somewhat distorted, but, in general, close to the truth.

Despite the fact that initially only used for kumys mare's milk, the Kalmyk nomads began to use the camel and cow's milk. Bashkirs still use a drink, traditional recipes, and the Turkmens and Kazakhs prefer to kumys camel milk.

Incidentally, the mare is the only intoxicating drinks authorized for Muslims.

The composition and caloric kumiss

While the form of fermentation, which is used to prepare koumiss, milk protein becomes digestible and milk sugars are converted to ethanol, lactic acid, carbon dioxide and aromatics. With this composition mare gets high nutritional, easily digestible, has a pleasant taste and delicate flavor.

Traditionally, the alcohol content of koumiss is between 0 and 2% to 3% ethanol. Strong koumiss prepared from mare milk, and contains up to 4, 5% alcohol. Kazakh cooking method involves the creation of a drink, a fortress which reaches 40%.

The drink contains a number of vitamins, including - thiamine, riboflavin, folic and pantothenic acid, biotin and vitamin B12, and C.

Calorie kumys the traditional manufacturing (from mare's milk) is 50 kcal per 100 g
Useful properties

Benefit Mare's milk in bottles
kumys marked by more than a thousand years ago, truly great. This drink is officially used, and later in the Soviet period, as a remedy in sanatoriums of the Volga region, Buryatia, Bashkortostan and Kyrgyzstan, and the treatment process called "kumysoterapiya." Now, unfortunately, the number of medical institutions, which is practiced kumysoterapiya greatly reduced. To date, only two are functioning actively resort located in Bashkiria.

The antibiotic substances contained in koumiss, do drink effective antimicrobial agent, increase the body's resistance to infectious diseases.

High nutritional value and ability to stimulate biological processes occurring in the body - the properties of koumiss, for which he also appreciated. Along with this, the drink is widely used to fill the shortage of vitamins and energy. It gives the body vitality, strength, stimulates the nervous system and helps to normalize metabolic processes in the body.

The content of the beverage alcohol, lactic acid and carbon dioxide stimulates the appetite and improves digestion.

Treatment kumis appointed in some forms of tuberculosis, anemia and to restore normal intestinal microflora.

Kumysfavor will surely appreciate those who suffer from the hangover. The drink is not only perfectly eliminates the causes of this condition, but also quenches thirst and gives strength.

Known benefits kumys and stomach: the regular use of a drink has a positive effect on the secretory activity of the digestive system, helps with gastric ulcer and dysentery.

According to some useful properties kumys allow you to use it as a means to help slow the progression of neoplastic processes in the body.

Raising the level of hemoglobin, leukocyte improvement, prevention of cardiovascular diseases - here's a small list of properties attributed to this drink.

It is also noteworthy that the application is not limited kumys age. It is equally useful for children and adults. It is not recommended to use it only for people with individual intolerance to the product, as well as those who suffer from diseases of the gastrointestinal tract in the acute form.

Health benefits of probiotics

Bacteria have a reputation for causing disease, so the idea of tossing down a few billion a day for your health might seem — literally and figuratively — hard to swallow. But a growing body of scientific evidence suggests that you can treat and even prevent some illnesses with foods and supplements containing certain kinds of live bacteria. Northern Europeans consume a lot of these beneficial microorganisms, called probiotics (from pro and biota, meaning "for life"), because of their tradition of eating foods fermented with bacteria, such as yogurt. Probiotic-laced beverages are also big business in Japan.

Enthusiasm for such foods has lagged in the United States, but interest in probiotic supplements is on the rise. Some digestive disease specialists are recommending them for disorders that frustrate conventional medicine, such as irritable bowel syndrome. Since the mid-1990s, clinical studies suggest that probiotic therapy can help treat several gastrointestinal ills, delay the development of allergies in children, and treat and prevent vaginal and urinary infections in women.

Self-dosing with bacteria isn't as outlandish as it might seem. An estimated 100 trillion microorganisms representing more than 500 different species inhabit every normal, healthy bowel. These microorganisms (or microflora) generally don't make us sick; most are helpful. Gut-dwelling bacteria keep pathogens (harmful microorganisms) in check, aid digestion and nutrient absorption, and contribute to immune function.

Probiotics benefits

Not all probiotics are the same. Different strains of the bacteria have different effects. For example, one strain may fight against cavity-causing organisms in our mouths and don't need to survive a trip through our guts.

Research has been promising for these friendly critters. Potential benefits of probiotics have been seen in the treatment or prevention of

diarrhea
irritable bowel syndrome
ulcerative colitis
Crohn's disease
H. pylori (the cause of ulcers)
vaginal infections
urinary tract infections
recurrence of bladder cancer
infection of the digestive tract caused by Clostridium difficile
pouchitis (a possible side effect of surgery that removes the colon)
eczema in children.
Probiotics and gastroinstestional issues

The best case for probiotic therapy has been in the treatment of diarrhea. Controlled trials have shown that Lactobacillus GG can shorten the course of infectious diarrhea in infants and children (but not adults). Although studies are limited and data are inconsistent, two large reviews, taken together, suggest that probiotics reduce antibiotic-associated diarrhea by 60%, when compared with a placebo.

More common than diarrhea is the opposite problem — constipation. In a search for studies on the benefits of probiotocs in treating constipation, researchers found that probiotics slowed "gut transit time" by 12.4 hours, increases the number of weekly bowel movements by 1.3, and helped to soften stools, making them easier to pass. But the jury is still out on specific recommendations when ot comes to the benefits of probiotics for constipation.

Probiotic therapy may also help people with Crohn's disease and irritable bowel syndrome. Clinical trial results are mixed, but several small studies suggest that certain probiotics may help maintain remission of ulcerative colitis and prevent relapse of Crohn's disease and the recurrence of pouchitis (a complication of surgery to treat ulcerative colitis). Because these disorders are so frustrating to treat, many people are giving probiotics a try before all the evidence is in for the particular strains they're using. More research is needed to find out which strains work best for what conditions.

Probiotics and vaginal health

Probiotics may also be of use in maintaining urogenital health. Like the intestinal tract, the vagina is a finely balanced ecosystem. The dominant Lactobacilli strains normally make it too acidic for harmful microorganisms to survive. But the system can be thrown out of balance by a number of factors, including antibiotics, spermicides, and birth control pills. Probiotic treatment that restores the balance of microflora may be helpful for such common female urogenital problems as bacterial vaginosis, yeast infection, and urinary tract infection.

Many women eat yogurt or insert it into the vagina to treat recurring yeast infections, a "folk" remedy for which medical science offers limited support. Oral and vaginal administration of Lactobacilli may help in the treatment of bacterial vaginosis, although there isn't enough evidence yet to recommend it over conventional approaches. (Vaginosis must be treated because it creates a risk for pregnancy-related complications and pelvic inflammatory disease.) Probiotic treatment of urinary tract infections is under study.

Probiotics are generally considered safe — they're already present in a normal digestive system — although there's a theoretical risk for people with impaired immune function. Be sure the ingredients are clearly marked on the label and familiar to you or your health provider. There's no way to judge the safety of unidentified mixtures**.**

UNIT-IV
SYLLABUS

Causative agents, foods involved, symptoms and preventive measures of the following diseases Food intoxications: *Staphylococcus aureus, Clostridium botulinum* and mycotoxins. Food infections: *Bacillus cereus, Vibrio parahaemolyticus, Escherichia coli, Salmonellosis, Shigellosis, Yersinia enterocolitica, Listeria monocytogenes* and *Campylobacter jejuni* , fungal diseases, toxins

Food poisoning is a term customarily applied to represent the illness caused both by the ingestion of toxins produced by the organisms in the food as well as resulting from the infection of the host by the organisms carried in by the food. But, more correctly, all food-borne diseases can be classified into two categories: 'food-poisoning' or 'food-intoxications' and 'food-infections'. Food-poisoning or food-intoxication diseases are those which are caused by the consumption of toxins produced by organisms in the food whereas food-infection diseases are those trial are caused by the organisms which enter into the body through ingestion of contaminated food.

Microbial 'Food-poisoning' or 'Food-intoxications'

Bacterial "Food-Poisoning" (Bacterial food-intoxications)

There are two major food-poisonings or food-intoxications caused by bacteria. These are: **Botulism** and **Staphylococoal poisoning**.

a. Botulism

Botulism is caused by the ingestion of food containing the neurotoxin (toxin that affects the nervous system) produced by *Clostridium botulinum*, an anaerobic spore forming bacterium. Sixty to seventy percent-cases of botulism die. There are 7 types (type A,B,C, D,E,F,G) of these neurotoxins recognized on the basis of serological specificity. The neurotoxin of C. botulinum is a protein. It has been purified and crystallized and is so powerful that only a does as low as 0.01 mg is said to be fatal to human being. The toxin is absorbed mostly in the small intestine and paralyzes the involuntary muscles of the body.

Source

The main sources of botulism are canned meat, fish, string beans, sweet corn, beets and other low medium acid foods. The foods implicated are generally those of a type that have undergone some treatment intended for the preservation of the product such as canning, pickling or smoking, but one which failed to destroy the spores of this bacterium. When the intended preservative treatment is inadequate and is followed by storage conditions which permit the germination and growth of the microorganisms, one of the most lethal toxins known to humanity is produced, The toxin has been known to persist in foods for long periods, especially when storage has been at low temperatures. It is unstable at pH value above 6.8.

Temperature is considered to be the most important factor in determining whether toxin production will take place and what the rate of production will be. Various strains of *C. botulinum* types A and B vary in their temperature requirements; a few strains grow at 10 to 11 °C. However, the lowest temperature for germination of spores of most of the strains is 15 °C and maximum of 48 °C.

Symptoms

Symptoms generally occur within 12 to 36 hours after consumption of the spoiled food. Early symptoms are digestive disturbances followed by nausea, vomiting, diarrhea together with dizziness and headache. Double vision may occur early and there may be difficulty in speaking. Mouth may become dry, throat constricted; tongue may get swollen, and coated. Involuntary Muscles become paralyzed and paralysis spreads to the respiratory system and to the heart. Death normally results from respiratory failure.

Prevention

Canned food should be properly processed by using approved heat processes.

Avoiding food that has been cooked but not well heated.Raw foods, frozen foods thawed and held at room temperature should be avoided. Gassy and spoiled canned foods should be rejected. Boiling of suspected food for at least 15 minutes.

Treatment:

Successful treatment is by the administration of polyvalent antitoxin in the early stages of infection. Once the symptoms appear the fails to prove useful.

b. Staphylococcal-poisoning:

This is the most common type of food-poisoning caused due to the food contaminated with a potent toxin namely, **enterotoxin.** This toxin is produced by certain strains of *Staphylococcus aureus*. A sudden onset of illness starts usually within 3to 6 hours after ingestion of the contaminated food.

Source

These bacteria are commonly present on the skin, nose and other parts of human body. People who handle foods carelessly usually transfer them to the food. Foods most commonly contaminated involve those which are eaten cold, e.g., cold meat, poultry, salads, bakery products etc.

Symptoms

As said earlier, the disease starts within 3 to 6 hours after ingestion of the contaminated food and is manifested by nausea, vomiting, abdominal pain and diarrhoea within 24 to 48 hours. If the case becomes severe, dehydration and collapse may follow. However, in usual conditions death is rare.

Control

The disease can be controlled by preventing the entry of the bacteria to food. It is important that all susceptible foods are kept under refrigeration to restrict the growth of the bacteria; and also by the destruction of the bacteria.

Bacterial Food Infections

a. Salmonellosis

This disease is caused through the ingestion of *Salmonella* bacteria present in food. A large number of species and serotypes are involved. An inoculum of about 600,500 cells is required to become established and cause illness in the host. These bacteria are gram-negative, non-spore forming rods and motile by means of peritrichous flagella. Various species of Salmonella get ingested with improperly cooked eggs, puddings and meat that have been contaminated by the carriers. The carriers may be cats, dogs, chickens and others.

The disease appears through gastrointestinal infections as a result of the growth of the bacteria in the intestine. Typical symptoms of salmonellosis are nausea, vomiting, abdominal pain and diarrhoea. Generally the symptoms persist for 2 to 4 days. The incubation period ranges between 4 to 36 hours.

Salmonellosis can be prevented by avoiding consumption of contaminated food, by heat destruction of the bacteria, or by refrigeration to check the growth of bacteria.

b. Perfringens poisoning

The disease caused by the strains of *Clostridium perfringenes* is called ‘perfringens poisoning’ or more technically, ‘*Clostridium perfringens* - gastroenteritis’. This bacterium is a gram-positive, anaerobic non-motile, spore former with an optimum growth temperature of 37-43°C.

This disease has been caused by the ingestion of prepared meat, meat products and poultry. Generally, the meat that has been cooked and allowed to cool slowly before consumption allows the growth of these microorganisms. What happens is that the cooking destroys only the vegetative cells not the spores. The latter survive the heating applied during cooking and germinate into vegetative cells. It could be avoided by adequate refrigeration of the food.

Symptoms

Symptoms appear in the form of diarrhoea, acute abdominal pain and, rarely, vomiting when the, growth of microorganisms takes place in the human intestine. Disease manifestation occurs between 8 to 22 hours after the contaminated food has been taken.

Prevention

Prevention of the disease includes rapid cooling of cooked meats and other foods and reheating of the remaining food before further consumption.

***Bacillus cereus* gastroenteritis**

Bacillus cereus is a gram-positive, aerobic, rod-shaped, spore forming bacterium that causes food infections called ‘gastroenteritis’. Its spores are heat resistant and remain viable even after considerable degree of cooling; germinate and produce vegetative cells. It is believed that the bacterial cells undergo lysis in the intestinal tract and release enterotoxin.

***Escherichia coli* gastroenteritis**

Escherichia coli bacterium is generally regarded as a part of the natural flora of the human and animal intestinal tract. In recent years, however, various serotypes of this bacterium have been thought responsible for human and animal diarrhoeal diseases. These bacteria can be classified into two groups: one group representing enteropathogenic E.coli and the other representing enterotoxin producing *E. coli*.

The enteropathogenic E. coli are pathogenic within the intestinal tract. They have ability to penetrate epithelial cells of the intestinal mucosa, cause spithelial necrosis and ulceration resulting in the presence of red blood cells and large number of neutrophils in the stool during dysentery. This acute gastroenteritis (dysentery-like syndrom) is generally reported in the new-born and in infant up to two years of age.

The enterotoxin-producing *E. coli* fails to invade the intestinal mucosa but release an enterotoxin which causes diarrhea like syndrome. The latter refers to a profuse watery discharge generally from the small intestine. Since these bacteria do not penetrate and cause epithelial necrosis, red blood cells and neutrophils are not present in the diarrheal stool.

Foods which are highly contaminated or inadequately preserved allow the growth of such *E. coli* serotypes. The latter are heat sensitive and can be destroyed by pasteurization or by proper cooking methods.

Cholera

This disease, generally called ‘asiatic cholera’, is caused by *Vibrio cholerae* and has been the cause of untold suffering and death. The symptoms include vomiting and profuse diarrhoeal (rice-water) stools which result in mineral deficiency, dehydration and increased blood acidity of the body tissues leading, finally, to the death.

Vibrio cholerae is a gram-negative, uniflagellate bacterium and is transmitted through contaminated flies, water, raw and exposed foods etc. They find their way through mouth into the intestines and produce endotoxins which disintegrate the epithelial cells of the intestines. Death rate is rather high and the course of the disease may be as short as 12 hours after the onset of the first symptoms. Individuals recovering from infection are said to be effective in controlling the disease. Cholera patients should be kept in quarantine and all materials contaminated by faeces burnt for checking infection spread.

Yersinia enterocolitica

This rare form of food poisoning occurs as a result of eating contaminated food, in particular undercooked pork. This results in those all too familiar symptoms of nausea, abdominal pain and diarrhoea which characterise most cases of food poisoning.

This type of illness affects both children and adults although children are affected more than adults. Anyone in a high risk group such as the elderly or those with a weakened immune system is also susceptible.Theyersinia enterocolitica bacteria

These bacteria form part of a larger group called the 'enterobacteriaceae'. This group also includes the *E coli* and salmonella bacteria.

Other similar strains include '*yersinia pestis'*(responsible for plague) and '*yersinia pseudotuberculosis'* (tuberculosis symptoms).

Not all strains of Y enterocolitica bacteria cause food poisoning in humans. The rod shaped bacterial strain which infects humans is found in pigs but other strains are found in cattle, horses, cats and dogs.

Causes of *yersinia enterocolitica* poisoning

This illness develops as a result of eating raw or undercooked pork, or pork based products. Other sources of contamination include unpasteurised milk or untreated water, or contact with an infected animal.

Another factor is person to person contact. If someone who has handled food or soil which has been contaminated by infected animal faeces, touches another person then this will transfer the infection to them. This tends to happen if the infected person fails to wash their hands properly or shows a lack of attention to basic hygiene. These bacteria can be transmitted to another person via a blood transfusion but this is very rare.

Symptoms of *yersinia enterocolitica* poisoning

These symptoms appear several days after initial contact with the bacteria, usually around 4 days to a week. They last from 1 to 3 weeks although they may persist even longer.

Symptoms include:

Abdominal pain
Fever
Diarrhoea (often bloody)

Many older children and adults experience abdominal pain on the right had side of their bodies which along with fever, is often mistaken for signs of appendicitis.

Complications of *yersinia enterocolitica* poisoning

These occur in only a small number of cases. They include a skin rash, pains in the joints or the bacteria spread into the bloodstream and cause diseases such as arthritis.

Diagnosing *yersinia enterocolitica* poisoning

This involves a physical examination and a stool sample. The stool sample is a very common test in which a small sample of faeces is obtained and sent for laboratory analysis.

The yersinia enterocolitica bacteria are not usually tested at laboratories so any laboratory that receives this type of sample will have to be notified beforehand.

There are other tests that can be done to confirm a diagnosis which include blood, urine and swabs taken from the throat.

Treatment for *yersinia enterocolitica* poisoning

Most cases resolve themselves without the need for treatment. But if they require some extra help then bed rest and consuming plenty of liquids will help.

This will also prevent against dehydration which is always a risk in food poisoning cases, usually due to the frequent bouts of vomiting and /or diarrhoea.

One way of dealing with this is to purchase re-hydration powders from a local pharmacy. These powders contain electrolytes which are a replacement for essential vitamins and minerals which have become depleted as a result of this illness.

Antibiotics are not usually prescribed unless symptoms are severe or complications have arisen.

Preventing *yersinia enterocolitica* poisoning

There are a few measures you can take to prevent this illness. These include:
Ensure that all pork is cooked at the correct temperature and cooking time. Do not eat undercooked pork.
Wash your hands with soap and water before and after handling food.
Use separate utensils, chopping boards and containers for raw and cooked foods.
Store raw food away from cooked food

Listeria Monocytogenes

This is the name given to the bacteria which causes listeria food poisoning. These bacteria are rod shaped in appearance and is one of the most dangerous forms of pathogenic bacteria known to humans.

These bacteria are found in poultry, sheep, cattle, dairy foods, fruit and vegetables. They enter the body via the gastrointestinal tract and release toxins which damage cells within the body. It also spreads through the bloodstream where it particularly targets the nervous system.

However it is considered a rare form of food poisoning and one that is treatable. But, it is nevertheless, a serious type of food poisoning which is particularly dangerous for pregnant women, the elderly and anyone with poor immunity.

Foods which contain the listeria bacteria

These bacteria are usually found in soft cheeses such as Brie or Camembert but it also appears in the following foods:

Pates
Butter
Ice cream
Sliced meats
Poultry, e.g. cooked chicken
Smoked salmon (packaged)
Packaged sandwiches
Unpasteurised milk
Canned fish
Unwashed fruit and vegetables

Listeria is a tough, durable type of bacteria which can resist extremes of temperature much better than other bacteria. It even thrives at temperatures of minus 24 Fahrenheit which means that it is able to survive refrigeration.

Refrigeration usually kills off most strains of bacteria but listeria appears to have a stronger than normal survival instinct in this respect.

Causes of listeria food poisoning

Listeria is caused by consuming food which has been contaminated by the listeria monocytogenes bacteria. These bacteria invade cells within the lining of the intestinal walls and releases toxins which cause an infection.These bacteria are able to travel throughout the body but are particularly attracted to the nervous system. This leads to a range of health problems such as meningitis and septicaemia.

These bacteria are found in a variety of foods which include processed ready meals, side salads such as coleslaw (mixed vegetables in mayonnaise), cooked poultry and canned fish.

But one of the biggest high risk foods is soft cheese. These include Brie, Camembert, Ricotta and Feta and have been highlighted as one of the main causes of listeria food poisoning.

Symptoms of listeria food poisoning

The time between the consumption of the contaminated food and the appearance of the first symptoms is known as the ‘incubation period’.With listeria, the symptoms take much longer to appear than with most other types of bacteria. In fact, it can be 8 weeks before the symptoms develop. Symptoms usually appear after a month which appears to be the average.

The symptoms start off as relatively mild but soon worsen once the immune system has been infected. They include:

Fever

Nausea
Vomiting
Diarrhoea
Muscle aches and pains
Tiredness
Loss of appetite
These are the initial symptoms of listeriosis and in many ways will feel like a bad case of 'the flu'.

But if the infection has affected the immune system it will cause the following symptoms:
Poor balance
Lack of co-ordination
Severe headaches
Stiff neck
Seizures\
Confusion
Meningitis or septicaemia is likely to develop if the infection has spread to the brain or throughout the bloodstream.

Listeria food poisoning and pregnancy

The group of people who are at a very high risk of listeriosis are pregnant women.
If a women contracts listeria food poisoning during her pregnancy then she will experience the symptoms mentioned above but these may be relatively mild
However, the risks to the unborn baby are anything but mild.
These bacteria are able to transfer from the mother to the baby via the placenta or at birth. If this happens they will enter the baby's bloodstream and once there, will cause a serious infection.
This will result in either a stillborn baby or a miscarriage.
Pregnant women appear to be a greater risk of listeria food poisoning than other women which means that they need to take greater care about what they eat and food safety in general.
This is covered in more detail in our pregnancy and food poisoning section.
Other high risk groups and listeria food poisoning
These include people who have undergone a transplant; cancer treatment, e.g. chemotherapy; who suffer from HIV or AIDS or have kidney or liver disease. This is because their immune systems are less effective at fighting off bacteria which cause infections such as listeriosis. People in any of these groups are more likely to develop a serious form of this illness and/or complications.

Diagnosing listeria food poisoning

Contact your GP if you have developed symptoms of this illness within the last month or two. Do this if you are in a high risk group, for example, you suffer from diabetes.
A blood test can detect the symptoms of listeria food poisoning. Another equally useful test is a spinal fluid test.

Treatment for listeria food poisoning

Listeriosis can be treated with antibiotics. If this food poisoning has occurred during pregnancy then antibiotics will be given to the mother as soon as possible to prevent the risk of the infection spreading to the unborn baby.Antibiotics are also prescribed if a newborn baby exhibits these symptoms although it may be given a different type or combination compared to an adult.

Preventing listeria food poisoning

There are a few measures you can take to avoid the risk of you contracting this form of food poisoning. These are especially important if you are pregnant or have a poorly functioning immune system.

They include:

Avoid eating canned meats and meat based products such as ham, luncheon meat and hot dog sausages.

Avoid soft cheeses such as Brie unless you know that they have been produced from pasteurised milk.

Avoid canned fish or pates.

Wipe kitchen surfaces, utensils and containers after use.

Store raw and cooked food separately

Campylobacter jejuni

This is the most common type of food poisoning which affects people in many countries around the world. The campylobacter bacteria cause a range of gastrointestinal illnesses but it is more commonly known for causing food poisoning.Campylobacter food poisoning affects anybody but there are certain groups of people who are particularly vulnerable to this illness. These include children, the elderly and anyone who has a weak immune system.

It occurs as a result of eating foods which have been contaminated by these bacteria. These bacteria do not grow within food but are transmitted to the human body via consumption of this food. Once there they cause an extremely unpleasant disease.This illness is also known as ‘campylobacteriosis’.

The Campylobacter bacteria

These bacteria have a spiral shape and are classed as a pathogenic type of bacteria. This means that they act as a type of ‘germ’which causes disease in its surrounding environment.In this case the surrounding environment is the human gastrointestinal tract.

Foods which contain the campylobacter bacteria

The worst offender is chicken but it also found in other type of poultry such as turkey, duck and goose.

It also occurs in these types of foods:

Red meat

Pork

Lamb

Offal, e.g. liver

Shellfish

Eggs

Fresh fruit and vegetables (unwashed)

These bacteria are also found within unpasteurised milk or unchlorinated water.

Causes of campylobacter food poisoning

There are several ways in which this bacteria causes food poisoning. These ways or ‘methods of transmission’ refer to how the bacteria get into the human body and cause an infection.

The most obvious method is through eating contaminated food or drinking infected water.

Other methods include a failure to wash the hands after coming into contact with infected faeces and contact with infected birds and animals. This often occurs after touching or stroking an infected pet, e.g. a dog or contact with its infected faeces.

Another factor is person to person contact.

These bacteria are able to access the gastrointestinal tract where they invade the cells within the lining of the intestines. They are aided in this by the release of a toxin. This toxin prevents the cells from reacting to this attack by stopping them from dividing which would trigger a response from the immune system.This gives the bacteria a short amount of survival time within the cells which enables it to cause damage within that area.

Symptoms of campylobacter food poisoning

The 'onset'of these symptoms refers to the period of time between initial contact with the bacteria and the appearance of the symptoms.

This is also known as the 'incubation period'.

With campylobacter food poisoning the incubation period is usually around 2 to 5 days but there are exceptions to this. In some cases the symptoms appear after little more than 2 days or as long as 10 days.This illness usually lasts for a week but may persist for up to 3 weeks in severe cases.

Symptoms of this food poisoning include:

Diarrhoea (this may be bloody)
Fever
Abdominal pains
Muscle aches
Headache

Vomiting is another symptom although this tends to be rare. Some people do experience nausea and vomiting but the most frequent symptom is diarrhoea. This can be severe and often bloody.

Diagnosing campylobacter food poisoning

A stool sample (sample of faeces) will determine if you have campylobacter food poisoning. It is a simple test in which you provide a sample of your stool which is then sent away to a laboratory for analysis.The results of this analysis will confirm or reject this diagnosis.

Treatment for campylobacter food poisoning

This involves plenty of rest and fluids.

It is important that you consume plenty of fluids to replace those lost during this illness. But what is equally important is replacing those vitamins and minerals lost due to severe diarrhoea and/or vomiting.

These electrolytes as they are known can easily be replaced. There are 'oral rehydration therapy' sachets you can purchase –either at a local pharmacy or online which you add to water or some other fluid. These are a quick and easy way of topping up your electrolyte levels.

This works with mild cases but if you have a severe form of food poisoning then intravenous fluids will be required. These are administered in hospital.

Hospital treatment is only required for people who are considered a 'high risk'group, for example, the very young, the very old and those people who have a weakened immune system.

Antibiotics can also help although there is evidence to show that some strains of bacteria have developed a resistance to them. However they are useful, particularly in severe cases and significantly shorten the period of illness.

Complications of campylobacter food poisoning

Most cases clear up without any problems but there are a few situations in which people experience a relapse. This means a reoccurrence of the symptoms or long term complications such as 'Guillain-Barre Syndrome'.

Guillain-Barre Syndrome is a disease which affects the nervous system and may leave some people with permanent damage.

Another complication is 'Miller Fisher Syndrome'. This is another neurological disorder which affects the nerves within the head rather than the rest of the body (as in Guillain-Barre Syndrome).

Then there is a chronic condition called reactive arthritis or 'Reiter's Syndrome' which commonly affects the knee joints and the bottom of the spine. This occurs in people who have a marked genetic tendency, for example they have a particular antigen which predisposes them towards this disorder.

Prevention of campylobacter food poisoning

Washing food and vegetables before use. This applies to foods which have been purchased at an outdoor market.

Ensure that meat and poultry have been properly defrosted before use. Also ensure that they are cooked through before consumption.

Avoid unpasteurised milk

Prevent cooked foods coming into contact with uncooked foods. This is known as 'cross contamination.

Wash your hands before and after handling food; visiting the bathroom and after stroking or touching a pet or farm animal.

Consider buying irradiated foods. These are foods which undergo a form of heat treatment which kills off any bacteria without affecting the taste or texture of the food.

Differentiate between the major types of food borne diseases -- infection, intoxication, and toxin-mediated infection.

Microbiological hazards cause most foodborne diseases in the United States. The three microbiological hazards of concern are bacteria, viruses, and parasites. These microorganisms can cause one of three types of illness -- infection, intoxication, or toxin-mediated infection.

Infection

A foodborne disease is when a person eats food containing harmful microorganisms, which then grow in the intestinal tract and cause illness. Some bacteria, all viruses, and all parasites cause foodborne illness via infection. The foodborne bacteria that cause infection are: Salmonella spp., Listeria monocytogenes, Campylobacter jejuni, Vibrio parahaemolyticus, Vibrio vulnificus, and Yersinia enterocolitica. The most common viral agents that cause foodborne disease are: Hepatitis A, norovirus, and rotavirus. The most common foodborne parasites are: Trichinella spiralis, Anisakis simplex, Giariaduodenalis, Toxoplasma gondii, Cryptosporidium parvum, and Cyclosporacayetanensis.

Intoxication

An intoxication results when a person eats food containing toxins that cause illness. Toxins are produced by harmful microorganisms, the result of a chemical contamination, or are naturally part of a plant or seafood. Some bacteria cause intoxication. Viruses and parasites do not cause food borne intoxication. The foodborne bacteria that cause intoxication are: *Clostridium botulinum*, *Staphylococcus aureus*, *Clostridium perfringens*, and *Bacillus cereus*. Chemicals that can cause intoxication include cleaning products, sanitizers, pesticides and metals (lead, copper, brass, zinc, antimony, and cadmium). Seafood toxins include ciguatera toxin, scombroid toxin, shellfish toxins, and systemic fish toxins. Plants and mushrooms can also cause intoxication.

POSSIBLE QUESTIONS

UNIT-I

PART-A (20 MARKS)

(Q.NO 1 TO 20 Online Examination)

Two Marks

1. What are the types of toxins produced by *E. coli*?
2. Define food borne infection?
3. What is ergotism?
4. What are the symptoms caused by aflatoxins?
5. Write two disease conditions caused by Salmonellosis ?
6. Types of fungal toxin
7. Difference between food infection and food toxin
8. Define incubation time
9. Symptoms produced by shigellosis
10. Four disease conditions of *Y. enterocolitica*

Eight Marks

1. Describe the two chief kinds of food intoxication
2. Elaborate about Salmonellosis
3. Write a detailed note on food borne infection caused by *Staphylococcus aureus*
4. Role of *Listeria monocytogens* in causing food borne disease
5. Write a detailed note on *Bacillus cereus*
6. Describe about fungal disease and toxins
7. Describe about *C. jejuni*
8. Discuss briefly on food intoxication caused by *S. aureus* and *C. botlium*
9. Write a detailed note on food borne infection caused by *Clostridium*sp
10. Mycotoxins in food poisoning

UNIT-V
SYLLABUS

Cultural and rapid detection methods of food borne pathogens in foods and introduction to predictive microbiology. HACCP,FSSAI(ISO 9001:2008) Indices of food sanitary quality (record maintenance and standards) and sanitizers

Food laws and Regulations

- To meet a country's sanitary and phytosanitary requirements, food must comply with the local laws and regulations to gain market access.
- These laws ensure the safety and suitability of food for consumers.
- The requirement of food regulation may be based on several factors such as
- whether a country adopts international norms developed by the Codex Alimentarius Commission of the Food and Agriculture Organization of the United Nations and the World Health Organization or a country may also has its own suite of food regulations.
- Each country regulates food differently and has its own food regulatory framework.

Food laws in our country

The Indian Parliament has recently passed the *Food Safety and Standards Act, 200*6 that overrides all other food related laws.

Such as;

Prevention of Food Adulteration Act, 1954
Fruit Products Order,1955
Meat Food Products Order ,1973;
Vegetable Oil Products (Control) Order, 1947
Edible Oils Packaging (Regulation) Order 1988
Solvent Extracted Oil, De- Oiled Meal and Edible Flour (Control) Order, 1967,
Milk and Milk Products Order, 1992 etc are repealed after commencement of FSS Act, 2006.

Food Safety and Standards Authority of India (FSSAI)

The Food Safety and Standards Authority of India (FSSAI) has been established under Food Safety and Standards Act, 2006 which consolidates various acts & orders that have hitherto handled food related issues in various Ministries and Departments.

FSSAI has been created for laying down science based standards for articles of food andto regulate their manufacture, storage, distribution, sale and import to ensure availability of safe and wholesome food for human consumption.

Functions performed by FSSAI

- Framing of Regulations to lay down the Standards and guidelines in relation to articles of food and specifying appropriate system of enforcing various standards.
- Laying down mechanisms and guidelines for accreditation of certification bodies engaged in certification of food safety management system for food businesses.
- Laying down procedure and guidelines for accreditation of laboratories and notification of the accredited laboratories.
- To provide scientific advice and technical support to Central Government and State Governments in the matters of framing the policy and rules in areas which have a direct or indirect bearing of food safety and nutrition .

- Collect and collate data regarding food consumption, incidence and prevalence of biological risk, contaminants in food, residues of various, contaminants in foods products, identification of emerging risks and introduction of rapid alert system.
- Creating an information network across the country so that the public, consumers, Panchayats etc receive rapid, reliable and objective information about food safety and issues of concern.
- Provide training programmes for persons who are involved or intend to get involved in food businesses.
- Contribute to the development of international technical standards for food, sanitary and phyto-sanitary standards.
- Promote general awareness about food safety and food standards.

Bureau of Indian Standards (BIS)

- The Bureau of Indian Standards (BIS), the National Standards Body of India, resolves to be the leader in all matters concerning Standardization, Certification and Quality.

Main Activities

- Harmonious development of standardization, marking and quality certification
- To provide new thrust to standardization and quality control.
- To evolve a national strategy for according recognition to standards and integrating them with growth and development of production and exports.
- Certification of Product
- Hallmarking of Gold Jewellery.
- Quality Management System
- Environmental Management Systems
- Occupational Health and Safety Management System
- Food Safety Management System
- Hazard Analysis and Critical Control Points
- Imported Products
- Laboratory Management
- International Activities
- Training Services

AGMARK

- The Directorate of Marketing and Inspection enforces the Agricultural Produce (Grading and Marketing) Act, 1937. Under this Act Grade standards are prescribed for agricultural and allied.
- AGMARK is a Quality Certification Mark .
- It ensures quality and purity of a product.
- It acts as a Third Party Guarantee to Quality Certified.
- Quality standards for agricultural commodities are framed based on their intrinsic quality.
- Food safety factors are being incorporated in the standards to complete in World Trade.
- Standards are being harmonized with international standards keeping in view the WTO requirements. Certification of agricultural commodities is carried out for the benefit of producer/manufacturer and consumer.
- Products available under AGMARK are as follows:-
- ✓ Pulses
- ✓ Whole spices & ground spices
- ✓ Vegetable oils

- ✓ Wheat Products
- ✓ Milk products.
- ✓ Other products such as Honey, Compounded asafetida, Rice, Tapioca Sago, Seedless tamarind, Besan (Gram flour).
- ✓ **HACCP Plan**: A document prepared in accordance with the principles of HACCP to ensure control of hazards which are significant for food safety in the segment of the food chain under consideration.
- ✓ **HACCP System:** The hazard analysis critical control point system (HACCP) is a scientific and systematic way of enhancing the safety of foods from primary production to final consumption through the identification and evaluation of specific hazards and measures for their control to ensure the safety of food. HACCP is a tool to assess hazards and establish control systems that focus on prevention rather than relying mainly on end-product testing.

Some establishments may use **Good Manufacturing Practices (GMP)** to reduce the likelihood of certain hazards. GMPs are minimum sanitary and processing requirements. GMPs are fairly broad and general, for example, "*Training: All employees should receive training in personal hygiene.*" GMPs are usually not designed to control specific hazards, but are intended to provide guidelines to help establishments produce safe and wholesome products.

- ✓ **Standard Operating Procedures (SOP)** are step-by-step directions for completing important procedures and are usually very specific. SOP may be used to address a specific hazard, for instance, an establishment may have specific preventive maintenance procedures for its processing equipment, which prevent the hazard of metal fragments.
- ✓ **Sanitation SOP (SSOP)** may be considered by establishments to reduce the likelihood of occurrence of some food safety hazards. For example, the SSOP may address washing and sanitizing of knife and hands between carcasses to reduce potential contamination with pathogens.

Product specific GMPs

- ➢ thermally processed low-acid canned foods
- ➢ acidified foods
- ➢ bottled drinking water

<u>GMPs Regulations</u>

21CFR Part 110

- o *Subpart A - General Provisions*
- o *Subpart B - Building and Facilities*
- o *Subpart C - Equipment*
- o *Subpart D - [Reserved]*
- o *Subpart E - Production and Process Controls*

- *Subpart F -* *[Reserved]*
- *Subpart G -* *Defect Action Levels*

GMPs - General Provisions

- provides definitions necessary for *important in understanding implications and applications*

✓ Buildings and Facilities. Buildings must be designed and constructed to facilitate *effective maintenance and sanitation.The*results specified rather than method for achieving detailed expectations in sanitation of operations**.**

✓ The equipment and utensils are *designed and constructed to be easily and properly cleaned*, temperature is measured and recorded by refrigerators and freezers. Also the critical parameters are measured.

✓ Production and Process Controls-

- The end results emphasizes *ensuring that no adulterated food enters marketplace.The terms used subject to variation in interpretation.*
- *The* raw materials and ingredients properly *inspected, analyzed, segregated, stored and handled.*
- manufacturing operations must be monitored
  - *pH, water activity, temperatures*
  - *elimination of metal from product*
- personnel should be trained and aware of GMP requirements

✓ Defect Action Levels

- natural or unavoidable defects may be in food
  - *not harmful at levels present*
  - *present even with GMPs*
- FDA establishes DALs when necessary and possible
- defect level may not be reduced by blending

Thus GMPs are Intended to prevent adulteration. Opportunity for considerable judgment in defining and interpreting regulations. *"spirit" of GMPs is to do what is reasonable and necessary to ensure safe and unadulterated food supply.*

Specific GMPs:

Low acid canned foods

- *Life threatening risk if improperly processed*
- Requires supervision of personnel who have been trained
- Regulations quite detailed for equipment design and operation
- Extensive record keeping requirements

Acidified foods:

- Defined as a low acid food with
  - A_w *greater than 0.85*
  - *acid added to lower pH to 4.6 or lower*
- Product examples
  - *includes beans, cucumbers, cabbage*
  - *excludes carbonated beverages*
- Personnel trained under approved program

Bottled Drinking Water:

- *All water sealed in bottles, packages for human consumption*

- Regulations are general and similar to umbrella GMPs
- Source of water must be approved
- Sanitation, equipment designed, personnel emphasized

Extensive record keeping

What is HACCP?

- The National Advisory Committee on Microbiological Criteria for Food (NACMCF) working group created guidelines and redefined the seven basic principles of HACCP as an effective and rational means of assuring food safety from harvest to consumption.
- The working group published the HACCP principles and application guideline document in August 1997.
- The hazard analysis critical control point system (HACCP) is a scientific and systematic way of enhancing the safety of foods from primary production to final consumption through the identification and evaluation of specific hazards and measures for their control to ensure the safety of food. HACCP is a tool to assess hazards and establish control systems that focus on prevention rather than relying mainly on end-product testing.
- Under the HACCP regulatory system, establishments assume full responsibility for producing products that are safe for consumers.

History of HACCP

- Developed by Pillsbury in 1959 as a nontesting approach to assure the safety level required by NASA for foods produced for the space program
- NASA's major concerns • Food crumbs • Foodborne illness
- NASA's Zero Defects program Testing materials
- National Research Council – 1985 • An Evaluation of the Role of Microbiological Criteria for Foods and Food Ingredients
- Microbiological hazards not controlled by testing
- Recommended using HACCP for food safety assurance
- **National Advisory Committee on Microbiological Criteria for Food (NACMCF) 1988**
- NACMCF proposed 7 principles of HACCP application, Published in 1989;
- 1st. Revision in 1992; 2nd. Revision (latest) in 1997

PRINCIPLES OF THE HACCP SYSTEM

The seven principles of HACCP, which encompass a systematic approach to the identification, prevention, and control of food safety hazards include:

PRINCIPLE 1 Conduct a hazard analysis.

PRINCIPLE 2 Determine the Critical Control Points (CCPs).

PRINCIPLE 3 Establish critical limit(s).

PRINCIPLE 4 Establish a system to monitor control of the CCP.

PRINCIPLE 5 Establish the corrective action to be taken when monitoring indicates that a particular CCP is not under control.

PRINCIPLE 6 Establish procedures for verification to confirm that the HACCP system is working effectively.

PRINCIPLE 7 Establish documentation concerning all procedures and records appropriate to these principles and their application.

APPLICATION

The application of HACCP principles consists of the following tasks as identified in the Logic Sequence for Application of HACCP (Diagram 1).

1. Assemble HACCP team

The food operation should assure that the appropriate product specific knowledge and expertise is available for the development of an effective HACCP plan. Optimally, this may be accomplished by assembling a multidisciplinary team. Where such expertise is not available on site, expert advice should be obtained from other sources, such as, trade and industry associations, independent experts, regulatory authorities, HACCP literature and HACCP guidance (including sector-specific HACCP guides). It may be possible that a well-trained individual with access to such guidance is able to implement HACCP inhouse.

The scope of the HACCP plan should be identified. The scope should describe which segment of the food chain is involved and the general classes of hazards to be addressed (e.g. does it cover all classes of hazards or only selected classes).

2. Describe product

A full description of the product should be drawn up, including relevant safety information such as: composition, physical/chemical structure (including Aw, pH, etc), microcidal/static treatments (heat treatment,freezing, brining, smoking, etc), packaging, durability and storage conditions and method of distribution. Within businesses with multiple products, for example, catering operations, it may be effective to group products with similar characteristics or processing steps, for the purpose of development of the HACCP plan.

3. Identify intended use

The intended use should be based on the expected uses of the product by the end user or consumer. In specific cases, vulnerable groups of the population, e.g. institutional feeding, may have to be considered.

4. Construct flow diagram

The flow diagram should be constructed by the HACCP team (see also paragraph 1 above). The flow diagram should cover all steps in the operation for a specific product. The same flow diagram may be used for a number of products that are manufactured using similar processing steps. When applying HACCP to a given operation, consideration should be given to steps preceding and following the specified operation

LOGIC SEQUENCE FOR APPLICATION OF HACCP

1. Assemble HACCP Team
2. Describe Product
3. Identify Intended Use
4. Construct Flow Diagram
5. On-site Confirmation of Flow Diagram
6. List all Potential Hazards
   Conduct a Hazard Analysis
   Consider Control Measures
7. Determine CCPs *See Dia*
8. Establish Critical Limits for each CCP
9. Establish a Monitoring System for each CCP
10. Establish Corrective Actions
11. Establish Verification Procedures
12. Establish Documentation and Record Keeping

5. On-site confirmation of flow diagram

Steps must be taken to confirm the processing operation against the flow diagram during all stages and hours of operation and amend the flow diagram where appropriate. The confirmation of the flow diagram should be performed by a person or persons with sufficient knowledge of the processing operation.

6. List all potential hazards associated with each step, conduct a hazard analysis, and consider any measures to control identified hazards

The HACCP team should list all of the hazards that may be reasonably expected to occur at each step according to the scope from primary production, processing, manufacture, and distribution until the point of consumption.

The HACCP team should next conduct a hazard analysis to identify for the HACCP plan, which hazards are of such a nature that their elimination or reduction to acceptable levels is essential to the production of a safe food.

In conducting the hazard analysis, wherever possible the following should be included:

• the likely occurrence of hazards and severity of their adverse health effects;
• the qualitative and/or quantitative evaluation of the presence of hazards;
• survival or multiplication of micro-organisms of concern;
• production or persistence in foods of toxins, chemicals or physical agents; and,
• conditions leading to the above.

Consideration should be given to what control measures, if any exist, can be applied to each hazard. More than one control measure may be required to control a specific hazard(s) and more than one hazard may be controlled by a specified control measure.

✓ A hazard is defined by NACMCF as a biological, chemical or physical agent that is **reasonably likely to occur**, and will **cause illness or injury in the absence of its control**. Establishments must consider all **three types of hazards – biological, chemical, and physical** – at each step of the production process.

7. Determine Critical Control Points

✓ A ***critical control point*** is defined as a point, step, or procedure in a food process at which control can be applied, and, as a result, a food safety hazard can be prevented, eliminated, or reduced to acceptable levels. Critical control points are locations in a process at which some aspect of control can be applied to control food safety hazards that have been determined reasonably likely to occur.

✓ Examples of CCPs include product temperature, certification of incoming product, microbiological testing, testing for foreign objects such as metal contamination, the chemical concentration of a carcass rinse or spray, and other such parameters.

There may be more than one CCP at which control is applied to address the same hazard.

The determination of a CCP in the HACCP system can be facilitated by the application of a decision tree, which indicates a logic reasoning approach. Application of a decision tree should be flexible, given whether the operation is for production, slaughter, processing, storage, distribution or other. It should be used for guidance when determining CCPs. This example of a decision tree may not be applicable to all situations. Other approaches may be used. Training in the application of the decision tree is recommended.

If a hazard has been identified at a step where control is necessary for safety, and no control measure exists at that step, or any other, then the product or process should be modified at that step, or at any earlier or later stage, to include a control measure.

8. Establish critical limits for each CCP

Critical limits (CL) are the parameters that indicate whether the control measure at the CCP is in or out of control. The National Advisory Committee on Microbiological Criteria for Foods (NACMCF) states that a CL is **a maximum or minimum value** to which a biological, chemical, or physical parameter must be controlled at a CCP to prevent, eliminate, or reduce to an acceptable level the occurrence of a food safety hazard.

Critical limits must be specified and validated for each Critical Control Point. In some cases more than one critical limit will be elaborated at a particular step. Criteria often used include measurements of temperature, time, moisture level, pH, Aw, available chlorine, and sensory parameters such as visual appearance and texture.

Where HACCP guidance developed by experts has been used to establish the critical limits, care should be taken to ensure that these limits fully apply to the specific operation, product or groups of products under consideration. These critical limits should be measurable.

9. Establish a monitoring system for each CCP

Monitoring is the scheduled measurement or observation of a CCP relative to its critical limits. The monitoring procedures must be able to detect loss of control at the CCP. Further, monitoring should ideally provide this information in time to make adjustments to ensure control of the process to prevent violating the critical limits. Where possible, process adjustments should be made when monitoring results indicate a trend towards loss of control at a CCP. The adjustments should be taken before a deviation occurs. Data derived from monitoring must be evaluated by a designated person with knowledge and authority to carry out corrective actions when indicated. If monitoring is not continuous, then the amount or frequency of monitoring must be sufficient to guarantee the CCP is in control. Most monitoring procedures for CCPs will need to be done rapidly because they relate to online processes and there will not be time for lengthy analytical testing. Physical and chemical measurements are often preferred to microbiological testing because they may be done rapidly and can often indicate the microbiological control of the product.

All records and documents associated with monitoring CCPs must be signed by the person(s) doing the monitoring and by a responsible reviewing official(s) of the company.

10. Establish corrective actions

Specific corrective actions must be developed for each CCP in the HACCP system in order to deal with deviations when they occur.

The actions must ensure that the CCP has been brought under control. Actions taken must also include proper disposition of the affected product. Deviation and product disposition procedures must be documented in the HACCP record keeping.

The corrective actions consist of:

- ✓ Identifying and eliminating the cause of the deviation,

- ✓ Ensuring that the CCP is under control after the corrective action is taken,
- ✓ Ensuring that measures are established to prevent recurrence, and
- ✓ Ensuring that no product affected by the deviation is shipped.

11. Establish verification procedures

Establish procedures for verification. Verification and auditing methods, procedures and tests, including random sampling and analysis, can be used to determine if the HACCP system is working correctly. The frequency of verification should be sufficient to confirm that the HACCP system is working effectively.

Verification should be carried out by someone other than the person who is responsible for performing the monitoring and corrective actions. Where certain verification activities cannot be performed in house, verification should be performed on behalf of the business by external experts or qualified third parties.

Examples of verification activities include:

• Review of the HACCP system and plan and its records;
• Review of deviations and product dispositions;
• Confirmation that CCPs are kept under control.

Where possible, validation activities should include actions to confirm the efficacy of all elements of the HACCP system.

12. Establish Documentation and Record Keeping

Efficient and accurate record keeping is essential to the application of a HACCP system. HACCP procedures should be documented. Documentation and record keeping should be appropriate to the nature and size of the operation and sufficient to assist the business to verify that the HACCP controls are in place and being maintained. Expertly developed HACCP guidance materials (e.g. sector-specific HACCP guides) may be utilised as part of the documentation, provided that those materials reflect the specific food operations of the business.

Documentation examples are:

Hazard analysis;
CCP determination;
Critical limit determination.

Record examples are:

• CCP monitoring activities;
• Deviations and associated corrective actions;
• Verification procedures performed;
• Modifications to the HACCP plan;

An example of a HACCP worksheet for the development of a HACCP plan is attached as Diagram 3.

A simple record-keeping system can be effective and easily communicated to employees. It may be integrated into existing operations and may use existing paperwork, such as delivery invoices and checklists to record, for example, product temperatures.

Benefits of HACCP

Although the adoption of HACCP systems worldwide is due primarily to the added food safety protection provided to consumers, there are other benefits to the food industry that can be realized by implementing a successful HACCP system.

a. Formally incorporates food safety principles as integral steps of production processes

HACCP recognition status cannot be completed without a firm commitment by senior management to formally support food safety control measures throughout the production process. The implementation and maintenance of those control measures play a critical role in raising awareness of front line production management and staff of the presence and importance of specific food safety procedures within their process.

b. Increased employees' ownership of the production of safe food

As a sign of this commitment, it is the responsibility of senior management to foster the idea within the facility that food safety is the responsibility of everyone. Through the process of developing and implementing a HACCP system, employees become more aware of food safety and their role in contributing to food safety. This increased knowledge leads to ownership of and pride in the production of a safe food product.

c. Increased buyer and consumer confidence

Establishments that have implemented a HACCP system provide buyers and consumers with a greater degree of confidence that the facility is producing a safe food product. Establishments can demonstrate by showing documents and records that food safety is under control.

d. Maintaining or increasing market access

Market forces continue to drive HACCP implementation throughout the food industry. In many cases, buyer demands and foreign governments require HACCP implementation to maintain market share and/or gain access to previously inaccessible markets. As HACCP systems are accepted worldwide, FSEP helps the Canadian industry to maintain and expand its international markets.

e. Reduced waste

The preventative nature of HACCP allows a company to control costs by minimizing the amount of product requiring rejection or recall, and by focusing resources on areas that have been identified as critical in the manufacture of a safe food product. With the regular monitoring inherent in a HACCP system, establishments become aware of problems earlier and the costs of waste are reduced.

POSSIBLE QUESTIONS

UNIT-I

PART-A (20 MARKS)

(Q.NO 1 TO 20 Online Examination)

Two Marks

1. What are the types of detecting methods followed
2. Role of HACCP
3. What is FDA and Agmark
4. Criteria for marketing food

Eight Marks

1. Write the role of food control agencies in brief.
2. HACCP and FSSAI as food quality and sanitizers
3. Write in detail about culture and rapid detection methods of food borne pathogens

S.No.	Questions	OPTION 1	OPTION 2	OPTION 3	OPTION 4	ANSWER KEY
1	Most spoilage bacteria grow at	acidic pH	alkaline pH	neutral pH	any of the pH	neutral pH
2	The microbiological examination of coliform bacteria in foods preferably use	MacConkey broth	violet Red Bile agar	Mac conkey agar	nutrient broth	MacConkey broth
3	Which of the following acid will have higher bacteriostatic effect at a given pH?	Acetic acid	Tartaric acid	Citric acid	Maleic acid	Acetic acid
4	Water activity can act as	warm temperature	a processing factor	an extrinsic factor	both b and c	both b and c
5	The different ACC's between food categories reflect the	expected level of contamination of the raw material	potential for microbial growth during storage	potential shelf life	all of the above	all of the above
6	Yeast and mould count determination requires	nutrient agar	acidified potato glucose agar	MacConkey agar	violet Red Bile agar	acidified potato glucose agar
7	A psychrophilic halophile would be a microbe that prefers	cold temperatures and increased amounts of salt	warm temperatures and increased amounts of pressure	cold temperatures and the absence of oxygen	warm temperatures and increased amounts of acid	cold temperatures and increased amounts of salt
8	NaCl can act as	Antagonist at optimal concentrations	synergistically if added in excess of optimum level	Both (a) and (b)	None of the above	Both (a) and (b)
9	Which of the bacteria can grow in alkaline pH?	*Lactobacilli*	*Vibrio cholera*	*Salmonella*	*Staphylococcus*	*Vibrio cholera*
10	The water activity range	0.93-0.98	0.98and above	0.60-0.76	below 0.98	0.93-0.98

	of fresh meat and fresh fish was ________					
11	The O-R potential of a system is measured by	mV	mM	aw	Eh	mM
12	When microbes can use fat as an energy source _________.	absence of sugar molecule	presence of glucose	presence of fructose	Presence of high sugar	absence of sugar molecule
13	The approximate range of bacteria present in fresh vegetable is _________	10^9 -10^7/g	10^3 -10^9/g	10^3 -10^7/g	10^1 -10^7/g	10^3 -10^4/g
14	In fruit juices the growth of the fermentative yeast are favored by _______ pH	4.0-4.5	6.0-6.5	2.0-2.5	3.0-3.5	4.0-4.5
15	The water requirement of a microorganism is expressed in terms of ______	water action	water adsorption	water affinity	water activity	water activity
16	The microorganism which apparently have no mechanism to tolerate acidic pH _______	bacteria	fungi	viruses	both a and b	fungi
17	---------------------------- is the thermoduric bacteria	*Acenetobacteria*	*Morexella*	*Bacillus*	*Flavobacterium*	*Morexella*
18	To retard the contamination and other microbial growth in meat is obtained by storing at _________ temperature	10°C	0°C	100°C	-10°C	0°C

19	The percentage of relative humidity is obtained by multiplying by________.	aw*10	aw*1000	aw*100	aw*0.1	aw*100
20	Which of the following can cause food to be contaminated because of physical hazards from food handlers?	Jewellery	Dust	Rodent droppings	Incorrectly diluted chemicals	Jewellery
21	Which of the following can cause food to be contaminated because of chemical hazards from food handlers?	Hair	Dust	Live insects	Perfume	Perfume
22	Cross-contamination of food occurs when	Cleaning and sanitising equipment and benches	Keeping food stored in food-grade containers	Washing hands before handling food	Using food handling gloves for handling money	
23	Which of the following are allergens?	Sources of gluten and Red meat	Fruits and vegetables	Fish and fish products	None of the above	Sources of gluten and Red meat
24	The undesirable change in a food that makes it or human consumption is referred as __________	food decay	food spoilage	food loss	all of the above	food spoilage
25	______ microorganisms reqire positive Eh values or positive mV O-R potentials	Aerobic	anaerobic	facultative	none of these	Aerobic
26	_______ acid produced by the propionibacteria in swiss cheese is inhibitory to molds	sorbic	acetic	propionic	acetic	propionic

27	______ bacteria oxidize ethylalcohol to acetic acid	Aeromonas	Acetobacter	Alcaligens	Alteromonas	Acetobacter
28	The endospores of ______ do not swell the rods in which they are formed	Streptococcus	Brochotrix	Brevibacterium	Bacillus	Bacillus
29	_______ is associated with the market disease called bacterial soft rot	Erwinia	Enterobacter	Corynebacterium	Klebsiella	Erwinia
30	________ is the causative organism for a bacterial pneumonia in human.	Flavobacterium	Escherichia	Klebsiella	Gluconobacter	Klebsiella
31	________ bacteria grow and cause discoloration on foods high in salt	Halobacterium	Enterobacter	Erwinia	Corynebacterium	Halobacterium
32	Aeromonas grows at an optimum temperature of _________	27 to 37 °C	22 to 28 °C	35 to 37 °C	40 °C	22 to 28 °C
33	The culture of Brevibacterium produces ______ pigmentation and helps ripening	orange-red	yellow	black	red	orange - red
34	________ bacteria is found aseptically in drawn milk and cause bovine mastitis	Corynebacterium	Clostridium	Campylobacter	Enterobacter	Corynebacterium
35	Pectins are complex __________ that are responsible for cell wall rigidity in vegetables	Proteins	lipids	carbohydrates	vitamins	Carbohydrate

	and fruits					
36	________ bacteria are those which grow in high concentration of sugars	Halophilic	thermophilic	osmophilic	none of these	osmophilic
37	_______ bacteria are able to grow at commercial refrigeration temperatures	Pschrotropic	halophilics	auttrophic	heterotrophic	Pschrotropic
38	Truly halophilic bacteria require minimal concentration of dissolved ______ for growth	NaCl2	Hcl	NaNo2	Cacl2	Nacl2
39	______ causes ropiness in milk	Lactobacillus plantarum	Klebsiella pneumonia	Klebsiella oxytoca	Flavobacterium	Klebsiella oxytoca
40	______ are short rods that are defined as aerobic and facultative anaerobic	Enterobacter	Coliforms	Proteus	Clostridium	Coliforms
41	The use of indicator microorganisms began with use of E. coli testing in ______	soil	plants	water	all of these	water
42	Many infectious disease agents of animals can be transmitted to people through _____	water	food	soil	juices	food
43	The _____ of many meat animals may contain micrococci,	Hair	nail	skin	foot	skin

	Staphylococci, and beta-hemolytic Streptococci					
44	______ used to fertilize plant crops will be contaminated with human pathogens	sewage	distilled water	mineralized water	drinking water	sewage
45	________ contain the greatest variety of microorganisms of any source of contamination of food	plants	sewage	water	soil	soil
46	Contamination of foods from _______ may be important for sanitary as well as economic reasons	air	soil	water	sewage	air
47	______ does not contain a antural flora of microorganisms	soil	air	water	sewage	air
48	There are ___ aspects of water bacteriology that are interested by food microbiologist	2	5	6	4	2
49	The surface of a well washed tomato show _____ microorganisms per square centimeter	100-200	400-700	100-300	200-400	400-700
50	Pig and beef carcasses may be contaminated with _____	Salmonellae	Klebsiella	E. coli	Enterobacter	Salmonellae
51	Natural water contaminated with	meat	vegetables	fruits	seafoods	sea foods

	sewage contribute their microorganism to ____					
52	Chlorination of _____ water is practised when there is any doubt about the sanitory quality of the water	sewage	drinking	distilled water	surface water	drinking
53	Cannery cooling water often contain _____	Coliforms	Aeromonas	Klebsiella	Clostridium	Coliforms
54	Many microorganisms cannot use the disaccharide lactose and therefore do not grow well in _______	milk	water	food	sewage	milk
55	_____ yeast is grown with dairy starter cultures to maintain the activity and increase the longevity of the lactic acid bacteria	Candida sp.	Trichosporon	Rhodotorula	Torulopsis	Candida sp.
56	Saccharomyces are reclassified by Lodder in the year ____	1985	1978	1982	1984	1984
57	______ has been used as starter culture in fermented sausages	Photobacterium	Pediococcus	Propionibacterium	Proteus	Pediococcus
58	______ bacteria produce lipase enzyme that hydrolysis fat to fatty acids and glycerol	Saccharolytic	Pectinolytic	lipolytic	proteolytic	lipolytic

S.No.	Questions	OPTION 1	OPTION 2	OPTION 3	OPTION 4	ANSWER KEY
1	The time temperature combination for HTST paterurization of 71.1°C for 15 sec is selected on the basis of	*Coxiella Burnetii*	*E. coli*	*B. subtilis*	*C. botulinum*	*Coxiella Burnetii*
2	The percentage fat constituent of double toned milk is	0.5	1.5	3	4.5	1.5
3	Which solvent is commonly used to determine fat content	Ethyl alcohol	Hexane	Acetone	Benzene	Hexane
4	Pasteurization is done to kill	Selective microorganism	All the microorganism	Yeast	Yeast and its spores	Selective microorganism
5	Bacteria which is present in raw or undercooked meat, eggs, sea food and unpasteurized milk is	E.coli	salmonella	staphylococcus	cyano bacteria	salmonella
6	Milk and curry left over can be turned into sour and spoiled at	high temperature	very low temperature	room temperature	constant temperature	room temperature
7	Preservation affects the growth of microorganism by	inhibition	retardation	arresting	degradation	retardation
8	Souring of canned meat is caused by ______.	thermoduric cells	thermostatic cells	thermo liable cells	thermostable	thermoduric cells
9	Sugars act as preservatives due to their ability to	make water unavailable to organism’s	interfere with the action of proteolytic enzyme	osmotic effect	chemical changes	interfere with the action of proteolytic enzyme

10	The minimal pH for the growth of staphylococcus is about --------------------	2.5	4.8	2	3.5	4.8
11	The concentration of salt used in high protein containing vegetables is _____	4.3-10.3	17.5-20.0	18.6-26.5	19.2-22.2	18.6-26.5
12	Fruit juice is sterilized by _________.	filteration	freezing	cooling	heating	filteration
13	The reddish liquid comes out from meat on thawing process is called as	drying	wilting	bleeding	leakage	bleeding
14	-------------- is a storage method uses bins or boxes for equalization of moisture	sweating	springer	cooling	freezing	springer
15	-------------- is mostly used preservative to prevent mold growth	sodium propionate	springer	sorbates	acetate	sodium propionate
16	The spoilage organism bring about the spoilage of meat by	purification	oxidation	decomposition	hydrolysis	decomposition
17	Significant numbers of *S. aureus* in a food can be determined by examining the food	RNase	thermostable nuclease	protease	thermostable DNase	protease
18	To retard the contamination and other microbial growth in meat is obtained by storing at _________	10°C	0°C	100°C	-10°C	0°C

	temperature					
19	-------------- is a storage method uses bins or boxes for equalization of moist	Sweating	Springer	Cooling	Freezing	Springer
20	To retard the contamination and other microbial growth in meat is obtained by storing at _________ temperature	10 °C	0°C	100°C	-10°C	0°C
21	Increase in the concentration of dissolved substances like sugar and salt helps in _______ of the food material	drying	freezing	moistening	thawing	drying
22	Sulfur stinker spoilage of canned food is caused by	*E.coli*	*D. nigrificans*	*Bacillus*	*Clostridium*	*D. nigrificans*
23	The minimum growth temperature of Bifidobacteria range from	43 to 45	25 to 28	29 to 32	30 to 35	43 to 45
24	Food should be cooked to which temperature?	5°C	75°C	100°C	60°C	75°C
25	Sanitising is_______	Applying detergent to a clean surface	Done before washing	Reducing bacteria by application of heat or chemical	Wiping all surfaces with a clean cloth	Reducing bacteria by application of heat or chemical
26	Food preservation involves_______	increasing shelf life of food	ensuring safety for human consumption	both a and b	boiling	both a and b

27	Pasteurization is a _________	low temperature treatment	steaming treatment	high temperature treatment	low and high temperature treatment	high temperature treatment
28	Which of the following statements are true about chemical preservatives _________	microbicidal or microstatic	chemical preservatives often hazardous to humans	sodium benzoate is a widely used preservative	all these	All of these
29	The sclerotia from a species of Penicillium can survive a heat treatment of ____	70 °C	90 to100 °C	50-60 °C	37 °C	90 to100 °C
30	During _____ the internal temperature of bread, cake or other bakery products approaches but never reaches 100 °C	Heating	boiling	baking	all of these	baking
31	______ in 1765 preserved food by heating it in a sealed containers	Spallanzani	Ruiz-Argueso	Rodrigeuz-Navarro	Christophersen	spallanzani
32	Combination of ______ irradiation with chilling storage helps preserve foods	Ultraviolet	infra red	gamma	none of the above	ultraviolet
33	______ freezing usually refer to freezing in air with only natural air circulation	Sharp	slow	quick	speed	sharp
34	Christophersen classified microroganisms on the basis of sensitivity to freezing in the	1984	1989	1973	1981	1973

	year______					
35	_____ temperature are more lethal	high freezing	frozen storage	freezing rate	thawing	high freezing
36	The simplest dryer is the _____	sun	air	heat	evaporator	evaporator
37	The sodium salt of ______ acid has been used extensively as an antimicrobial agent in foods	propionic	benzoic	sorbic	acetic	benzoic
38	______ is used most extensively in the prevention of mold growth and rope development in baked goods	calcium propionate	calcium sorbate	monocholroacetic acid	nitrates	calcium propionate
39	_____organic acid is used in syrups, drinks, jam and jellies	lactic	acetic	propionic	citric	citric
40	______ is used as treatment for wrappers used on butter	sodium diacetate	calcium carbonate	sodium nitrate	potassium nitrite	sodium diacetate
41	_____ alcohol is used as coagulant and enaturizer of cell proteins	methanol	ethanol	butanol	none of these	ethanol
42	The fumes of burning ____ are used to treat light colored dehydrated fruits	sulfur	ethylene	potassium	sodium	sulfur
43	______ solvent is poisonous and should not be added to foods	propylene	ethanol	methanol	glycerol	methanol
44	______ can be used to control bacterial and fungal growth in	paraformaldehyde	benzaldehyde	formaldehyde	all of these	paraformaldehyde

	tapholes of maple tree					
45	_____ contains a large number of olatile compounds that may have bacteriostatic and bactericidal effect	spices	woodsmoke	formaldehyde	alcohol	woodsmoke
46	_____ acid is used in soft drinks such as colas	phosphoric	benzoic	acetic	sorbic	phosphoric
47	_____ drying is limited to climates with a hot sun and dry atmosphere to fruits	mechanical	solar	freeze	chemical	solar
48	_____ rays are streams of electrons emitted from radioactive materials	beta	cathode	gamma	X-rays	beta
49	Gazing at ultraviolet lamps produces irritation of the ____ within few seconds	eye	ear	nose	throat	Eye
50	Radiation dose in kilograys of ____ inhibits sprouting in potatoes, onions and garlic	0.05-0.15	0.01-0.14	0.05-0.07	0.05-0.11	0.05-0.15
51	_____ can be dried by a process called explosive puffing	meat	vegetables	fruits	juices	vegetables
52	Jones and Loackhead found enterotoxin forming Staphylococci in _____food	frozen corn	cheese	bread	jam	frozen corn

53	______ is a term used to label foods treated with low level ionizing radiation	Radicidation	radurization	picowaved	radappertization	Picowaved
54	97 to 99 % of E.coli in air were killed in _____ seconds with a 15 watts lamp	40	10	50	30	10
55	Flavoring etracts such as vanilla and lemon etracts are preserved by their content of _____	sugar	salt	alcohol	ethylene	alcohol
56	_______ from retail market contain from 0 to2 million bacteria per piece	caramels	jellies	fudges	candies	candies
57	About _____ percent of the suspected samples contained viable spores	20	10	30	50	10

S.No.	Questions	OPTION 1	OPTION 2	OPTION 3	OPTION 4	ANSWER KEY
1	Which of the following toxin causing botulism is less toxic to human beings?	Type A	Type B	Type C	Type D	Type B
2	Which of the following is a food infection?	Salmonellois	Botulism	Staphylococcal intoxication	Tetanus	Salmonellois
3	The staphylococcal intoxication refers to presence of	an enterotoxin	neurotoxin	mycotoxin	exotoxin	an enterotoxin
4	A bacterial food intoxication refers to	illness caused by presence of pathogens	food borne illness caused by the presence of a bacterial toxin formed in food	both (a) and (b)	food poisoning	food borne illness caused by the presence of a bacterial toxin formed in food
5	The method of successful treatment of botulism prior to appearance of botulism symptoms involve administration of	antibiotic	analgesic	antitoxin	antipyretic	antitoxin
6	Botulism is caused by the presence of toxin developed by	*Clostridium tyrobutyricum*	*Clostridium sporogenes*	*Clostridium botulinum*	*Bacillus*	*Clostridium botulinum*
7	Salmonellois is caused by the	enterotoxin of *Salmonella* spp	endotoxin of *Salmonella* spp	neurotoxin of *Salmonella* spp	exoenterotoxin of *Salmonella* spp	endotoxin of *Salmonella* spp
8	Group I *C. botulinum* strains generally includes in	all types of strains (proteolytic)A, B and F	all types of strains (non-proteolytic) E and F	all types of strains (proteolytic)C, D and F	none of the above	all types of strains (proteolytic)A, B and F
9	The application of Gamma rays destroys botulism toxin. The dose of gamma rays required for this purpose is	73 Gy	73 Rad	7.3 Mrad	173 Rad	7.3 Mrad
10	The *Bacillus* cereus causes gasteroenteritis by the production	cell growth	cell autolysis	cell permeation	cell damage	cell autolysis

	of an exoenterotoxin which is released in food as a result of					
11	Staphylococcal intoxication is caused by the toxin in the food from	*Staphylococcus aureus*	*S. cerevisiae*	*S. thermophillus*	none of these	*Staphylococcus aureus*
12	What is the main type of micro-organism responsible for food poisoning?	Bacteria	Mould	Virus	Parasite	Bacteria
13	Common food poisoning microbes are_______	Clostridium and Salmonella	Clostridium and E. coli	E. coli and Salmonella	Clostridium and Streptococcus	Clostridium and Salmonella
14	Botulism prevention involves________	Proper heat sterilization before food canning	addition of chemical preservatives	Proper low temperature treatment before food canning	freezing	Proper heat sterilization before food canning
15	Clostridium perfingens poisoning is associated with_________	meat products	vegetables	canned foods	fish products	meat products
16	Clostridium perfingens poison is an __________	exotoxin	enterotoxin produced during sporulation	endotoxin	enterotoxin produced during vegetative phase	enterotoxin produced during sporulation
17	Which of the following statements are true regarding Staphylococcus food poisoning__________	is an enterotoxin	causes gastroenteritis	is produced by Clostridium botulinum	Both a and b	Both a and b
18	Salmonellois involves _______	an enterotoxin and exotoxin	an enterotoxin and cytotoxin	is produced by Staphylococcus aureus	endotoxin	an enterotoxin and cytotoxin
19	The major carrier of Salmonellosis are ____________	meat and eggs	meat and fish	eggs and fish	eggs and fruits	meat and egs
20	Aflatoxin is produced by ______________	Aspergillus sp.	Salmonella sp.	Fusarium sp.	Streptococcal sp.	Aspergillus sp.
21	Botulism is caused by ________	Clostridium botulism	All Clostridium species	Clostridium tetanai	Clostridium subtilis	Clostridium botulinum

22	Which of the following statements are regarding botulinal toxin ___________	is a neurotoxin	water soluble exotoxin	is produced by Clostridium botulinum	caused by Staphylococcus	is produced by Clostridium botulinum
23	Human beings and animals are directly or indirectly the source of the contamination of food with _____	Salmonella	Staphylococcus	Bacillus	E. coli	Salmonella
24	The disease gastroenterities caused by C. perfringens was first reported in the year___-	1952	1961	1978	1945	1945
25	The incubation period of Vibrio parahaemolyticus infection is ______	2-48 hrs	5-24 hrs	40 hrs	37 hrs	2-48 hrs
26	The etiologic agent of diarrheal syndrome is ____	Shigellosis	Yersiniosis	Bacillus cereus	Vibrio	Bacillus cereus
27	The sore and throat symptom caused by ______ etiologic agent	Streptococcus pyogenes	Staphylococcus aureus	Bacillus anthrax	E.coli	Streptococcus pyogenes
28	The control measure of foods that cause disease by Vibrio parahaemolyticus infection is to ______	reheat left over	sanitize equipment	control files	pastuerization	sanitize equipment
29	The symptoms such as nausea and dehydration is caused by _____	Shigella sonnei	Yersinia	Arizona	E.coli	Shigella sonnei
30	Entheropathogenic Escherischia coli infection is involved in ____ foods	vegetables	apple cider	ice creams	cheese	cheese
31	The etiological agent of Arizona infection is ____	Vibrio	E. coli	Arizona	Streptococcus	Arizona
32	The optimal temperature for growth of Shigellosis is _____	27 °C	37 °C	40 °C	50 **°C**	37 °C

33	Yersinia enterocolitica is a small _____ shaped bacteria	cocci	chain	rod	bacilli	rod
34	Nursery epidemics diarrheal disease in infants was implicated in the year _____	1950	1940	1962	1980	1940
35	The term heat tolerant is a misnomer and refers to growth at ___ temperature	37 °C	40 °C	42 °C	25 °C	42 °C
36	_____ is associated with warm blooded animals	C. jejuni	C. botulinum	C. perferigens	E. coli	C. jejuni
37	Miller and Kolurger examined forty environmental isolates of P. shigelloides in the year _____	1987	1982	1980	1986	1986
38	Aeroonas hydrophillia is a gram negative motile rods which are ubiquitous in ____	air	soil	water	land	water
39	The toxin patulin is produced by ______fungi	Penicillium expansum	Fusarium	Aspergillus flavus	Mucor	Penicillium expansum
40	The mold Penicillium islandicum produces _____ toxin	Luteoskyrin	aflatoxin	penicillic acid	roquefortine	Luteoskyrin
41	In the early _____ numerous surveys have been conducted on the detection aflatoxins in foods	1980s	1940s	1950s	1960s	1960s
42	The _____ virus enters a person through oral route in the fecal contamination of food	Poliomyelitis	Hepatitis	Adeno	Herpes	Hepatitis
43	The mode of transmission of poliomyelitis is _______	food	air	contaminated water	all of these	contaminated water
44	The pH near ____ favors C. botulinum	neutrality	alkalinity	acidic	both b and c	neutrality

45	The growth of Staphylococcus aureus on solid media is usually ____ in color	red	brown	pink	yellow	yellow
46	The term ___ is used to distinguish strains of different antigenetic complements	biovars	serovar	herbivore	none of these	serovar
47	Depending on the food and the serotype the _____ values from 0.06 to 11.3 min	D50 C	D40 c	D60 c	D30 c	D60 c
48	______ organism can be isolated from seafoods and sea water	Vibrio cholerae	Vibrio vulnificus	Vibrio parahaemolyticus	All of these	Vibrio vulnificus
49	Pathogenecity involves the release of a ______ endotoxin which affects the intestinal mucosa	lipopolysaccharides	monosaccharides	polysaccharides	peptidoglycon	lipopolysaccharides
50	The incubation period of Streptococcus faecalis is _____	5 to 10	2 to 10	2 to 18	8 to 12	2 to 18
51	The optimal pH for enteropathogenic E. coli is _______	4.0 to 5.0	7.0 to 7.5	3.0 to 4.0	8.0 to 9.0	7.0 to 7.5
52	A_____ refers to food borne illnesses caused by the entrance of bacteria into the body through ingestion of comtaminated food	Food infection	food poisoning	food intoxication	contamination	food infection
53	Typhoid fever is caused by ________	Salmonell enteritidis	Salmonella infantis	Salmonella typhi	Salmonella typhimurium	Salmonella typhi
54	______ agencies aprove the Good house keeping institute	Commercial	State	Federal	Private	Private
55	The FDA and USDA cooperative is a _____ surveillance program	Pseudomonas	E. coli	Salmonella	Vibrio	Salmonella

	for dry milk products					
56	The food and Drug Administration act was amende in the year ____	1983	1980	1989	1988	1980
57	_____ involves the identification of ingredients and products that have effect on food safety	Hazard analysis	critical control points	fishery service	research and development service	Hazard analysis

S.No.	Questions	OPTION 1	OPTION 2	OPTION 3	OPTION 4	ANSWER KEY
1	The concentration of salt used in high protein containing vegetables is _____	4.3-10.3	17.5-20.0	18.6-26.5	19.2-22.2	18.6-26.5
2	_____ is a term used to label foods treated with low level ionizing radiation	Radicidation	radurization	picowaved	radappertization	Picowaved
3	Flavoring etracts such as vanilla and lemon etracts are preserved by their content of ____	sugar	salt	alcohol	ethylene	alcohol
4	Which of the following statements are true about chemical preservatives _________	microbicidal or microstatic	chemical preservatives often hazardous to humans	sodium benzoate is a widely used preservative	all these	All of these
5	The time temperature combination for HTST paterurization of 71.1°C for 15 sec is selected on the basis of	*Coxiella Burnetii*	*E. coli*	*B. subtilis*	*C. botulinum*	*Coxiella Burnetii*
6	_____ contains a large number of olatile compounds that may have bacteriostatic and bactericidal effect	spices	woodsmoke	formaldehyde	alcohol	woodsmoke
7	______ has been used as starter culture in fermented sausages	sweating	springer	cooling	freezing	springer
8	______ is used most extensively in the prevention of mold growth and rope	calcium propionate	calcium sorbate	monocholroacetic acid	nitrates	calcium propionate

	development in baked goods					
9	_____ can be dried by a process called explosive puffing	meat	vegetables	fruits	juices	vegetables
10	______ in 1765 preserved food by heating it in a sealed containers	Spallanzani	Ruiz-Argueso	Rodrigeuz-Navarro	Christophersen	spallanzani
11	Combination of ______ irradiation with chilling storage helps preserve foods	Ultraviolet	infra red	gamma	none of the above	ultraviolet
12	Which solvent is commonly used to determine fat content	Ethyl alcohol	Hexane	Acetone	Benzene	Hexane
13	During _____ the internal temperature of bread, cake or other bakery products approaches but neve reaches 100 °C	Heating	boiling	baking	all of these	baking
14	Pasteurization is done to kill	Selective microorganism	All the microorganism	Yeast	Yeast and its spores	Selective microorganism
15	Sanitising is_______	Applying detergent to a clean surface	Done before washing	Reducing bacteria by application of heat or chemical	Wiping all surfaces with a clean cloth	Reducing bacteria by application of heat or chemical
16	The simplest dryer is the _____	sun	air	heat	evaporator	evaporator
17	Bacteria which is present in raw or undercooked meat, eggs, sea food and unpasteurized milk is	*E.coli*	*Salmonella*	*Staphylococcus*	cyano bacteria	*salmonella*
18	Milk and curry left over can be turned into sour and spoiled at	high temperature	very low temperature	room temperature	constant temperature	room temperature
19	_____ rays are streams of	beta	cathode	gamma	X-rays	beta

	electrons emitted from radioactive materials					
20	Increase in the concentration of dissolved substances like sugar and salt helps in _______ of the food material	drying	freezing	moistening	thawing	drying
21	Sulfur stinker spoilage of canned food is caused by	*E.coli*	*D. nigrificans*	*Bacillus*	*Clostridium*	*D. nigrificans*
22	Radiation dose in kilograys of ____ inhibits sprouting in potatoes, onions and garlic	0.05-0.15	0.01-0.14	0.05-0.07	0.05-0.11	0.05-0.15
23	Preservation affects the growth of microorganism by	inhibition	retardation	arresting	all the above	retardation
24	Souring of canned meat is caused by ______.	thermoduric cells	thermostatic cells	thermo liable cells	none of the above	thermoduric cells
25	Significant numbers of S. aureus in a food can be determined by examining the food	RNase	thermostable nuclease	protease	thermostable DNase	protease
26	To retard the contamination and other microbial growth in meat is obtained by storing at _________ temperature	10°C	0°C	100°C	-10°C	0°C
27	Gazing at ultraviolet lamps produces irritation of the ____ within few seconds	eye	ear	nose	throat	eye
28	Sugars act as preservatives due to their ability to	make water unavailable to	interfere with the action of	osmotic effect	both a and c	interfere with the action of

		organism's	proteolytic enzyme			proteolytic enzyme
29	The minimal pH for the growth of staphylococcus is about --------------------	2.5	4.8	2	3.5	4.8
30	_____ alcohol is used as coagulant and enaturizer of cell proteins	methanol	ethanol	butanol	none of these	ethanol
31	The fumes of burning ____ are used to treat light colored dehydrated fruits	sulfur	ethylene	potassium	sodium	sulfur
32	______ can be used to control bacterial and fungal growth in tapholes of maple tree	paraformaldehyde	benzaldehyde	formaldehyde	all of these	paraformaldehyde
33	Christophersen classified microroganisms on the basis of sensitivity to freezing in the year_____	1984	1989	1973	1981	1973
34	The percentage fat constituent of double toned milk is	0.5	1.5	3	4.5	1.5
35	------------- is mostly used preservative to prevent mold growth	sodium propionate	springer	sorbates	acetate	sodium propionate
36	______ solvent is poisonous and should not be added to foods	propylene	ethanol	methanol	glycerol	methanol
37	_____ drying is limited to climates with a hot sun and dry	mechanical	solar	freeze	all of these	solar

	atmosphere to fruits					
38	Food should be cooked to which temperature?	5°C	75°C	100°C	60°C	75°C
39	The sclerotia from a species of Penicillium can survive a heat treatment of ____	70 °C	90 to100 °C	50-60 °C	37 °C	90 to100 °C
40	The sodium salt of ______ acid has been used extensively as an antimicrobial agent in foods	propionic	benzoic	sorbic	acetic	benzoic
41	Fruit juice is sterilized by _________.	filteration	freezing	cooling	heating	filteration
42	Pasteurization is a _________	low temperature treatment	steaming treatment	high temperature treatment	low and high temperature treatment	high temperature treatment
43	The reddish liquid comes out from meat on thawing process is called as	drying	wilting	bleeding	leakage	bleeding
44	The spoilage organism bring about the spoilage of meat by	purification	oxidation	decomposition	hydrolysis	decomposition
45	The minimum growth temperature of Bifidobacteria range from	43 to 45	25 to 28	29 to 32	30 to 35	43 to 45
46	_____ acid is used in soft drinks such as colas	phosphoric	benzoic	acetic	sorbic	phosphoric
47	______ freezing usually refer to freezing in air with only natural air circulation	Sharp	slow	quick	all of these	sharp

48	Jones and Loackhead found enterotoxin forming Staphylococci in _____food	frozen corn	cheese	bread	jam	frozen corn
49	______ from retail market contain from 0 to2 million bacteria per piece	caramels	jellies	fudges	candies	candies
50	-------------- is a storage method uses bins or boxes for equalization of moist	Sweating	Springer	Cooling	Freezing	Springer
51	To retard the contamination and other microbial growth in meat is obtained by storing at _________ temperature	10 °C	0°C	100°C	-10°C	0°C
52	_____organic acid is used in syrups, drinks, jam and jellies	lactic	acetic	propionic	citric	citric
53	Food preservation involves_______	increasing shelf life of food	ensuring safety for human consumption	both a and b	none of these	both a and b
54	97 to 99 % of *E.coli* in air were killed in ____ seconds with a 15 watts lamp	40	10	50	30	10
55	______ is used as treatment for wrappers use don butter	sodium diacetate	calcium carbonate	sodium nitrate	potassium nitrite	sodium diacetate
56	_____ temperature are more lethal	high freezing	frozen storage	freezing rate	thawing	high freezing
57	About ____ percent of the suspected samples contained viable spores	20	10	30	50	10

58	Sugars act as preservatives due to their ability to	make water unavailable to organism’s	interfere with the action of proteolytic enzyme	osmotic effect	both a and c	interfere with the action of proteolytic enzyme
59	_____organic acid is used in syrups, drinks, jam and jellies	lactic	acetic	propionic	citric	citric
60	Sanitising is_______	Applying detergent to a clean surface	Done before washing	Reducing bacteria by application of heat or chemical	Wiping all surfaces with a clean cloth	Reducing bacteria by application of heat or chemical
61	______ is used most extensively in the prevention of mold growth and rope development in baked goods	calcium propionate	calcium sorbate	monocholroacetic acid	nitrates	calcium propionate

S.No.	Questions	OPTION 1	OPTION 2	OPTION 3	OPTION 4	ANSWER KEY
1	Which of the following toxin causing botulism is less toxic to human beings?	Type A	Type B	Type C	None of these	Type B
2	Which of the following statements are true regarding *Staphylococcus* food poisoning__________	is an enterotoxin	causes gastroenteritis	is produced by Staphylococcus aureus	All of these	All of these
3	Aflatoxin is produced by _____________	*Aspergillus sp.*	*Salmonella sp.*	*Fusarium sp.*	*Streptococcal sp.*	*Aspergillus sp.*
4	Which of the following statements are regarding botulinal toxin __________	is a neurotoxin	water soluble exotoxin	is produced by Clostridium botulinum	All of these	is produced by Clostridium botulinum
5	The sore and throat symptom caused by ______ etiologic agent	*Streptococcus pyogenes*	*Staphylococcus aureus*	*Bacillus anthrax*	*E.coli*	*Streptococcus pyogenes*
6	Botulism is caused by the presence of toxin developed by	*Clostridium tyrobutyricum*	*Clostridium sporogenes*	*Clostridium botulinum*	*none of these*	*Clostridium botulinum*
7	The control measure of foods that cause disease by *Vibrio parahaemolyticus* infection is to ______	reheat left over	sanitize equipment	control files	pastuerization	sanitize equipment
8	Salmonellois involves _______	an enterotoxin and exotoxin	an enterotoxin and cytotoxin	is produced by Staphylococcus aureus	All of these	an enterotoxin and cytotoxin
9	The term heat tolerant is a misnomer and refers to growth at ___ temperature	37 °C	40 °C	42 °C	25 °C	42 °C

10	The mold Penicillium islandicum produces _____ toxin	Luteoskyrin	aflatoxin	penicillic acid	roquefortine	Luteoskyrin
11	The major carrier of Salmonellosis are ____________	meat and eggs	meat and fish	eggs and fish	eggs and fruits	meat and egs
12	Yersinia enterocolitica is a small _____ shaped bacteria	cocci	chain	rod	bacilli	rod
13	The staphylococcal intoxication refers to presence of	an enterotoxin	neurotoxin	mycotoxin	All of these	an enterotoxin
14	The FDA and USDA cooperative is a _____ surveillance program for dry milk products	*Pseudomonas*	*E. coli*	*Salmonella*	*Vibrio*	*Salmonella*
15	The application of Gamma rays destroys botulism toxin. The dose of gamma rays required for this purpose is	73 Gy	73 Rad	7.3 Mrad	173 Rad	7.3 Mrad
16	The Bacillus cereus causes gasteroenteritis by the production of an exoenterotoxin which is released in food as a result of	cell growth	cell autolysis	cell permeation	cell damage	cell autolysis
17	Nursery epidemics diarrheal disease in infants was implicated in the year _____	1950	1940	1962	1980	1940
18	Botulism is caused by ________	*Clostridium botulism*	*All Clostridium species*	*Clostridium tetanai*	*Clostridium subtilis*	*Clostridium botulinum*
19	The toxin patulin is produced	*Penicillium*	*Fusarium*	*Aspergillus flavus*	*Mucor*	*Penicillium*

	by ______fungi	*expansum*				*expansum*
20	Miller and Kolurger examined forty environmental isolates of P. shigelloides in the year _____	1987	1982	1980	1986	1986
21	Which of the following is a food infection?	Salmonellois	Botulism	Staphylococcal intoxication	None of these	Salmonellois
22	The symptoms such as nausea and dehydration is caused by _____	*Shigella sonnei*	*Yersinia*	*Arizona*	*E.coli*	*Shigella sonnei*
23	Staphylococcal intoxication is caused by the toxin in the food from	*Staphylococcus aureus*	*S. cerevisiae*	*S. thermophillus*	none of these	*Staphylococcus aureus*
24	The etiologic agent of diarrheal syndrome is ____	*Shigellosis*	*Yersiniosis*	*Bacillus cereus*	*Vibrio*	*Bacillus cereus*
25	_____ involves the identification of ingredients and products that have effect on food safety	Hazard analysis	critical control points	fishery service	research and development service	Hazard analysis
26	The term ___ is used to distinguish strains of different antigenetic complements	biovars	serovar	herbivore	none of these	serovar
27	A bacterial food intoxication refers to	illness caused by presence of pathogens	food borne illness caused by the presence of a bacterial toxin formed in food	both (a) and (b)	none of the above	food borne illness caused by the presence of a bacterial toxin formed in food
28	Salmonellois is caused by the	enterotoxin	endotoxin	neurotoxin	exoenterotoxin	endotoxin

		of Salmonella spp	of Salmonella spp	of Salmonella spp	of Salmonella spp	of Salmonella spp
29	Group I *C. botulinum* strains generally includes in	all types of strains (proteolytic)A, B and F	all types of strains (non-proteolytic) E and F	all types of strains (proteolytic)C, D and F	none of the above	all types of strains (proteolytic)A, B and F
30	A_____ refers to food borne illnesses caused by the entrance of bacteria into the body through ingestion of comtaminated food	Food infection	food poisoning	food intoxication	all of these	food infection
31	______ organism can be isolated from seafoods and sea water	*Vibrio cholerae*	*Vibrio vulnificus*	*Vibrio parahaemolyticus*	All of these	*Vibrio vulnificus*
32	Botulism prevention involves________	Proper heat sterilization before food canning	addition of chemical preservatives	Proper low temperature treatment before food canning	All of these	Proper heat sterilization before food canning
33	Entheropathogenic Escherischia coli infection is involved in ____ foods	vegetables	apple cider	ice creams	cheese	cheese
34	The etiological agent of Arizona infection is ____	*Vibrio*	*E. coli*	*Arizona*	*Streptococcus*	*Arizona*
35	Aeroonas hydrophillia is a gram negative motile rods which are ubiquitous in ____	air	soil	water	land	water
36	The term ___ is used to distinguish strains of different antigenetic complements	biovars	serovar	herbivore	none of these	serovar

37	The method of successful treatment of botulism prior to appearance of botulism symptoms involve administration of	antibiotic	analgesic	antitoxin	antipyretic	antitoxin
38	______ organism can be isolated from seafoods and sea water	*Vibrio cholerae*	*Vibrio vulnificus*	*Vibrio parahaemolyticus*	All of these	*Vibrio vulnificus*
39	The optimal temperature for growth of Shigellosis is _____	27 °C	37 °C	40 °C	50 °C	37 °C
40	The FDA and USDA cooperative is a _____ surveillance program for dry milk products	*Pseudomonas*	*E. coli*	*Salmonella*	*Vibrio*	*Salmonella*
41	_____ is associated with warm blooded animals	*C. jejuni*	*C. botulinum*	*C. perferigens*	*E. coli*	*C. jejuni*
42	Human beings and animals are directly or indirectly the source of the contamination of food with _____	*Salmonella*	*Staphylococcus*	*Bacillus*	*E. coli*	*Salmonella*
43	The food and Drug Administration act was amende in the year ____	1983	1980	1989	1988	1980
44	The _____ virus enters a person through oral route in the fecal contamination of food	Poliomyelitis	Hepatitis	Adeno	Herpes	Hepatitis
45	The mode of transmission of poliomyelitis is _______	food	air	contaminated water	all of these	contaminated water

46	Clostridium perfingens poisoning is associated with_________	meat products	vegetables	canned foods	fish products	meat products
47	Clostridium perfingens poison is an __________	exotoxin	enterotoxin produced during sporulation	endotoxin	enterotoxin produced during vegetative phase	enterotoxin produced during sporulation
48	The pH near ____ favors *C. botulinum*	neutrality	alkalinity	acidic	both b and c	neutrality
49	In the early _____ numerous surveys have been conducted on the detection aflatoxins in foods	1980s	1940s	1950s	1960s	1960s
50	The optimal pH for enteropathogenic E. coli is _______	4.0 to 5.0	7.0 to 7.5	3.0 to 4.0	8.0 to 9.0	7.0 to 7.5
51	The disease gastroenterities caused by C. perfringens was first reported in the year___-	1952	1961	1978	1945	1945
52	Depending on the food and the serotype the _____ values from 0.06 to 11.3 min	D50 C	D40 c	D60 c	D30 c	D60 c
53	Pathogenecity involves the release of a ______ endotoxin which affects the intestinal mucosa	lipopolysaccharides	monosaccharides	polysaccharides	peptidoglycon	lipopolysaccharides
54	Common food poisoning microbes are_______	*Clostridium and Salmonella*	*Clostridium and E. coli*	*E. coli and Salmonella*	*Clostridium and Streptococcus*	*Clostridium and Salmonella*

55	Typhoid fever is caused by ________	*Salmonell enteritidis*	*Salmonella infantis*	*Salmonella typhi*	*Salmonella typhimurium*	*Salmonella typhi*
56	The incubation period of Vibrio parahaemolyticus infection is ______	2-48 hrs	5-24 hrs	40 hrs	37 hrs	2-48 hrs
57	The incubation period of Streptococcus faecalis is _____	5 to 10	2 to 10	2 to 18	8 to 12	2 to 18
58	The growth of Staphylococcus aureus on solid media is usually ____ in color	red	brown	pink	yellow	yellow
59	A_____ refers to food borne illnesses caused by the entrance of bacteria into the body through ingestion of comtaminated food	Food infection	food poisoning	food intoxication	all of these	food infection
60	What is the main type of micro-organism responsible for food poisoning?	Bacteria	Mould	Virus	Parasite	Bacteria
61	______ agencies aprove the Good house keeping institute	Commercial	State	Federal	Private	Private

Reg. No. : --------------------

[17MBU302]

KARPAGAM ACADEMY OF HIGHER EDUCATION
(Under Section 3 of UGC Act 1956)
COIMBATORE – 641 021
FIRST INTERNAL ASSESSMENT, JULY- 2018
THIRD SEMESTER
MICROBIOLOGY
FOOD AND DAIRY MICROBIOLOGY

Time: 2 hours **Maximum: 50 marks**
Date: /07/2018 [N] **Class: II B.Sc. MB**

PART A – (20 x 1 = 20 marks)
Answer all the questions

1. The microbiological examination of coliform bacteria in foods preferably use
a) Macconkey broth b) violet Red Bile agar c) nutrient broth d) nutrient agar
2. Water activity can act as
a) Warm temperature b) a processing factor c) an extrinsic factor d) pH
3. Yeast and mould count determination requires
a) nutrient agar b) acidified potato glucose agar c) Macconkey agar d) violet Red Bile agar
4. Which of the bacteria can grow in alkaline pH?
a) *Lactobacilli* b) *Vibrio cholera* c) *Salmonella* d) *Staphylococcus*
5. The water activity range of fresh meat and fresh fish was
a) 0.93-0.98 b) 0.98 and above c) 0.60-0.76 d) below 0.98
6. The O-R potential of a system is measured by
a) mV b) mM c) aw d) Eh
7. When microbes can use fat as an energy source _________.
a)absence of sugar molecule b) presence of glucose c) presence of fructose d) Presence of high sugar
8. The water requirement of a microorganism is expressed in terms of ______.
a) water action b) water adsorption c) water affinity d) water activity
9. The microorganism which apparently have no mechanism to tolerate acidic pH _______.
a) bacteria b) fungi c) viruses d) parasite
10. _______ bacteria are able to grow at commercial refrigeration temperatures.
a) Pschrotropic b) halophilics c) autrophic d) heterotrophic
11. ______ causes ropiness in milk
a) *Lactobacillus plantarum* b) *Klebsiella pneumonia* c) *Klebsiella oxytoca* d) *Flavobacterium*
12. Many infectious disease agents of animals can be transmitted to people through _____
a) water b) food c) soil d) juices
13. ______ has been used as starter culture in fermented sausages.
a) Photobacterium b) Pediococcus c) Propionibacterium d) Proteus

14. ______ bacteria produce lipase enzyme that hydrolysis fat to fatty acids and glycerol

a) Saccharolytic b) Pectinolytic c) lipolytic d) proteolytic

15. ________ bacteria is found aseptically in drawn milk and cause bovine mastitis

a) *Corynebacterium* b) *Clostridium* c) *Campylobacter* d) *Enterobacter*

16. Pasteurization is a _________

a) low temperature treatment b) steaming treatment

c) high temperature treatment d) low and high temperature treatment

17. The minimal pH for the growth of staphylococcus is about ----

a) 2.5 b) 4.8 c) 2 d) 3

18. The spoilage organism bring about the spoilage of meat by

a) purification b) oxidation c) decomposition d) hydrolysis

19. Sulfur stinker spoilage of canned food is caused by

a) *E.coli* b) *D. nigrificans* c) *Bacillus* d) *Clostridium*

20. Fruit juice is sterilized by _________.

a) filteration b) freezing c) cooling d) heating

PART B – (03 x 02 = 06 marks)

Answer all Questions

21. What are intrinsic factors
22. Types of spoilage in fruits
23. Define preservation

PART C – (03 x 08 = 24 marks)

Answer all questions choosing either a (or) b. (All questions carry equal marks)

24. Explain briefly about the sources of contamination of food **(OR)**

List out and explain the genera of bacteria important in food

25. Write short notes on the methods and principles of food preservation. **(OR)**

Explain about canning and drying methods of preservation.

26. Comment on the importance of extrinsic factors which affects the food. **(OR)**

Write short notes on high temperature of food preservation.

Reg. No. : ---------------------

[17MBU302]

KARPAGAM ACADEMY OF HIGHER EDUCATION
(Under Section 3 of UGC Act 1956)
COIMBATORE – 641 021
SECOND INTERNAL ASSESSMENT, AUGUST- 2018
THIRD SEMESTER
MICROBIOLOGY
FOOD AND DAIRY MICROBIOLOGY

Time: 2 hours **Maximum: 50 marks**
Date: 14/08/2018 [AN] **Class: II B.Sc. MB**

PART A – (20 x 1 = 20 marks)
Answer all the questions

1._____ rays are streams of electrons emitted from radioactive materials
a) beta b) cathode c) gamma d) X-rays

2. Pasteurization is a _________
a) low temperature treatment b) steaming treatment
c) high temperature treatment d) low and high temperature treatment

3. _____organic acid is used in syrups, drinks, jam and jellies
a) lactic b) acetic c) Citric d) Propionic

4. Preservation affects the growth of microorganism by
a) inhibition b) retardation c) arresting d) degradation

5. Radiation dose in kilograys of ____ inhibits sprouting in potatoes, onions and garlic
a) 0.05-0.15 b) 0.01-0.14 c) 0.05-0.07 d) 0.05-0.11

6. The sodium salt of ______ acid has been used extensively as an antimicrobial agent in foods
a) propionic b) benzoic c) sorbic d) acetic

7. ______ is used as treatment for wrappers used on butter
a) sodium diacetate b) calcium carbonate
c) sodium nitrate d) potassium nitrite

8. The fumes of burning ____ are used to treat light colored dehydrated fruits
a) sulfur b) ethylene c) potassium d) sodium

9. _____ acid is used in soft drinks such as colas
a) phosphoric b) benzoic c) acetic d) sorbic

10. Flavoring etracts such as vanilla and lemon etracts are preserved by their content of ____
a) sugar b) salt c) alcohol d ethylene

11 Combination of ______ irradiation with chilling storage helps preserve foods
a)Ultraviolet b) infra red c) gamma d) beta

12. The reddish liquid comes out from meat on thawing process is called as
a) drying b) wilting c) bleeding d) leakage

13. Food should be cooked to which temperature
a) 5°C b) 75°C c) 100°C d) 60°C

14. Sanitising is_______
a) Applying detergent to a clean surface b) Done before washing
c) Reducing bacteria by application of heat d) Wiping with a clean cloth

15.Gazing at ultraviolet lamps produces irritation of the ____ within few seconds

a) Eye b) Ear c) Nose d) Throat

16. . _____ contains a large number of volatile compounds that may have bacteriostatic and bactericidal effect

a) Spices b) Woodsmoke c) Formaldehyde d) Alcohol

17. The percentage fat constituent of double toned milk is

a 0.5 b) 1.5 c) 3 d) 4.5

18. Milk fermentation to produce cheese is done initially by inoculating with

a*). S. cerevisiae* b). *S. lactis & Lactobacillus*

c). S.thermophilus d). *L. bulgaris*

19. During _____ the internal temperature of bread, cake or other bakery products approaches but never reaches 100 °C

a) Heating b) boiling c) baking d) cooling

20. ____ can be dried by a process called explosive puffing

a) meat b) vegetables c)fruits d) juices

PART B – (03 x 02 = 06 marks)

Answer all Questions

21. Define chemical preservation
22. Organisms involved in yogurt production
23 Define probiotics

PART C – (03 x 08 = 24 marks)

Answer all questions choosing either a (or) b. (All questions carry equal marks)

24a) Write in brief about preservation of food using radiation.

(OR)

b) Write in detail about the production of sauerkraut and soy sauce.

25a) Write a detailed note on the preservation of food by chemicals.

(OR)

b) Comment on Health benefits of probiotics

26 a) Explain detail about the production of yogurt and cheese and its characteristic value as food

(OR)

b) Describe about sterilization by dry heat and moist heat

Reg. No. : ---------------------

[17MBU302]

KARPAGAM ACADEMY OF HIGHER EDUCATION
(Under Section 3 of UGC Act 1956)
COIMBATORE – 641 021
THIRD INTERNAL ASSESSMENT, OCTOBER- 2018
THIRD SEMESTER
MICROBIOLOGY
FOOD AND DAIRY MICROBIOLOGY

Time: 2 hours **Maximum: 50 marks**
Date: /10/2018 [N] **Class: II B.Sc. MB**

PART A – (20 x 1 = 20 marks)
Answer all the questions

1.The mold Penicillium islandicum produces _____ toxin
a. Luteoskyrin b) aflatoxin c) penicillic acid d)roquefortine

2. The etiologic agent of diarrheal syndrome is ____
a. *Shigellosis* b. *Yersiniosis* c. *Bacillus cereus* d. *Vibrio*

3. The spoilage organism bring about the spoilage of meat by
a.Purification b.Oxidation c. Decomposition d. Hydrolysis

4. Aflatoxin is produced by _____________
a. *Aspergillus* sp. b. *Salmonella* sp. c. *Fusarium* sp. d.*Streptococcal* sp.

5. Entheropathogenic *Escherischia coli* infection is involved in ____ foods
a. Vegetables b.Apple cider c. Ice creams d. Cheese

6. The incubation period of Streptococcus faecalis is _____
a. 5 to 10 b. 2 to 10 c. 2 to 18 d. 8 to 12

7. The minimum growth temperature of Bifidobacteria range from
a. 43 to 45 b. 25 to 28 c. 29 to 32 d. 30 to 35

8. Botulism is caused by the presence of toxin developed by
a. *C. tyrobutyricum* b. *C. sporogenes* c. *C. botulinum* d. *C. perifringes*

9. *Yersinia enterocolitica* is a small _____ shaped bacteria
a. Cocci b. Chain c. Rod d. Bacilli

10. The staphylococcal intoxication refers to presence of
a.An enterotoxin b. Neurotoxin c. Mycotoxin d. Exotoxin

11. The term ___ is used to distinguish strains of different antigenetic complements
a. Biovars b. Serovar c. Herbivore d. none of these

12. The method of successful treatment of botulism prior to appearance of botulism symptoms involve administration of______
a. Antibiotic b. Analgesic c. Antitoxin d. Antipyretic

13. The incubation period of Vibrio parahaemolyticus infection is ______
a. 2-48 hrs b. 5-24 hrs c. 40 hrs d. 37 hrs

14. The _____ virus enters a person through oral route in the fecal contamination of food
a. *Poliomyelitis* b.*Hepatitis* c. *Adeno* d. *Herpes*

15. The optimal pH for enteropathogenic E. coli is _______
a. 4.0 to 5.0 b. 7.0 to 7.5 c. 3.0 to 4.0 d. 8.0 to 9.0

16. The pH near ____ favors C. botulinum
a. Neutrality b. Alkalinity c. Acidic d. Mild acidic
17. The major carrier of Salmonellosis are ___________
a. Meat and eggs b.Meat and fish c.Eggs and fish d.Eggs and fruits
18. The symptoms such as nausea and dehydration is caused by _____
a. *Shigella sonnei* b. *Yersinia* c. *Arizona* d. *E.coli*
19. The optimal temperature for growth of Shigellosis is _____
a. 27 °C b. 37 °C c. 40 °C d. 50 °C
20. The FDA and USDA cooperative is a _____ surveillance program for dry milk products

a. *Pseudomonas* b. *E. coli* c. *Salmonella* d. *Vibrio*

PART B – (03 x 02 = 06 marks)

Answer all Questions

21. Define food borne infection
22. Types of fungal toxin
23. What is FDA and Agmark

PART C – (03 x 08 = 24 marks)

Answer all questions choosing either a (or) b. (All questions carry equal marks)

24.Write a detailed note on food borne infection caused by *Staphylococcus aureus*

(OR)

Elaborate about *Bacillus cereus*

.

25. What is FDA and Agmark

(OR)

Explain detail about HACCP

26. Role of Listeria monocytogens in causing food borne disease

(OR)

Mycotoxins in food poisoning