B.Sc.Microbiology **2019-2020**

Semester – III

19MBU302 **FOOD AND DAIRY MICROBIOLOGY** **(4H – 4C)**

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

End Semester Exam: 3 Hours

COURSE OBJECTIVES

- To encode the importance of the role of microorganisms in food industries both in beneficial and harmful ways.

COURSE OUTCOME

Provides information about the role of microorganisms in many food, and beverage industries both in production and spoilage processes.

Unit I

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 II

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, SO_2, nitrite and nitrates, antibiotics and bacteriocins, sterilization of dry heat, moist heat, chemical, physical and radition.

Unit III

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 IV

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.

Unit V

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.

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.
4. Gould GW. (1995). New Methods of Food Preservation. Blackie Academic and Professional, London.
5. Banwart JM. (1987). Basic Food Microbiology. 1st 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.

KARPAGAM ACADEMY OF HIGHER EDUCATION

(Deemed to be University)
(Established Under Section 3 of UGC Act 1956)
Coimbatore – 641 021.
(For the candidates admitted from 2017 onwards)

DEPARTMENT OF MICROBIOLOGY

SUBJECT NAME: FOOD AND DAIRY MICROBIOLOGY
SEMESTER: III
SUB.CODE:18MBU301 **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
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UNIT-I

Introduction

Foods and microorganisms have long and interesting associations which developed long before the beginning of recorded history. Foods are not only nutritious to consumers, but are also excellent source of nutrients for microbial growth. Depending upon the microorganisms present, foods may spoil or preserved by fermentation.

Microorganisms can be used to transform raw foods into fermented delights, including yoghurt, cheese, sausages, tempeh, pickles, wine, beers and other alcoholic products. On the other hand, foods also can act as a reservoir for disease transmission, and thus detection and control of pathogens and spoilage organisms are important areas of food microbiology. During the entire sequence of food handling from the producer to the final consumer, microorganisms can affect food quality and human health.

History of microorganisms in food

There is no documentation to exactly pinpoint as to when man first became aware of the presence of microorganisms in food. The year 1674 marks the birth year of microbiology when Leeuwenhoek first examined microorganisms in a sample of lake water. It was after about 100 years when Microbiology was established as science. Several experiments conducted by scientists to explain the origin of microorganisms provided indirect evidence of association of microorganisms in food. The period prior to establishment of Microbiology/ Bacteriology as science is designated as prescientific era which includes a food gathering period and food producing period.

Food gathering period covers time of man's origin about 3 million years up to 8000-10000 years ago. In this period man was carnivorous and plant foods entered his diet later. Man also learnt to cook food during this period also. Food producing period ranges from 8000- 10000 years ago and includes present time. Many problems related to prepared foods were encountered during this period for example the problem of food spoilage due to improper storage and problem of food poisoning with prepared foods as well as problem of disease transmission by foods. Although scientific basis for the preservation of foods were not known at that time but some of the methods used for preservation were use of oils, snow, smoking of meats, etc.

Perhaps the first man to suggest role of microorganisms in food spoilage was a Monk Kircher who referred to worms in decaying bodies, spoiled milk etc. The observations by Spallanzani that heated meat infusion in a hermetically sealed flask remained unspoiled and free from microorganisms and experiments by Pasteur while disproving the spontaneous generation theory demonstrated the idea of food preservation by heat.

The spoilage of food and presence of food poisoning organisms in food are very important from the point of food safety. Today the emphasis is on total quality of food which means that not only food should be nutritionally balanced but should be microbiologically safe too. In this chapter we will study general principles of microbial spoilage of food, detection and enumeration of food spoilage and food poisoning microorganisms.

Natural flora and source of contamination of foods.

The microbial flora of a food consists of the microorganisms associated with the raw material, those acquired during handling and processing, and those surviving any preservation treatment and storage. Since these microorganisms do not arise by spontaneous generation, they must contaminate the food at some stage of production, harvesting, handling, processing, storage, distribution, or preparation for consumption. Most foods are subjected to many potential sources of microorganism· isms. Why should we be concerned with sources of contamination? Primarily so that we can control contamination and keep the microbial load on or in the food as low as possible. By doing this, we obtain a longer shelf life for the food; we hope that this reduces the chance of microbial food borne illness when the food is ingested. By keeping the contamination low, we can more easily control or eliminate the microorganisms with food-preservation techniques. The potential sources of contamination are soil, water, air, plants, feed or fertilizer, animals, human beings. sewage, processing equipment, ingredients, product to product, and packaging materials. Microorganisms can be exchanged between these sources. For example, animals contaminate the soil with fecal material. Then rain washes the microorganisms into the creeks and rivers. This water may be used for irrigation and contaminate plants used for food. Thus, although water is the carrier, the microorganisms originally come from animals.

For some foods, it is difficult to determine how many of the organisms in the flora are contaminants and how many are the result of multiplication on or in the food.

Soil

Soil is the natural habitat of many microorganisms which, at times, may be found there in high numbers. The microbial density is greater nearer the soil surface than at deeper levels. The types and numbers of microorganisms vary with the type of soil (sandy, clay), as well as with environmental conditions. The environment is changing constantly, ex· pecially moisture and temperature.

Growth of Microorganisms The microbial growth in soil is limited to areas of organic material. These areas include the roots of plants, plant debris falling onto the soil, animal carcasses, fecal deposition by animals, and dead microorganisms. Besides the animal carcasses on the soil surface, dead earthworms, insects, and other small animals are in the soil.

The growth of microorganisms is influenced by the chemical composition of the materials undergoing decomposition, the rate of decomposition of the chemical constituents of these substances, and the environ mental conditions. Fats, waxes, and lignins may gradually accumulate in the soil because of their relative resistance to decomposition. This residual, called humus, is subject to slow and gradual attack by a variety of microorganisms. The main factor affecting multiplication is nutrient depletion. In general, the soil environment is not a good medium for the growth of microorganisms. However, they tend to survive.

Water

Natural waters not only contain several microorganisms native to the aquatic environment but also from soil, raw/treated sewage and pollutants entering the water body. The microbial numbers and types vary in different water bodies depending on the nutrient status. Thus, all kinds of microorganisms found in water are likely to be associated with the aquatic organisms as surface flora. Use of such water for food processing will add microorganisms from water to food. Sewage waters containing human pathogenic microorganisms contaminate foods when such waters are used without proper treatment. The water used in food processing should meet agree able chemical land bacteriological characteristics.

Air

Air contains several microorganisms which may get deposited on the food being processed and handled. Though the air does not contain natural flora of microorganisms, whatever microorganisms encountered are those associated with the suspended solid material and water droplets. The sources of microorganisms to air are from dust, dry soil, and water spray from natural surface waters, droplets of moisture from coughing, sneezing and talking by food handlers, from sporulating moulds growing on walls, ceilings, floor, foods and food ingredients. Thus, it is likely that the microorganisms persisting in air get deposited on the food being processed and contribute for microbial load and subsequent spoilage of food.
The number of microorganisms present in air depends on factors such as extent of movement of air, sunshine, humidity, location and amount of suspended dust in air. Quiet air allows settling of microorganisms but the moving air brings in microorganisms and keeps them suspended. Thus, the number of microorganisms in air is increased by air currents caused by movement of people, by ventilation and by breeze. The rain or snow removes microorganisms from the air.

Food contamination

Food contamination is a commonly used term. However, only a few people are aware of the exact reasons for food contamination and its effects on your health. When food items are not handled or cooked safely, the

disease-causing organisms such as bacteria, parasites, and viruses result in food contamination. The disease-causing parasites produce toxins that may also lead to food intoxication. In addition, the presences of pesticides, certain cleaning compounds, contaminate the food. The common reasons for food contamination are:

Improper storing, handling and preparing food

Unhygienic hands and fingernails

Poor personal hygiene habits

Improperly cleaned or sanitized utensils

Contamination by flies, cockroaches, insects, and pests

Different Types of Food Contamination

There are a number of reasons that can lead to food contamination. However, food contamination falls under four different categories which are:

Biological contamination

Chemical contamination

Physical contamination

Cross-contamination

Read on to find out more about the different types of food contamination and their effect on your health.

Biological Contamination

Biological contamination is one of the common causes of food poisoning as well as spoilage. Contamination of food items by other living organisms is known as biological food contamination. During biological contamination, the harmful bacteria spread on foods that you consume. Even a single bacterium can multiply very quickly when they find ideal growth conditions. Not just bacteria, but also their process of multiplying can be quite harmful to humans. The common places where you can find bacteria are:

Dust
Raw meat
The air
The human body
Pets and pests
Clothes of food handler
Kitchen clothes

The best ways to avoid food contamination is by washing the food items with KENT vegetable and fruit cleaner and wash the kitchen cloths on a regular basis.

Physical Contamination

Physical contamination during handling of food

When harmful objects contaminate the food it leads to physical contamination. At times, food items can have both physical and biological contamination. Physical contaminants such as rats, hair, pests, glass or metals which can contaminate food and make it unhealthy. Some of the safety tips that you can follow when handling food items to prevent food contamination are:

Hair-Tie your hair when handling food

Glass or Metal-Clean away cracked or broken crockery and utensils to avoid contamination

Fingernails-Keep your fingernails short or wear clean gloves when handling food

Dirt-Wash fruits and vegetables with KENT Vegetable and Fruit Cleaner to remove dirt

Jewelry-Wear minimum jewelry when preparing food

Chemical Contamination

pesticides in food

Chemical contaminants are one of the serious sources of food contamination. These contaminants can also lead to food poisoning. Pesticides present in fruits and vegetables are one of the main sources of contamination. In addition, kitchen cleaning agents, food containers made of non-safe plastic, pest control products also lead to food contamination. Though we make it a point to wash fruits and vegetables thoroughly, however, plain water can't remove all the contaminants. This is where KENT Vegetable and Fruit Cleaner can help you out. The smart kitchen appliance uses ozone disinfection technology that removes contaminants from the surface of the fruits and vegetables to make it safe for consumption.

Cross-Contamination

Many of us are not aware of cross contamination; however, this type of contamination can lead to a number of health problems. Cross-contamination takes place when pathogens are transported from any object that you use in the kitchen. Dirty kitchen clothes, unclean utensils, pests, raw food storage can lead to cross-contamination. Here are some of the ways to avoid cross-contamination:

Personal Hygiene- Thoroughly wash your hands and face when handling food. Coughing, sneezing or even touching your hair can lead to cross contamination

Utensils-Use separate utensils to prepare different types of foods. Avoid using the same chopping board and knife for ready to eat foods

Storing Food-Make sure raw foods don't come in contact with ready to eat foods. Cover and store raw foods below cooked foods to prevent cross-contamination.

Disposing Waste- Make sure you store and seal garbage correctly to prevent cross-contamination. Clean and sanitize the waste bins to prevent infestation risk.

Growth of Microorganisms in Food: Intrinsic & Extrinsic Factors

The interaction between microorganisms and other living things in the earth is natural, constant and which plays a significant role in maintaining the ecological balance and stability of biogeochemical cycling. As microorganisms are associated with living things in nature they play a significant role for survival of plants and animals.

Majority of food materials are obtained from plants and animals and it is rich in different type of microorganisms. Some microorganisms serve as food for human and animal, e.g. mushrooms, some present in food are helpful and some others are harmful to our health. Microorganisms use food as the substrate for their growth and colonization.

Depending on the type of microorganisms the growth of many organisms in food can result in improving overall quality of food and in some cases they can deteriorate the quality also. Growth of harmful microorganisms especially bacteria and fungIIn food constitutes food spoilage and sometimes cause several diseases on consumption of such food.

The major reason for food spoilage is due to increase in number of microorganisms, utilization of nutrients, causing enzymatic changes resulting in bad flavors due to breakdown of some food materials or synthesis of new compounds. Food becomes unfit for human consumption because of such microbial activities. Microorganisms can oxidize reduced carbon; nitrogen and sulfur compounds present in dead plants and animals and can contribute the minerals to the biogeochemical cycling.

Food acts as good medium for transmission of many diseases and infections. If the food is contaminated by pathogenic microorganisms or their spores, they can grow and increase their population and can produce various types of toxins which may leads to several diseases.

Sometime microorganisms may not grow in food but food can act as transmission route of many diseases. Therefore, food act as good medium for spread of diseases. Several food borne diseases are the result of microorganism present in food or their growth in them.

Growth of microorganisms in food is dependent on various parameters. The factors influencing the growth of microorganisms are physical, chemical and biological in nature. The factors can be generally classified as intrinsic and extrinsic factors.

The intrinsic and extrinsic factors affecting the growth of microorganisms in food

Intrinsic Parameters in Food:

The parameters present in substrates in which the microorganisms are growing, that are internal parts of the substrate are called as intrinsic parameters.

The most important types of internal factors in food are:

1. Hydrogen Ion Concentration (pH):

All the microorganisms have a minimal, maximal and optimal pH for their growth, survival and activity of their enzymes. Growth of microorganisms is affected by the pH of growth environments in food (growth medium) resulting large number of enzymes responsible for metabolism and growth. Influence of pH of food not only has effect on growth of microorganisms but also on processing conditions. Food having acidic contents promotes growth of acid loving microorganisms such as yeasts, moulds and some acidophilic bacteria. Mould can grow over a wider range of acidic pH than bacteria and yeast. Most of the fermentative yeasts can grow at pH of about 4.0 to 4.5, as in fruit juices and acid food such as sauerkraut and pickles. A food with an acid pH would tend to be more microbiologically stable than neutral or alkaline food. Because of this restrictive pH the food such as fruits, soft drinks, fermented milks, sauerkraut and pickles are stable against bacterial spoilage.

Most of the bacteria, except acid fermentors are favored alkaline or neutral pH. Most of the bacteria preferred a pH range between 7.0-7.5 but some proteolytic bacteria can grow on food substrate with high pH. The buffer content in the food is important to maintain the stability against microbial spoilage.

Buffers permit an acid (or alkali) fermentation to go on longer with a greater yield of products and organisms. Vegetable juices have low buffering capacity permitting a decrease in pH with the production of only small amount of acid by the lactic acid bacteria during the early stage of sauerkraut and pickle fermentation. This helps to inhibit the growth of pectin hydrolyzing and proteolytic competing bacteria in food.

Food acidification by fermentation in home food preparations is the oldest practice man has been doing.

It is due to production of organic acids in food by growth and fermentation of microorganisms such as lactic and acetic acid bacteria. The inhibitory properties of many of the organic acids such as citric acid, lactic acid, benzoic acid, propionic acid, sorbic acids, etc. can be used as effective acidulants or chemical preservatives against food spoilage bacteria.

2. Water Activity or Moisture Content (a_w):

Water is an excellent solvent for all life processes in every living organism for biocatalytic activity. The amount of water required varies for different organisms. Water requirement of microorganisms is expressed as available water or water activity a_w. Water activity is the vapor pressure of the solution (of solutes in water in most food) divided by the vapor pressure of the solvent (usually water).

In other words it is defined by the ratio of the water vapor pressure of food substrate to the vapor pressure p of pure water at the same temperature – $a_w = p/p_o$, where P is the vapor pressure of the solution and Po is the vapor pressure of the solvent (usually water). The a_w content is very well related to relative humidity (RH) in the following way: RH = 100 x a_w.

Pure water has an a_w of 1.00, a 22% NaCl solution (w/v) has an a_w of 0.86, and a saturated solution of NaCl has an a_w of 0.75. The water activity (a_w) of most fresh foods is above 0.99. In general, bacteria require more water activity than moulds and yeasts. Gram-negative bacteria have higher water requirements than gram-positive bacteria.

Most of the food spoilage bacteria do not grow below a_w 0.91, while spoilage moulds can grow even at a_w 0.80. The aerobic food poisoning bacterium Staphylococcus aureus is found to grow at a_w as low as 0.86 while anaerobic Clostridium botulinum does not grow below a_K 0.94. Moulds differ considerably in optimal a_w for vegetative growth and spore germination.

The lowest a_w value for food borne bacteria is 0.75 for halophiles (“salt-loving”), whereas xerophilic (“dry-loving”) moulds and osmophilic (preferring high osmotic pressures) yeasts have been reported to grow at a_w values of 0.65 and 0.61. The lowest water activity values permitting growth of spoilage microorganisms is given in the Table 3.1.

Table 3.1: Lowest a_w values for different types of microorganisms spoiling food

Group of Microorganism	Minimal (a_w) value
Bacteria	0.91
Yeasts	0.88
Moulds	0.80
Halophilic bacteria	0.75
Xerophilic fungi	0.65
Osmophilic yeasts	0.60

The effect of lowering a_w below optimum is to increase the length of the lag phase of growth and to decrease the growth rate and size of final population of microorganisms. This is due to adverse influences of lowered water on all metabolic activities in microorganisms since all chemical reactions in cells require an aqueous environment.

The a_w is influenced by other environmental parameters such as pH, Eh (redox potential) and growth temperature required for microorganisms. The other factors which influence the water activity are the kinds of solute employed to reduce water activity, the nutritive significance of culture medium, temperature, supply of oxygen, hydrogen ion concentration and presence of inhibitors.

3. Redox Potential (Eh):

The reducing and oxidizing power of the food will influence the type of organism and chemical changes produced in the food. The concentration of oxygen in food, chemical composition and type of microorganisms associated contribute to the oxidation-reduction (O-R) potential of food and affect growth of microorganisms in them. The O-R potential of a food may be defined as the ease with which the substrate loses or gains electrons.

The Redox potential of food is determined by characters such as:

(a) Oxygen tension of atmosphere above the food,
(b) Access of atmosphere to the food,
(c) Resistance of food to the changes occurring and
(d) O-R state of materials present in food.

On the basis of the ability of microorganism to utilize oxygen, organisms are classified as aerobic, anaerobic and facultative anaerobes. Aerobes require free oxygen and anaerobes don't prefer oxygen as it is toxic to them, hence, it is grow in the absence of molecular oxygen. Facultative may grow both aerobic and anaerobic conditions.

Generally fungi- mould and yeasts are aerobic. But bacteria are variables of these aspects. Some are aerobic, some are anaerobic and others are facultative anaerobes. If oxidation potential is high then aerobes will grow better than anaerobes, but if conditions become more reduced then anaerobes will be the predominant organisms.

The O-R potential is written as Eh and measured and expressed as millivolts (mV). If the substrate is highly oxidized would have a positive Eh and substrate is reduced is a negative Eh. Aerobic microorganisms such as bacilli, cocci, micrococci, pseudomonas, acinetobacters require and grow at positive O-R potential and anaerobe such as Clostridia and bacteriodes require negative O-R potential for their growth.

Most of the fresh plant and animal food have low redox potential because of reducing substances present in them. Fresh vegetables and fruits contain reducing substances such as ascorbic acid, reducing sugars and animal tissues have sulfhydryl (-SH) and other reducing group compounds considered as antioxidants.

Fresh vegetables, fruits and meat promote growth of aerobic microorganisms in the surface regions because of positive redox potential. However, the anaerobic microorganisms grow in inner parts of vegetables, fruits and meat because of negative redox potential. Most of processed plant and animal food gain positive redox potential therefore promote growth of aerobic organisms.

4. Composition of Nutrients:

Nutrients are one of the most important compounds for the growth and functioning of microorganism. Nutritional quality of food depends on the chemical composition, nutritive value or nutrients, their proportion and growth promoting ability to the microorganisms.

The most important factors which have to be considered are the energy substances in food, nitrogen substances, growth promoting substances, accessory food substances or vitamins, minerals, and water content which all are very essential for growth or energy production of organisms.

The most energy sources of organisms are carbohydrates. Complex carbohydrates such as cellulose, hemicelluloses, starch, pectin, etc. can be utilized by various types of microorganisms. At the same time other carbon compounds such as esters, alcohols, peptides, amino acids, organic acid and their salt are also serving as energy sources for many organisms.

Bacteria are identified and classified based on their ability or inability to utilize various sugars and alcohols. Most organisms can hydrolyses complex carbohydrates and can use glucose as energy source. Some organisms have the ability to hydrolyze pectin by producing the enzyme pectinase.

Some microorganism can hydrolyze triglycerides and other types of fats by microbial lipase and produces glycerol and smaller fatty acid. In this step triglycerides are hydrolyzed in to diglycerides then monoglycerides

and glycerol under alkaline condition by microbial lipase. The glycerol and fatty acids are excellent sources of carbon and energy sources of many aerobic organisms.

Hydrolytic products of proteins and peptides serves as sources of nitrogen for many proteolytic bacteria such as Pseudomonas sps. The primary nitrogen sources utilized by heterotrophic microorganisms are amino acids. A large number of other nitrogenous compounds may serve this function for various types of organisms. Some microbes are able to utilize nucleotides and free amino acids, whereas others are able to utilize peptides and proteins.

In general, simple compounds such as amino acids will be utilized by almost all organisms before any attack is made on the more complex compounds such as high-molecular-weight proteins. Protein rich food promotes more growth of bacteria than moulds and yeasts.

Some microorganisms require vitamins and other growth factors for their growth and that has to be supplied with the growth medium. Such microorganisms are called fastidious organisms. Food contains different vitamins, minerals and other growth factors and their composition and content may vary.

Fresh plant and animal food contain vitamin B complex and fruits are low, but fruits are high in ascorbic acid. Processing of food often reduces the vitamin content. Thiamine, pantothenic acid, folic acid and ascorbic acid are heat-labile and drying cause's loss in vitamins such as thiamine and ascorbic acid.

Storage of food for long may also result in decrease in vitamins and other growth factors. Some microorganisms produce vitamins and other growth factors which support growth of others organisms present in food. Each kind of microorganisms has a range of food requirements.

Water is another very important component for food nutrients. The water requirement of organisms will depend on the type of organisms. Generally moulds have the lowest requirement, followed by gram-negative bacteria, yeasts, and gram-positive bacteria.

5. Inhibitory Substances:

Inhibitory substances are present in the food as its own origin, or added purposely by preventing or inhibiting the growth of organisms. The stability of certain foods against attack by microorganisms is due to the presence of certain naturally occurring substances that possess and express antimicrobial activity.

Some plant species are known to contain essential oils that possess antimicrobial activity. Eugenol in cloves, allicin in garlic, cinnamic aldehyde and eugenol in cinnamon, allylisothiocyanate in mustard, eugenol and thymol in sage and carvacrol (isothymol) and thymol in oregano are some of the best studied examples. Milk contains several antimicrobial substances, including lactoferrin, conglutinin and the lactoperoxidase system.

Milk casein and some fatty acids have been shown to be antimicrobial property against some organisms.

Lactoferrin is an iron-binding glycoprotein that is inhibitory to a number of food borne bacteria and its use as a microbial blocking agent on beef carcasses. Eggs contain lysozyme; ovotransferrin and conalbumin have shown some antimicrobial properties.

6. Biological Structures:

The natural covering of some foods provides excellent protection against the entry and subsequent damage by spoilage organisms. The inner part of healthy tissues of living plants and animals are sterile and contains less microbial count. The protective covering of food such as the skin of eggs, the skin on poultry, rind on fruits and vegetables, shell on nuts and artificial coating helps to protect its inner structures from microbial contamination and spoilage.

The physical protection of the food my help for preservation and determination of kind, rate and course of spoilage. Layers of fat over meat may protect that part of the flesh, or scales may protect the outer part of fish. In the case of nuts such as pecans and walnuts, the shell or covering is sufficient to prevent the entry of all organisms.

Once cracked nut meats are subject to spoilage by moulds. The outer shell and membranes of eggs prevent the entry of all microorganisms when stored under the proper conditions of humidity and temperature. Fruits and vegetables with damaged covering undergo spoilage much faster than those not damaged.

Extrinsic Parameters:

The extrinsic parameters are substrate independent and in this case the storage environment that affect both the food and their microorganisms.

The main extrinsic parameters influence the foods are:

1. Relative Humidity (RH):

The relative humidity of the storage environment is important extrinsic parameter both from the standpoint of a_w within foods and the growth of microorganisms at the surfaces. When foods with low a_w contents are placed in high RH environments, the foods takes up more moisture until equilibrium has been established.

Similarly foods with a high a_w lose moisture when placed in an environment of low RH. There is a relationship between RH and temperature that should be borne in mind in selecting proper storage environments for foods. Generally, if the temperature high then the RH low and vice versa.

2. Atmospheric Gases:

Like O_2, Carbon dioxide (CO_2) is also most important atmospheric gas that is used to control microorganisms in foods. Modified atmosphere packaged (MAP) foods are make use of this types of gases. Ozone (O_3) is the other atmospheric gas that has high antimicrobial properties; it has strong oxidizing property hence it should not use for fat rich food as it will undergo auto-oxidation. It has been noticed that ozone extend the shelf life of many foods and it has shown to be effective against a variety of microorganisms.

3. Temperature:

Microorganisms can grow over a wide range of temperatures. The lowest temperature at which a microorganism has been reported to grow is -34°C; the highest is somewhere in excess of 100°C.But some spore producing bacteria such as Bacillus stearothermophilus, Clostridium tetani and Clostridium perfringens can grow above 100°C.

Based on the temperature range microorganisms are classified as three groups –

i. Psychrophiles (Psychrotrophs), those organisms are grown between the temperature ranges of 2°C to 20-30°C.

ii. Mesophiles, the organism preferably grow at the temperature between 20°C and 45°C and

iii. Thermophiles, the organisms grow better in range of 55°C-65°C.

The most important psychrotrophs include Alcaligenes, Shewanella, Brochothrix, Corynebacterium, Flavobacterium, Lactobacillus, Micrococcus, Pectobacterium, Pseudomonas, Psychrobacter, Enterococcus and others. The psychrotrophs found most commonly on foods are those that belong to the genera Pseudomonas and Enterococcus.

These organisms grow well at refrigerator temperature and cause spoilage at 5-7°C of meats, fish, poultry, eggs, and other foods normally held at this temperature. Mesophilic species and strains are known bacteria among all genera and may be found on food held at refrigerator temperatures. Most important thermophilic bacteria in food belong to the genera Bacillus, Paenibacillus, Clostridium, Geobacillus, Alicyclobacillus and Thermoanaerobacter.

Like bacteria fungi are also able to grow over wide ranges of temperature. Many moulds are able to grow at refrigerator temperatures, especially some strains of Aspergillus, Cladosporium, and Thamnidium, which may be found growing on eggs, sides of beef and fruits. Yeasts prefer psychrotrophic and mesophilic temperature ranges but generally not within the thermophilic range.

4. Other Microbial Flora:

Microorganisms present in the food can undergo various types of negative interactions. These kinds of interaction cause inhibition of some microorganisms as they are undergoing competitions and antibiosis. Some organisms especially moulds can produce various types of secondary metabolites such as antibiotics that are toxic to many bacteria. Some foodborne organisms produce substances that are either inhibitory or lethal to others; these include bacteriocins, hydrogen peroxide and organic acids.

Microbial Spoilage of Foods

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 + proteolyticmicroorganisms amino acids +amines+ ammonia+ H2S. 10 Fermentation: Carbohydrate foods +saccharolyticmicroorganisms organic acids + alcohol + gases. Rancidity: Fatty foods + lipolyticmicroorganisms 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 fresh and ready-to-eat meat products Raw Meat 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 11 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 Aw > 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. HeterofermentativeLeuconostoccarnosum and Leuconostocgelidum 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. Shewanellaputrefaciens, which can grow under both aerobic and anaerobic conditions, metabolizes amino acids (particularly cysteine) to produce methylsulfides 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. To reduce spoilage of' Fresh meats, storage at low temperatures (~ 0 to 1°C), modified atmosphere packaging, and vacuum packaging are extensively used. Several other methods to reduce initial microbial load and slow down growth of Gram-negative rods have been used which include the addition of small amounts of organic acids to lower the pH of meat (slightly above pH 5.0), drying of meat surfaces (to reduce aW), and a combination of the above factors including lower storage temperature.

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 gaspackaged products, during storage, can be spoiled by psychrotrophic Lactobacillus and Leuconostoc spp. In some products, growth of Serratialiquifaciens 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 proteolyticGrampositive 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. 13

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 (Table 11) 15 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, and others (Table 11). 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, and reducing aW, vacuum packaging and heat treatment

Eggs

Spoilage of eggs is promoted by cracking the eggshell, improper washing, and storage techniques. The most predominate spoilage (rot) of shell eggs is caused by Gram-negative motile rods: *Pseudomonas*, *Proteus*, *Alcaligenes*, *Aeromonas*, and coliforms. Pasteurized egg products at refrigerated temperatures have limited shelf life, unless additional preservatives are used. The predominant bacteria causing spoilage in pasteurized egg products are psychrotrophic Gram-negative. Dried eggs are not susceptible to microbial spoilage due to low water activity. Examination of an unbroken egg with transmitted light using candle can identify grossly contamination of eggs or rotten egg.

A great extent of pasteurization should be included during heat treatment of shell egg since the temperatures required for the killing of microorganisms are close to those at which the egg proteins coagulate. Fumigation of eggs with gaseous ethylene oxide before storage protects eggs against bacterial spoilage.

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, C02, and H2 leading to curdling and souring of milk. Some Alcaligenesspp 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 Flavobacteriumetc 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 ≥106 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 Torulaspp, 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 *Rhizopusstolonifer*(referred as bread mold), *Penicilliumexpansum*, *Aspergillusniger*. *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 *Endomycosisfibuligera* and *Trichosporonvariable.*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 *Serratiamarcescens*. 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- *Penicilliumexpansum*

Bread mold- *Rhizopusstolonifer*.

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 *Endomycopsisfibuligera* and *Trichonospora*

Microbial Spoilage of Canned Foods

The microbial spoilage of canned food is classified as caused by thermophilic bacteria and mesophilic organisms. Most common spoilages of microbial origin are known as flat sour spoilage, Thermophilic anaerobic (TA) spoilage and putrefaction. These different types are briefly described here.

Spoilage by thermophilic spore forming bacteria

Spoilage by these types of bacteria is most prevalent in under processed heat treated canned foods. Their spores survive the heat treatment and undergo vegetative cell formation and subsequent growth in canned conditions. Major spoilages by these organisms are:

Flat sour spoilage

This is caused by souring bacteria. One characteristic of this spoilage is that ends of can remain flat during souring. Because of this condition, the detection of spoilage from outside is not possible thereby culturing of contents become necessary to detect the type of organisms. Main organisms involved are *Bacillus,* while it occurs more frequently in low acid foods. *Bacillus* spp. has ability to produce acid without gas formation.

TA spoilage

This type of spoilage is caused by thermophilic anaerobe not producing hydrogen sulfide. *Clostridium thermosaccharolyticum* is the main organism involved. It produces acid and gas in foods. Spoiled food produces sour or cheesy smell.

Sulfur stinker spoilage

This type of spoilage occurs in low acid foods and primarily *Desulfotomaculumnigricans* is involved. The spores of these organisms are destroyed at optimal heat treatment, thus presence of this organism usually indicates under processing in terms of heat treatment. It produces hydrogen sulfide which produce typical odour.

Spoilage by Mesophillic Spore formers

Bacillus and Clostridium are involved in this type of spoilage which is usually indicative of under spoilage.

Spoilage by Non-Spore Formers

Presence of non spore formers in cans indicate post processing contamination. The organisms whose vegetative cells are heat resistant are more readily found. Following organisms are more prominent:

Enterococcus	*Streptococcus thermophilus*
Micrococcus	*Lactobacillus*
Leuconostoc	*Microbacterium*

Presence of these organisms indicates leakage of container. Cooling water is one of the important source of contamination, thus coilforms also gain entry into the can through leakage.

Spoilage by Fungi

Yeasts

Yeasts and their spores are not thermo tolerant, thus they are not found in suitably heat treated cans. Their presence indicates under processing or post pasteurization contamination through leakage. Fermentative yeasts are more prominent and they produce carbon dioxide, thus causing swelling of cans. Film yeasts too can grow on the surface of the food products.

Molds

Among molds, *Aspergilus* and *Penicillium* are most spoiling organisms. These can grow at high sugar concentration. Acidification is considered method of preventing growth of molds. Some of the molds are resistant to heat. Molds are more common in home canned foods where heating as well as sealing is not under total aseptic conditions.

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CLASS: II B.Sc MB
COURSE CODE: 18MBU301

COURSE NAME: FOOD AND DAIRY MICROBIOLOGY
BATCH-2018-2021

UNIT1						
S.NO	**QUESTIONS**	**OPTIONA**	**OPTIONB**	**OPTIONC**	**OPTIOND**	**ANSWERS**
1	_____ is the first to suggest the role of microbes in food spoilage	Spallanzani	Pasteur	MonkKircher	Weizmann	MonkKirher
2	Spoilage of food may be a result of_____	Insect damage	Freezing and drying	Enzyme activity	All the above	All the above
3	Of the following which is not an intrinsic factor?	Redox potential	Water activity	Slicing	Noneofthe above	Slicing
4	Molds invade fruits due to___	Low pH, positive	High pH, positive Eh	Low pH, negative	High pH, negative Eh	Low pH, positive
5	The water activity for *Clostridium botulinum* to grow is _____	0.2	0.91	0.55	0.6	0.91
6	Osmophilic yeasts which will have the minimum water activity is	*Torulopsis*	*Saccharomyces bisporus*	*A. flavus*	*Wallemia sp.*	*Saccharomyces bisporus*
7	*Salmonella* sp. Can grow in the water activity upto	0.5	1-0.95	0.75-0.65	0.95-0.91	0.95-0.91
8	Most of the bacteria will grow at a pH range of	4.5-6.8	8.0-11	6.5-7.5	1.5-3.5	6.5-7.5
9	Which of the following will produces of the rot there by spoiling vegetables_____	*Pseudomonas*	*Erwiniaca rotovora*	*Bacillus*	Both a and b	Both a and b
10	_____Plays an important role in the spoilage of fish	*Proteus*	*Streptococcus*	*Shewanella sp.*	*Flavobacterium*	*Shewanella sp.*

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11	Water activity is expressed as____	Vapour pressure of the solution /vapourpressure of the solvent	100×aW	-aW=p/p0	None	vapourpressure of the solution/vapour pressure of the solvent
12	Water activity of pure water is	0.5	0.75	1	0.91	1
13	Which of the following will need more water activity than others?	Mold	Yeast	Gram negative bacteria	Gram positive bacteria	Gram negative bacteria
14	Iron binding glycol protein in milk which has an antimicrobial activity is_____	Casein	Lysozyme	Allicin	Lactoferrin	Lactoferrin
15	Drying can cause loss of vitamins	Pantothenic acid	Thiamine	Thymol	Carvacrol	Thiamine
16	Which of the following is not a psychrotroph	*Pectobacterium*	*Brochothrix*	*Alcaligenes*	*Geobacillus*	*Geobacillus*
17	Nutrients available in post riger meat is_	High proteins	Low carbohydrate	Both a and b	None	Both a and b

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18	Which of the facultative anaerobic organism produce ammonia and mercaptans there by cause putrefaction	*Serratia*	*Lactobacillus*	*E.coli*	All	*Serratia*
19	Which of the following will cause rotting of eggshell	*Botrytis*	*Candida*	*Aeromonas*	*Hansenula*	*Aeromonas*
20	A mold causing surface discolouration and flavour defects is_____	*Pseudomonas*	*Geotrichum*	*Penicillium*	*Aspergillus*	*Geotrichum*
21	Which will not grow favourably in water phase?	*Alcaligenes*	*Enterococcus*	*Pseudomonas*	*Coliforms*	*Alcaligenes*
22	In ropiness of bread ,proteinase will hydrolyse	Gluten	Lactose	Lactalbumin	Gelatin	Gluten
23	Chalky bread is caused by the yeast_____	*Rhizopusstolonifer*	*Trichonospora*	*Endomycosis fibuligene*	Both b and c	Both b and c
24	A mold of osmophilic nature causing swelling of cans is	Aspergillus	Penicillium	Mucor	Both a and b	Both a and b
25	Redox potential of pyruvate or lactate is_	80	-320	-190	11	-190

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26	Which is not an antimicrobial barrier in milk	Thymol	Lactaferrin	Casein	Lysozyme	Thymol
27	In meat, mold is formed by	*Acetobacter*	*Erwinia*	*Botrytis*	*Rhizopus*	*Rhizopus*
28	Which of the following will not involved in the process of ropiness of milk	*Lactobacillus*	*Flavobacterium*	*Micrococcus*	*Streptococcus*	*Flavobacterium*
29	Red spot caused by the aerobic mold in Meat is_	*Rhodotorula*	*Sporotrichum*	*Serratia marcescens*	*Photobacterium sp.*	*Serratia marcescens*
30	Black spot caused by the aerobic mold in meat is_	*Cladosporium herbarium*	*Thamnidium*	*Leuconostoc*	None	*Cladosporium herbarium*
31	_____produces H2S, will oxidize myoglobin to caused is coloration in meat	*Proteus*	*Clostridium sp.*	*Shewanella putrifaciens*	*Bacillus*	*Shewanellap utrefaciens*
32	Which of the following is the lactose hydrolyzing enzyme?	lactose	Beta galactosidase	Capric acid	Both a and b	Both a and b
33	Which of the following is not the gram negative psychrotrophic rod?	*Lactococcus*	*Alcaligenes*	*Flavobacterium*	*Pseudomonas*	*Lactococcus*

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34	The fat content in evaporated milk is about_	8.50%	7.50%	3.60%	1.20%	7.50%
35	Bacterial soft rot is caused by___	*Erwinia carotovora*	*Phytopthora*	*Bremia*	*Alternaria*	*Erwinia Carotovora*
36	Green mold rots in fruits is caused by	*Cladosporium*	*Trichoderma*	*Aspergillus niger*	Both a and b	Both a and b
37	Which is the causative agent in black rot in vegetables?	*Alternaria*	*Aspergillus niger*	Both a and b	*Coleototrichum*	Both a and b
38	Bloating defect in dill pickles from CO2 preparation by	*Candida*	*Mucor*	*Hansenula*	*Acetobacter*	*Candida*
39	*Sclerotinia sclerotiorum* can cause in apple cider	Blue mold rot	Watery soft rot	Sliminess	Anthraciness	Watery soft rot
40	Agram negative anaerobic spore former which darkens the product with rotten eggodoris	*Clostridium sp.*	*Desulfotomaculumnigrificans*	*Bacillus sclerothermophilus*	*All*	*Desulfotomaculumnigrificans*
41	Which of the following are the causes of gastro intestinal disorders?	Toxic mushrooms	Red kidney bean poisoning	Preformed toxins	All	All

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42	*Bacillus cereus* causes	*Salmonellosis*	*gastroenteritis*	*Food poisoning*	*constipation*	*gastroenteritis*
43	Neuro toxin produced by anaerobic Spore forming bacteria	*C.botuinum*	*Salmonella*	*Bacillus*	*Shigella*	*B. botulinum*
44	Enter hemorrhagic *E.coli colitis* is caused by	*Entero toxigenic E.coli*	*E.coliO26:H11*	*Entero pathogenic E.coli*	*E.coliO157:H7*	E.coliO157:H7
45	Selective medium for the growth of *Staphylococcus aureus*	Baird parker agar	Gioletticantoni broth	Esteraseagar	Both a and b	Both a and b
46	Salt condition for *C. botulinum* for the survivalis -	5.50%	8.50%	4.50%	-1.50%	5.50%
47	Fluorescent antibody method which is a immunological method for the detection of	*Streptococcus*	*Staphylococcus*	*Salmonella*	*Listeria*	*Salmonella*
48	The feacal oral contamination in which affects children is caused by	*Shigella*	*Salmonella*	*Listeria*	*Yersinia*	*Shigella*
49	Selective media for the growth of green Colonies of *Salmonella* is_	Macckonkey agar	Blood agar	Hektoenenteric agar	EMB agar	Hektoenenteric agar

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50	Egg yolk agar with polymyxin Bas the selective medium for is -	*B.cereus*	*Yersinia*	*Vibrio*	*Campylobacter*	*Yersinia*
51	---------- is an extrinsic factor	Redox Potential	Nutrient content	pH	Relative Humidity (RH)	Relative Humidity (RH)
52	The filamentous bacteria belongs to	Micrococci	Corynebacteria	Streptomyces	Aspergillus	Streptomyces
	The Sporophores fungi such as	Cladosporium	Penicillium	Yeast	Fusarium	
53	Lactic acid bacteria release in antimicrobial agent	Citric acid	Amino acid	Sodium hydroxide	Acetic acid	Acetic acid
54	The phylloplane flora is	Surface of root	Surface of vegetables	Surface of leaf	Surface of fruits	surface of leaf
55	Erwina carotorova pathogen causing blackleg disease	Potato	Tomato	Cabbage	Apple	Potato
56	The moisture content of system measured by	mV	mM	aW	Eh	aW

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CLASS: II B.Sc MB
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57	Mesophiles the organisms preferably grow at the temperature between	20^0C -30 ^{0}C	20^0C-45^0C	55^0C -65^0C	above 100^0C	20^0C-45^0C
58	Gray mold rot caused by	*Erwinia*	*Pseudomonas*	*Clostridium*	*Botrytis*	*Botrytis*
59	When can microbes use fat as an energy source ----------	Absence of sugar molecules	Presence of glucose	presence of fructose	Presence of high sugar	Presence of glucose
60	Which bacteria are able to grow at commercial refrigeration temperature	Pschrotrophic	Halophilics	Autrophic	Heterotrophic	Pschrotrophic
61	Identification of Aerobic molds *Sporotrichum cernis* in meat spoilage ----------	Block spot	White spot	Green spot	Pink Spot	Pink Spot
62	The quality of milk is assessed by ----------	MBRT	Alkaline Phosphates	Standard plant count	Straining method	MBRT
63	The most predominate spoilage (rot) of shell eggs is caused by ----------	*Alcaligene*	*Leuconostoc*	*Bacillus*	*Serratia*	*Alcaligene*
64	Pink mold rotin fruits and vegetables are caused by ----------	*Cladosporium*	*Trichotecium roseum*	*Trichoderma*	*Rhizopus*	*Trichotecium roseum*

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65	Which species of spoilage in butter ----------	*Geotrichum*	*Candida*	*Torulopsis*	*Saccharomyces*	*Geotrichum*
66	Red bread mold ----------	*Neurospora sitophila*	*Trichonospora*	*Rhizopus stolonifera*	*endomycopsisfibuliger*	*Rhizopus stolonifera*
67	Botulinum toxin is produced by ----------	*Clostridium botulinum*	*Clostridium tetani*	*Clostridium butyricum*	*Clostridium speticum*	*Clostridium botulinum*
68	What is the temperature of Liquid nitrogen ----------	-76^0C	-176^0C	-196^0C	-169^0C	-196^0C
69	*E.coli, salmonella* and *Vibrio* are sensitive to hydrostatic pressure of ----------	400-10,000MPa	500-1000MPa	500-10,000MPa	400-1000MPa	400-1000MPa

Introduction

Foods are mainly composed of biochemical compounds which are derived from plants and animals. Carbohydrates, proteins and fats are the major constituents of food. In addition, minor constituents such as minerals, vitamins, enzymes, acids, antioxidants, pigments, flavours are present. Foods are subject to physical, chemical, and biological deterioration. The major factors affecting food spoilage are

1) Growth and activities of microorganisms (bacteria, yeasts, and molds)

2) Activities of food enzymes and other chemical reactions within food itself

3) Infestation by insects, rodents

4) Inappropriate temperatures for a given food

5) Either the gain or loss of moisture

6) Reaction with oxygen

7) Light

The vast majority of instances of food spoilage can be attributed to one of two major causes: (1) the attack by microorganisms such as bacteria and molds, or (2) oxidation that causes the destruction of essential biochemical compounds and/or the destruction of plant and animal cells. Chemical and/or biochemical reactions results in decomposition of food- due to microbial growth. There is a adverse effect on appearance, flavour, texture, colour, consistence and/or nutritional quality of food.

Food Preservation

Food preservation is the process of treating and handling food to stop or greatly slow down spoilage (loss of quality, edibility or nutritive value) caused or accelerated by micro-organisms. Preservation usually involves preventing the growth of bacteria, fungi, and other micro-organisms, as well as retarding the oxidation of fats which cause rancidity. It also includes processes to inhibit natural ageing and discolouration that can occur during food preparation such as the enzymatic browning reaction in apples after they are cut. Preservative for food may be defined as any chemical compound and/or process, when applied to food, retard alterations caused by the growth of microorganisms or enable the physical properties, chemical composition and nutritive value to remain unaffected by microbial growth.

Principles of Food Preservation

The principles of various methods for food preservation are as
1) Prevention or delay of microbial decomposition
• By keeping out microorganisms (asepsis)
• By removal of microorganisms
• By hindering the growth and activity of microorganisms (e.g. by low temperatures, drying, anaerobic conditions, or chemicals)
• By killing the microorganisms (e.g. by heat or radiation)
2) Prevention or delay of self decomposition of the food
• By destruction or inactivation of food enzymes (by blanching)
• By prevention or delay of chemical reactions (By using antioxidant)

Methods of Food Preservation

Preservation of food is achieved by application of physical, chemical and/or biological methods are as follows:

Physical methods

• Cooling to
→ Low temperature refrigeration (0 to 7°C) - preserves for shorter period (days) → Freezing - preserves for several months
• Heating → pasteurization, cooking, sterilization etc
• Exposure to ionizing radiation → U.V., γ, etc
• Application of high pressure
• Drying → removal of water to a level which does not support the growth of microorganism

Chemical methods

• Quite often it is either impossible or undesirable to employ conventional physical methods of the preservation.
• In such situation one has to opt for chemical methods of preservation.
• It involves application of chemical additives which act as antimicrobial agents.

Biological methods

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

Thermal treatment

The term "thermal" refers to processes involving heat. Heating food is an effective way of preserving it because the great majority of harmful pathogens are killed at temperatures close to the boiling point of water. In this respect, heating foods is a form of food preservation comparable to that of freezing but much superior to it in its effectiveness. A preliminary step in many other forms of food preservation, especially forms that make use of packaging, is to heat the foods to temperatures sufficiently high to destroy pathogens.

In many cases, foods are actually cooked prior to their being packaged and stored. In other cases, cooking is neither appropriate nor necessary. The most familiar example of the latter situation is pasteurization. Conventional methods of pasteurization called for the heating of milk to a temperature between 145 and 149 °F (63 and 65 °C) for a period of about 30 minutes, and then cooling it to room temperature. In a more recent revision of that process, milk can also be "flash-pasteurized" by raising its temperature to about 160 °F (71 °C) for a minimum of 15 seconds, with equally successful results. A process known as ultra high pasteurization uses even higher temperatures of the order of 194 to 266 °F (90 to 130°C) for periods of a second or more.

Low temperature

The lower the temperature, the slower will be chemical reactions, enzyme action, and microbial growth. Each microorganism present has an optimal temperature for growth and a minimal temperature below which it cannot multiply. As the temperature drops from this optimal temperature toward the minimal, the rate of growth of the organism decreases and is slowest at the minimal temperature. Cooler temperatures will prevent growth, but slow metabolic activity may continue. Most bacteria, yeasts, and molds grow best in the temperature range 16-38^{o}C (except psychrotrophs). At temperatures below 10^{o}C, growth is slow and becomes slower the colder it gets. The slowing of microbial activity with decreased temperatures is the principal behind refrigeration and freezing preservation.

Drying

One of the oldest methods of food preservation is by drying, which reduces water activity sufficiently to prevent or delay microbial growth. The term water activity is related to relative humidity. Relative humidity refers to the atmosphere surrounding a material or solution. Water activity is the ratio of vapour pressure of the solution to the vapour pressure of pure water at the same temperature. Under equilibrium conditions water activity equals RH/100. At the usual temperatures permitting microbial growth, most bacteria require a water activity as low as 0.90-1.00. Some yeasts and molds grow slowly at a water activity as low as 0.65. Food is dried either partially or completely to preserve it against microbial spoilage.

Irradiation

The lethal effects of radiation on pathogens has been known for many years. The radiation used for food preservation is normally gamma radiation from radioactive isotopes or machine-generated x rays or electron beams. One of the first applications of radiation for food preservation was in the treatment of various kinds of herbs and spices, an application approved by the United States Food and Drug Administration (FDA) in 1983. In 1985, the FDA extended its approval to the use of radiation for the treatment of pork as a means of destroying the pathogens that cause trichinosis. Experts predict that the ease and efficiency of food preservation by means of radiation will develop considerably in the future.

Preservation of Food through Irradiation

Radiation processing of food involves exposure of food to short wave radiation energy to achieve a specific purpose such as extension of shelf-life, insect disinfestation and elimination of food borne pathogens and parasites. In comparison with heat or chemical treatment, irradiation is considered a more effective and appropriate technology to destroy food borne pathogens. It offers a number of advantages to producers, processors, retailers and consumers. Radiation processing of food involves exposure of food to short wave radiation energy to achieve a specific purpose such as extension of shelf-life, insect disinfestation and elimination of food borne pathogens and parasites.

Type of Radiation

The type of radiation used in processing materials is limited to radiations from high energy gamma rays, X-rays and accelerated electrons. These radiations are also referred to as ionizing radiations because their energy is high enough to dislodge electrons from atoms and molecules and to convert them to electrically-charged particles called ions.

Gamma rays and X-rays, like radiowaves, microwaves, ultraviolet and visible light rays, form part of the electromagnetic spectrum and occur in the short-wavelength, high-energy region of the spectrum and have the greatest penetrating power. They have the same properties and effects on materials, their origin being the main difference between them. X-rays with varying energies are generated by machines. Gamma rays with specific energies come from the spontaneous disintegration of radionuclides.

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Naturally occurring and man-made radionuclides, also called radioactive isotopes or radioisotopes, emit radiation as they spontaneously revert to a stable state. The time taken by a radionuclide to decay to half the level of radioactivity originally present is known as its half-life, and is specific for each radionuclide of a particular element. Only certain radiation sources can be used in food irradiation. These are the radionuclides cobalt-60 or cesium-137; X-ray machines having a maximum energy of five million electron volts (MeV) (an electron volt is the amount of energy gained by an electron when it is accelerated by a potential of one volt in a vacuum); or electron accelerators having a maximum energy of 10 MeV. Energies from these radiation sources are too low to induce radioactivity in any material, including food.

Unit of Radiation Dose

Radiation dose is the quantity of radiation energy absorbed by the food as it passes through the radiation field during processing. It is measured using a unit called the Gray (Gy).

In early work the unit was the rad (1 Gy = 100 rads; 1 kGy =1000 Gy).

Application of Radiation processing of food

Interest in the practical application of the process is emerging for many reasons. High food losses caused by insect infestation, microbial contamination and spoilage; mounting concern over food borne diseases, harmful residues of chemical fumigants and the impact of these chemicals on the environment, the stiff standards of quality and quarantine restrictions in international trade are some of the reasons. Though irradiation alone cannot solve all the problems of food preservation, it can play an important role in reducing post-harvest losses and use of chemical fumigants.

On the basis of radiation dose, applications of radiation can be classified into:

Low Dose Applications

Medium Dose Applications

High Dose Applications

Aseptic packaging

Aseptic packaging can be defined as the filling of a commercially sterile product into a sterile container under aseptic conditions and hermetically sealing the containers so that reinfection is prevented. This results in a product, which is shelf-stable at ambient conditions. The term "aseptic" is derived from the Greek word "septicos" which means the absence of putrefactive micro-organisms. In practice, generally there are two specific fields of application of aseptic packaging technology: • Packaging of pre-sterilised and sterile products. Examples are milk and dairy products, puddings, desserts, fruit and vegetable juices, soups, sauces, and products with particulates. • Packaging of non-sterile product to avoid infection by micro-organisms. Examples of this application include fermented dairy products like yoghurt. Aseptic packaging technology is fundamentally different from that of conventional food processing by canning. In canning, the process begins with treating the food prior to filling. Initial operations inactivate enzymes so that these will not degrade the product during processing. The package is cleaned, and the product is introduced into the package, usually hot. Generally, air that can cause oxidative damage is removed from the interior. The package is hermetically sealed and then subjected to heating. The package must be able to withstand heat up to about 100°C for high acid products and up to 127°C for low acid products, which must receive added heat to destroy heat-resistant microbial spores. Packages containing low-acid (above pH 4.5) food must withstand pressure as well. Although conventional canning renders food products commercially sterile, the nutritional contents and the organoleptic properties of the food generally suffer in the processing. Moreover, tinplate containers are heavy in weight, prone to rusting and are of high cost.

Methodology Aseptic processing comprises the following:

• Sterilisation of the products before filling

• Sterilisation of packaging materials or containers and closures before filling

• Sterilisation of aseptic installations before operation (UHT unit, lines for products, sterile air and gases, filler and relevant machine zones) Conventional Process Flow Aseptic Process Flow 311

• Maintaining sterility in this total system during operation; sterilization of all media entering the system, like air, gases, sterile water

• Production of hermetic packages

MICROWAVE PROCESSING

Introduction

Microwaves are part of electromagnetic spectrum in the frequency range falling between radio and infrared region. Two frequencies have been set aside for exclusive use of microwave heating application namely 915 MHz and 2450 MHz.

Microwave heating is a method that offers technique of heating requiring neither conduction nor convection. Microwave generates heat within the food rapidly raising the temperature to the desired extent. Special oscillator tubes called magnetrons and keltron, which generate the microwaves are used. These devices convert low frequency electrical energy into hundreds and thousands of megacycles. The electromagnetic energy at microwave frequency is conducted through a coaxial tube or wave-guide at a point of usage. The microwaves are channeled along a wave guide, then a stirrer or paddle distributes them evenly into cavity. Once they are inside the cavity, three things can happen to the microwaves, i.e. reflection, transmission and absorption.

The microbial inactivation kinetics for microwaves are essentially the same as the inactivation kinetics of conventional thermal processing. Although as many as four separate effects have been proposed -selective heating of micro-organisms, electroporation, cell membrane rupture and cell lyses due to electromagnetic energy coupling are the significant ones. It has also been suggested that microorganism load can be reduced to a greater extent by microwave treatment.

Mechanism of Microwave Heating

Heating with microwave frequency involves primarily two mechanisms dielectric and ionic. Water in the food is often the primary component responsible for dielectric heating. Due to their dipolar nature, water molecules try to follow the electric field associated with electromagnetic radiation as it oscillates at the very high frequency. Such oscillation of trip molecules produces heat. The second major mechanism of heating with microwave frequency is through the oscillatory migration of ions in the food that generate heat under the influence of the oscillating electric field. Kinetic energy is actually imparted to the ions by the electric field so that the field is alternating rapidly heat.

Microwaves penetrate materials and release their energy in the form of heat as the polar molecules (ones with positively and negatively charged ends - such as water) vibrate at high frequency to align themselves with the frequency of the microwave field. The microwaves interact directly with the object being heated. The interaction is related to the chemical properties of the object and it is possible to apply heat in ways that can not be achieved by conventional means: convection heating, conductive heating or radiant heating .

45.2.1 Microwave Generation

The microwaves are generated by special oscillator tubes called "Magnetrons and Kystron". These are devices that convert low frequency electrical energy into hundreds and thousands of megacycles. The electromagnetic energy, at microwave frequency is conducted through a coaxial tube or wave guide at a point of usage. Both Magnetron and Kystron are electron tubes which generate microwaves.

1. **Magnetron:** It is a cylindrical diode with a ring of resonant cavities that acts as a anode structure. The cavity is the space in the tube which becomes excited in a way that makes at a source for the oscillation of microwave energy . The Magnetron is a vacuum valve in which the electron, emitted by the cathode, turn around under the action of a continuous electric field produced by the power supply and of a continuous magnetic field. The movement produces the electro-magnetic radiation.

2 **Keltron:** It is a vacuum tube in which the oscillation are generated by alternatively slowing down and speeding upon electron beam. This results in periodic bunching of electrons. Keltron uses the transit time between two given points to produce this modulated electron stream which then delivers pulsating energy to a cavity resonator and sustain oscillation within the cavity.

Advantages of Microwave Processing:

The main advantage of a microwave oven over the conventional oven (electric and gas oven) is its high thermal efficiency in converting the energy in electricity into heat in the food. Other advantages are:

1. Speedy: microwave cookers heat food more quickly than any other conventional oven (shortening of processing time often by 70-85% and more).
2. Clean: with microwave cooking there is no risk of the food burning onto the cooker walls or they do not become hot in the way that the surfaces of conventional oven do. In addition, most foods are cooked covered and so remain in their containers (higher quality of product).

3. Smell free: because food is contained within the cooker cavity (and usually also in a covered dish), smells are kept to a minimum.
4. Less washing up: it is often possible to microwave food in serving containers or on the plate from which it is to be eaten. This is reducing the kind of washing up required when saucepans and metal oven dishes are used.
5. Thawing: thawing can be done quickly in a microwave cooker, saving hours in the fridge or kitchen and removing, the need for too much forward planning.
6. Nutritionally sound: many foods retain more nutrients than when cooked conventionally, as cooking time is so short, and there is little or no added water, particular examples are fish, vegetable.
7. Easy to use: once controls and cooking techniques are mastered, microwave cookers are extremely easy to use.
8. Cool: unlike conventional ovens, microwave cookers do not produce external heat and so can be used anywhere that is convenient such as a dining room.
9. Higher capacity: due to shorter residence time
10. Less space requirement by up to 50-90% against other methods
11. Better hygiene of working environment
12. Easier and faster maintenance
13. Savings of electric energy in comparison with conventional methods are frequently within the range of 25-50%.

Waste elimination and lower consumption of fossil fuels, causing lowering of environmental stress.

Disadvantages of Microwave processing

1. Because of speed, and the way in which microwave energy cooks, food cooked in a microwave oven will not be brown, so no crust formation or browning in case of bread or meat (in such cases microwave with grilling can be used).
2. High initial cost.
3. Short cooking time does not allow flavors to develop and this makes food unacceptable.

Application of Microwave in dairy and Food Processing

1. Baking: for internal heating microwave, for external heating hot air (electric coil) or infrared for crust formation.
2. Concentrating: concentration of heat sensitive fluids and slurries at relatively low temperature in relatively short time.
3. Cooking: it cooks relatively larger pieces without high temperature gradients between surface and interior (for continuous cooking of meals).
4. Curing: effective for glue-line curing of laminates (as in package) without direct heating of the laminate themselves.
5. Drying: microwave selectively heats water with little direct heating of most solids. Drying is uniform throughout the product, drying at relatively low temperature.
6. Enzyme inactivation (blanching): rapid and uniform heating inactivates enzymes, so it is adapted for blanching of fruits and vegetables without leaching losses associated with hot water or steam and it does not overcook the outside before core enzymes are inactivated.
7. Finish drying: when most of the water has been removed by conventional drying, microwaves remove the last traces of moisture from the interior of the product quickly, and without overheating the already dried material.
8. Freeze drying: the ability of the microwave energy to selectively heat ice crystals in matter makes it attractive for accelerating the final stages of freeze drying.
9. Heating: almost any heat transfer problem can benefit from the use of microwaves because of their ability to heat in depth without high temperature gradient.
10. Pasteurizing: microwaves heat the product rapidly and uniformly without the overheating associated with conventional methods.
11. Precooking: it is well suited for precooking ‘heat and serve’ because there is no overcooking and no cooking losses.
12. Puffing and foaming: rapid internal heating by microwave causes puffing and foaming when the rate of heat transfer is made greater than the rate of vapor transfer out of the product interior. May be applied to puffing of snack foods and other materials.

Solvent removal: many solvents other than water are efficiently vaporized by microwave, permitting solvent removal at relatively low temperature.

13. Sterilizing: where adequate temperature may be reached (acid foods), quick, uniform come up time may permit HTST sterilization. Selective heating of moisture containing microorganisms makes possible the sterilization of such materials as glass, and plastic films, which are not themselves heated appreciably by microwaves (it will not destroy bacterial spores)
14. Tempering: microwave heating is roughly proportional to moisture content, so it can equalize the moisture in a product that came from the process of non uniform condition.
15. Thawing: controlled, rapid thawing of bulk items is possible due to substantial penetration f microwaves into frozen materials.

Microwave processing technique has attracted considerable attention in the dairy and food processing area. However, its application in the dairy industry has not aroused as much interest. Some of the applications of microwave in dairy industry include -inactivation of bacteriophage in cheese whey, production of anhydrous milk fat, heat treatment of whey protein concentrates, mass crystallization of lactose in sweetened condensed milk, sterilization of milk, pasteurization of milk (HTST method), in packaging sterilization of yoghurt and tempering of frozen butter. The process can also be used for cooking of cut curd cubes during cheese making, and plasticizing of Provolone and Mozzarella cheese.

Microwave energy is unique energy sources that may allow shorten processing time, saving in energy, labor and space and often better quality products. Advances in technology concentrating, focusing and controlling microwave energy has increased the feasibility of developing microwave processing for the food and dairy industry. Microwave processing is expected to grow beyond our expectation due to increasing consumers demands for newer type of convenience foods having more nutritional value and better sensory quality in the recent years. There is a great potential for the combination ovens because they are more effective than either oven alone in the manufacture of shelf stable packed foods. Advances in microwave oven design and narrowing gap in cost between microwave and thermal processing will provide and incentive for the development of newer microwave processes.

Microwave food processing design development will require additional research on mechanisms of microwave heating of foods, particularly in the areas of energy coupling and propagation modes, and further development of quantitative electro physical and electrochemical models as an aid to microwave process design

HIGH PRESSURE PROCESSING

Introduction

High hydrostatic pressure processing (HPP), a relatively new technology to the food industry inactivates microorganisms without causing significant flavour and nutritional changes to foods. On the other hand, the effectiveness of thermal processing technologies explains why it remains as the prevailing method to achieve microbial safety and the inactivation of enzymes and microorganisms responsible for food spoilage. However, the high temperatures used in these processes cause significant chemical changes in foods. Particularly important are thermal degradation reactions leading to off-flavours, destruction of nutrients and other product quality losses.

For example, high-temperature short-time (HTST) pasteurization treatments (72°C for 15 s) impart a slight cooked, sulphurous note that has become acceptable to milk consumers but its refrigerated shelf life is only approximately 20 days. Ultra pasteurization (UP), a process similar to HTST pasteurization using more severe treatments (e.g. 1 s at 89 ^{0} C, 0.1 s at 96 ^{0} C or 0.01 s at 100 ^{0} C) lowers flavour quality and causes more nutrient damage but yields milk with a refrigerated shelf life of approximately 30 days. Pressure treatments of 400 MPa for 15 min or 500 MPa for 3 min at room temperature achieves microbiological reductions similar to thermal pasteurization but it is not used commercially because long pressure processing times are not financially viable. HPP treatments (586 MPa for 3 and 5 min) at moderate temperature (55°C) extend the refrigerated shelf life of milk to over 45 days while retaining milk volatile profiles similar to those observed after conventional HTST treatments. Finally, ultra high temperature (UHT) processing (135–150°C for 3–5 s) yields milk that is stable at room temperature for 6 months; however, this process induces strong ‘cooked’ off-flavour notes thus limiting its consumer acceptance in important markets.

Future advances are expected from the synergistic effects of using high pressure and high temperature combinations in the rapidly evolving pressure-assisted thermal processing technology (PATP). PATP is not yet a commercial application and will require more complex safety validation procedures than HPP, particularly for the case of low-acid foods (pH under 4.5). PATP conditions are sufficiently severe to achieve the inactivation of bacterial spores and recent studies suggest that pressure can lower the degradation rate of product quality caused by high temperature treatments.

High pressure processing at refrigeration, ambient or moderate heating temperature allows inactivation of pathogenic and spoilage microorganisms in foods with fewer changes in food quality as compared to conventional technologies. Pressure acts by disrupting mainly hydrogen bonds without affecting covalent bonds. Therefore, high pressure processing (HPP) treatments at low (approximately 0–30°C) and moderate (approximately 30–50°C) temperature cause minimum losses in quality factors associated with small molecules such as vitamins, pigments and volatile flavours. Research has confirmed that the sensory characteristics of HPP products make them often indistinguishable from untreated controls. Five decimal reductions in pathogens including *Salmonella typhimurium, S. enteritidis, Listeria monocytogenes, Staphylococcus aureus* and *Vibrio parahemolyticus* can be achieved by HPP.

Principle

The high pressure technique is essencially additive-free, mostly non-thermal or involves reduced heat treatments. Based on the pascal or isostatic principle, the hydrostatic pressure at a given point is the same in all directions and pressure is transmitted uniformly and immediately through the pressure transferring medium. Thus, the effects of pressure are independent on product size and geometry. It is often stated that HP processing is a uniform way of processing foods.

The effectiveness of a high pressure treatment is influenced by various intrinsic and extrinsic factors. Treatment time, pressurization or decompression rate, temperature and the number of pulses are critical to the effectiveness of the process. Moreover, the factors which include the effect of pressure on water, adiabatic heating and heat dissipation, food composition and the physiological states of microorganisms to be inactivated must be taken into account when optimising pressure treatments for the production of safe, quality foods.

Effects of HPP

· Microorganism inactivation

·Modification of biopolymers including enzyme activation and inactivation, protein denaturation and gel formation.

· Quality retention (colour, flavour, nutritional value)

· Modification of physiochemical properties of water

General Description of HP Equipment For Food Industry

The main components of an HP system are a pressure vessel, a pressure generation system, a temperature control device and a material handling system. Most pressure vessels are made from a high tensile steel alloy 'monoblocs' (forged from a single piece of material), which can withstand pressure of 400-600 MPa. For high pressures, pre-stressed multilayer or wire-wound vessels are used. In operation, after all air has been removed, a pressure-transmitting medium (either water or oil) is pumped from a reservoir into the pressure vessel using a pressure intensifier until the desired pressure is reached. Temperature control in commercial operations can be achieved by pumping a heating/cooling medium through a jacket that surrounds the pressure vessel. This is satisfactory in most applications as a constant temperature is required but if it is necessary to change the temperature regularly, an internal heat exchanger is fitted.

There are two methods of processing foods in high pressure vessels: in-container processing and bulk processing. Since foods reduce in volume at the very high pressure used during processing, there is considerable stress and distortion to the package selection is an important issue in using this method. Materials handling for in-container processing is achieved using equipment similar to that used to load/unload batch retorts. Bulk handling of liquids is simpler, requiring only pumps, pipes and valves.

There are two main types of High pressure equipments:

1. Batch type: A batch press can be used for any kinds of food in flexible packages, such as pouches, cups, or bulk bags. With the food already packed in the final consumer package at the processing stage, the risk of contamination is eliminated. The food packaged, are placed in the pressure vessel where they are isostatically compressed.

2. Continuous type: Continuous systems can be used for pumpable food. The system is installed with other equipment, and in the end the liquid food reaches an asceptic or clean filler. Thus any kind of consumer package can be used. Top of-the-line, high quality juice may be perceived as more valuabe if sold in glass bottles, rather than PET or other plastic that would require for batch cycling.

The volume in a pressure vessel for continuous use is better utilized that in a batch press, where there is dead space between the food packages. Thus the output volume is large despite the fairly small dimensions of the vessels used.

The principle of the continuous system is comparable to a four stroke engine. A valve is opened at the top of the press cylinder to let the product in and then closed. A floating piston inside the cylinder acts as a movable divider, and separates the water from the product. The pressure is the same on both the sides of the floating piston. When full pressure has been reached, it is held for a short period of time. After the hold time is over, the water is released through the bottom of the vessel and thus the vessel is decompressed. Another valve is then opened at the top, and the product leaves the cylinder when water is pumped in at the vessel filling, one for holding, and one for emptying the product. As the vessels take turns delivering the high pressure cycled product. There is an almost continuous output of product. With a balance tank in line with the system, the output will be continuous.

Advantages of HPP

· Retention of flavour and texture of the product

· Increase in Microbiological safety and shelf-life

· Low energy consumption

· Minimal heat input

· Minimal effluent and losses

· Uniform isostatic pressure & adiabatic temperature distribution

· Combination with heat gives better effects

Applications of HPP

- Milk treated at pressures of upto 500 MPa for few minutes has been shown to have a shelf-life at least equivalent to HTST pasteurized milk. Most vegetative cells, including non-sporeformingthermodurics, can be eleminated.
- HHP treatment (200 MPa, 10 min) after acidification (rise of acidity after acidification) in yogurt, increases the water binding capacity of whey proteins.

- The cheese yield is not influenced when milk treated at pressure ≤ 250 MPa, but at 600-800 MPa, it gets increased by up to 25% with increase in moisture content in curd and decrease in protein content in whey.
- Cheese Ripening can be accelerated by using the High Pressure treatment, which avoids the usage of elevated temperatures, addition of cheese slurries or exogenous enzymes or by the use of adjunct starters.

Cheddar cheese, when exposed to HP from 5 to 300 MPa for 3 days at 25°C, shows free amino acid levels of 26.5 mg/g at 50 MPa compared to 21.3 mg/g in the 6-month old cheese (which had not been HP treated). The taste of both the cheese were described as ‘‘excellent’’. This shows a considerable reduction in the ripening times of the cheese, attained through the application of HPP.

High pressure sterilization is possible by starting at elevated temp. e.g. 60–90°C, & using the adiabatic compression for rapid heating to higher temperatures. High pressure sterilisation is a combined process where both pressure and temperature contribute to sterilisation by the inactivation of spores and enzymes. The result is a shelf stable product, and in many cases a higher general quality than those products obtained using conventional processing.

CANNING AND OTHER METHODS OF THERMAL PROCESSING

Introduction

In continuation of the previous lesson, the reader would now be introduced to some of the other post harvest processing operations of fruits and vegetables such as canning, osmotic dehydration, etc.

Canning

The process of sealing fruits and vegetables or any other foodstuffs hermetically (air tight) in containers and sterilizing them by heat for long storage is known as canning. In 1904, Nicholas Appert of France invented this process and he is called as Father of Canning. The process of canning is also known as Appertization. Fruits and vegetables are canned in the season when the raw material is available in plenty. The canned products are sold in off-season and give better returns to the grower. The process flow diagram for canning is given in Fig. 9.1. Most of the preliminary operations of canning such as selection of the raw material, washing, sorting and grading, blanching have already been discussed in previous lesson and hence not repeated.

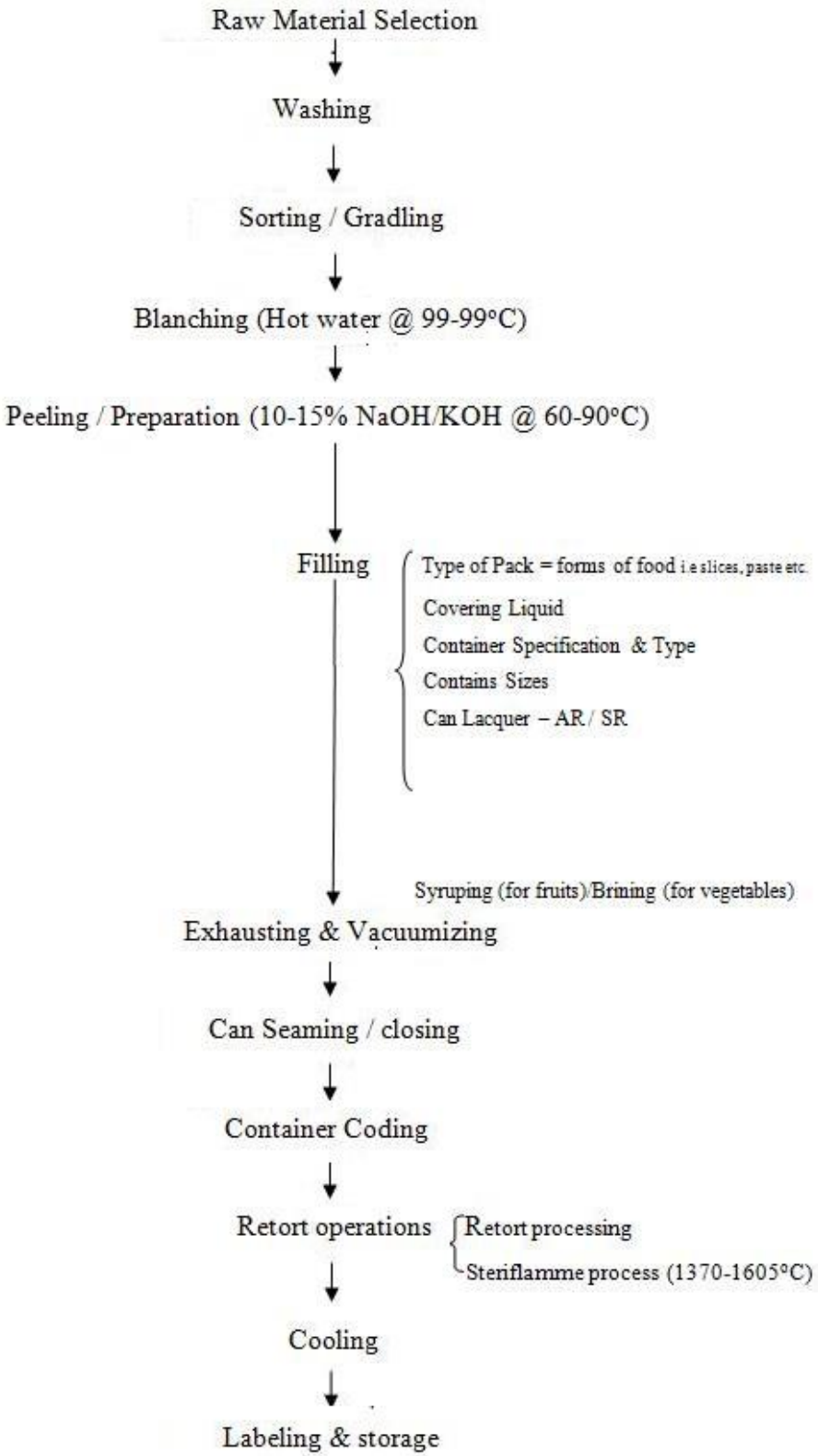
Raw Material Selection
Washing
Sorting / Gradling
Blanching (Hot water @ 99-99°C)
Peeling / Preparation (10-15% NaOH/KOH @ 60-90°C)
Filling
Type of Pack = forms of food i.e slices, paste etc.
Covering Liquid
Container Specification & Type
Contains Sizes
Can Lacquer – AR / SR
Syruping (for fruits)/Brining (for vegetables)
Exhausting & Vacuumizing
Can Seaming / closing
Container Coding
Retort operations
Retort processing
Steriflamme process (1370-1605°C)
Cooling
Labeling & storage

Fig. 9.1 Flow diagram for the canning process of fruits and vegetables

9.2.1 Can filling

Can filling is the process of aseptically filling whole or sized fruit or vegetables into the containers. The cans are washed with water or subjected to steam jet to remove any adhering dust or foreign matter. Tin cans made of thin steel plate of low carbon content, lightly coated on either side with tin metal to a thickness of about 0.25 mm are usually used in canning. The thickness of coating varies from 0.31 mm to 1.54 mm. The following are the different types of base plates used for can manufacture:

A) Type L: It is a high purity steel with low metalloid and residual content. This kind of base plate is used for highly acidic foods.

B) Type MR: It is a low metalloid steel with no severe restriction on residual content. It is used for moderate acid foods.

C) Type MC: It is similar to MR type but has high phosphorus content to give mechanical strength or stiffness. It is usually used for low acid foods.

Lacquering

It is difficult to coat steel plate uniformly with tin during the process of manufacture. Small microscopic spaces are always left uncoated, although the coating may appear perfect to the naked eye. The content of the can may react with the exposed parts of container and cause discolouration of the product or corrosion of the tin plate. When the corrosion is severe, the steel is attacked and black stains of iron sulphide are produced. Hence, it is necessary to coat the inside of the can with some material like lacquer, which would prevent discolouration, but would not impart its own flavor or injure the wholesomeness of the contents. The process of coating of inner side of the can to prevent discolouration of the product is called as lacquering. Lacquers include oleo-resinous material, synthetic resins, phenolic resins, epoxy resins and vinyl resins. There are two types of lacquers: (a) acid resistant and (b) sulphur resistant. The acid-resistant lacquer is ordinary gold colouredenamel and the cans treated with it are called as A.R-enamel cans. The sulphur-resistant lacquer is also of golden colour and the cans coated with it are called C-enamel cans or S.R. cans. Acid-resistant cans are used for packing of fruits of the acid group with soluble colouring matter such as raspberry, strawberry, red plum, coloured grapes, etc. Sulphur-resistant cans are used for non-acid products like peas, corn, beans, etc.

Syruping and brining

In canning, syrups are added to fruits whereas brine (salt solution) is added to the vegetables. Purpose of adding syrups or brine is to improve the flavor, fill the space between the pieces of canned product and aid in the heat transfer during sterilization. Cane sugar, glucose syrup, invert sugar and high fructose corn syrups are used for canning. Brine containing 1 to 2 percent of common salt is generally used for vegetables. Strength of syrup is measured by using hydrometer or a refractometer while strength of brine is measured by salometer or salinometer. The syrup or brine should be added to the can at a temperature of about 90�C, leaving suitable headspace in the can.

Exhausting

Exhausting usually means heating the can and can contents before sealing. Sometimes it is may also refer to the treatment of the container under a mechanically produced vacuum. But in either case it is done to remove air from the can interior and prevent corrosion. It also prevents undue strains upon the can during sterilization and prevents overfilling of can contents. Removing of air also helps in better retention of vitamins especially of vitamin C. The other advantages of the exhaust process are prevention of bulging of the can when stored at high altitudes or in hot climates. In heat exhaust method, the cans are generally passed through a tank of hot water at about 92-97�C or on a moving belt through a covered steam box. The time of exhaust varies between 5 to 25 minutes. After exhausting cans are immediately sealed with the help of double rolling operation of seamer.

Processing of the cans

The term processing as used in canning technology, means heating of canned foods (fruits, vegetables and other food stuffs) to inactivate bacteria. This is also called as retorting. Processing consists of determining just the temperature and the extent of cooking that would suffice to eliminate all possibilities of bacterial growth. In retort, saturated steam is supplied to heat the product. Time-temperature combination of processing depends upon the type and physical state of the product, the heat resistance of microorganisms or enzymes likely to be present in the food, the heating conditions, pH of the food, and size of the can to get complete sterility. In low acid foods (pH > 4.5), *Clostridium botulinum* is the most dangerous heat resistant spore forming pathogen likely to be present. Under anaerobic conditions inside a sealed can it can grow to produce a powerful exotoxin, botulin, which is sufficiently potent to be 65% fatal to humans.

Because of the extreme hazard from botulin, the destruction of this microorganism is therefore a minimum requirement of heat processing (i.e. in canning and sterilization). Normally foods receive more than this minimum treatment as other more heat-resistant spoilage bacteria may also be present. In more acidic foods (pH 4.5 – 3.7), other microorganisms (e.g. yeast and fungi) or heat-resistant enzymes are used to establish processing times and temperatures. In acidic foods (pH < 3.7), enzyme inactivation is the main reason for processing and hence, heating conditions are less severe. The preservative effect of heat processing is due to the denaturation of proteins, which destroys enzyme activity and enzyme-controlled metabolism in microorganisms.

The rate of destruction is a first-order reaction; that is when food is heated to a temperature that is high enough to destroy contaminating microorganisms, the same percentage die in a given time interval regardless of the number present initially. This is known as the logarithmic order of death and is described by *thermal death rate* curve (Fig. 9.2). The time needed to destroy 90% of the microorganisms (to reduce their numbers by a factor of 10) is referred to as the decimal reduction time or ***D-value***. D-values differ for different microbial species (Table 9.1) and a higher D-value indicates greater resistance. The thermal destruction of microorganisms is temperature dependent and cells die more rapidly at higher temperature. By collating D-values at different temperatures, a *thermal death time* (TDT) curve is constructed (Fig. 9.3).

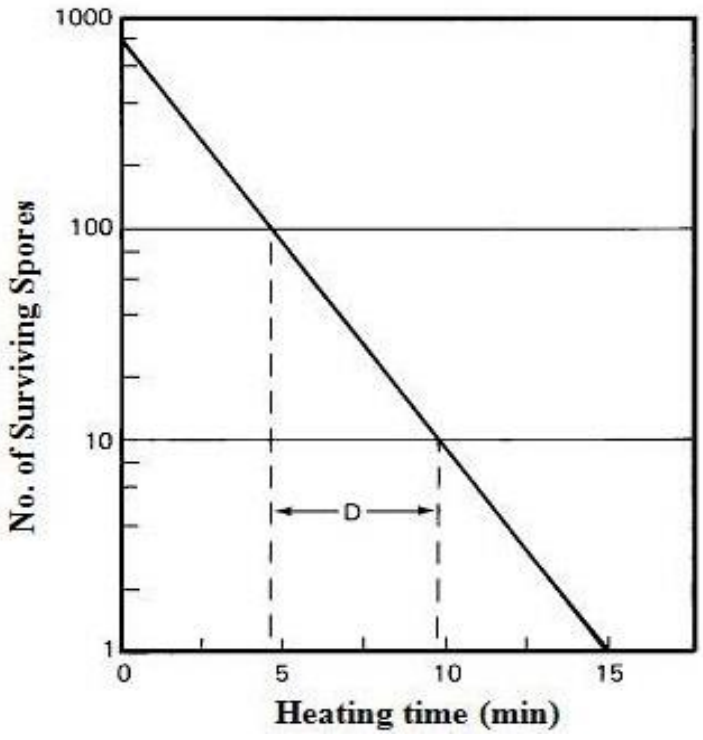

Fig. 9.2 Thermal death rate curve

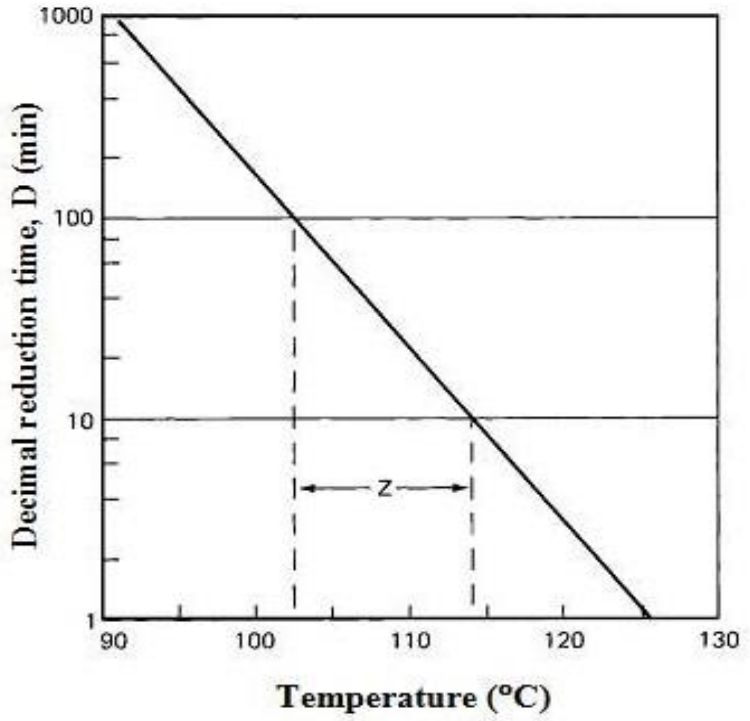

Fig. 9.3 Thermal death time curve

The thermal death time or ***F-value*** is used as a basis for comparing heat sterilization procedures. F-value is the time required to achieve a specified reduction in microbial numbers at a given temperature and it represents the total time-temperature combination received by a food. The slope of the TDT curve is termed the ***z-value*** and is defined as the number of degrees Celsius required to bring about a 10-fold change in decimal reduction time. F-value is quoted with suffixes indicating the retort temperature and the z value of the target microorganism. For example, a process operating at 110°C based on a microorganism with a z-value of 10°C would be expressed as F^{10}_{110}. Hence, D-value and z-value are used to characterize the heat resistance of a microorganism and its temperature dependence, respectively while F-value is used for comparing sterilizing procedures.

Table 9.1 Heat resistance of some spore-forming bacteria used as a basis for heat sterilization of low-acid foods

Microorganism	z-value (°C)	D_{121} value (min)	Typical foods
Thermophilic (35-55°C)			
Bacillus stearothermophilus	9 – 10	3.0 – 4.0	Vegetables, milk
Clostridiumthermosaccharolyticum	7.2 – 10	3.0 – 4.0	Vegetables
Mesophilic (10-40°C)			
Clostridium sporogenes	9.9 – 11.1	0.7 – 1.5	Meats
Bacillus subtilis	4.1 – 7.2	0.3 – 0.76	Milk products
Clostridium botulinum toxins A and B	5.5	0.1 – 0.3	Low-acid foods
Bacillus coagulans	6 – 9	0.01 – 0.07	Milk
Bacillus cereus	36	3.9	Milk
Psychrophilic (-5 to -1.5°C)	10	3.0 (60°C)	Low-acid foods

Rate of heat penetration in processing

Heat is transferred from steam or pressurized water through the container and into the fruit or vegetable or any other canned food. The heat transfer patterns in canned foods are given in Fig. 9.4. The rate of heat penetration is measured by placing a thermocouple at the thermal centre of a container (the point of slowest heating) to record temperatures in the food during processing (Fig. 9.5). It is assumed that all other points in the container receive more heat and are therefore adequately processed. The zone of slowest heating in a container is called as ***cold point***, which is most difficult to sterilize. In cylindrical containers the thermal centre is at the geometric centre for conductive heating foods and approximately one third up from base of the container for convective heating foods (Fig.9.6).

The important factors that influence the rate of heat penetration into a food are given below:

– **Type of product** – Liquid or particulate foods (for example peas in brine) in which natural convection currents are established heat transfers faster than in solid food in which heat is transferred by conduction (for example pastes or purees). The low thermal conductivity of foods is a major limitation to heat transfer in conduction

– **Size of the container** – Heat penetration to the centre is faster in small containers than in large

- **Agitation of the container** – End-over-end agitation and to a lesser extent, axial agitation increases the effectiveness of natural convection currents and thereby increases the rate of heat penetration in viscous or semi-solid foods (for example beans in tomato sauce).
- **Temperature of the retort** – A higher temperature difference between the food and the heating medium causes faster heat penetration.
- **Shape of the container** – Tall containers promote convection currents in convective heating.
- **Type of container** – Heat penetration is faster through metal than through glass or plastics owing to differences in their thermal conductivity.

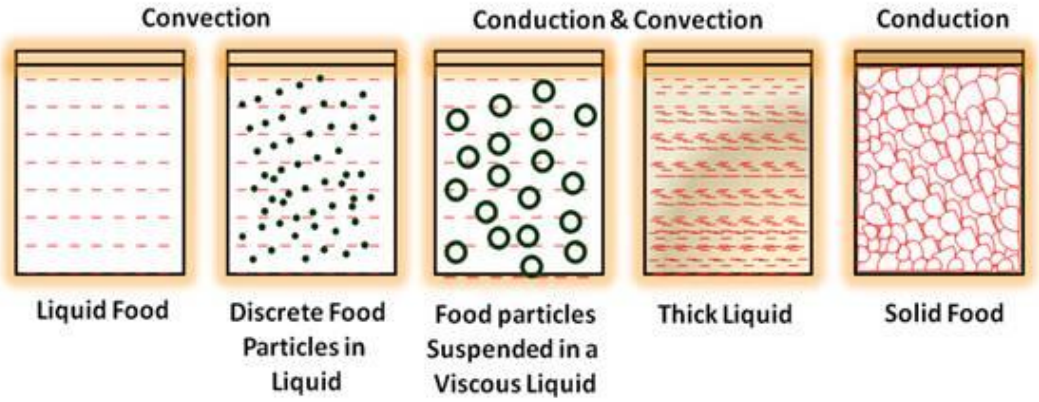

Fig. 9.4 Heat transfer pattern in canned foods

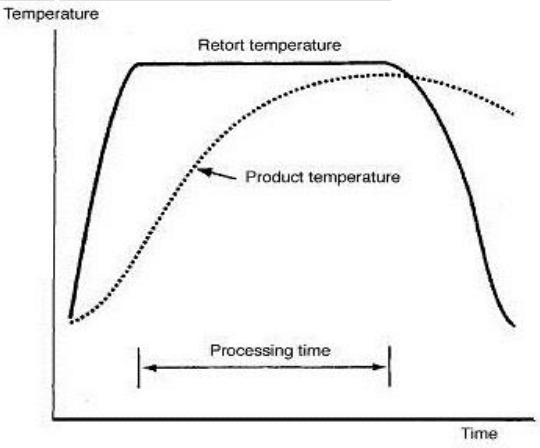

Fig. 9.5 Heat penetration into a can of conductive heating food

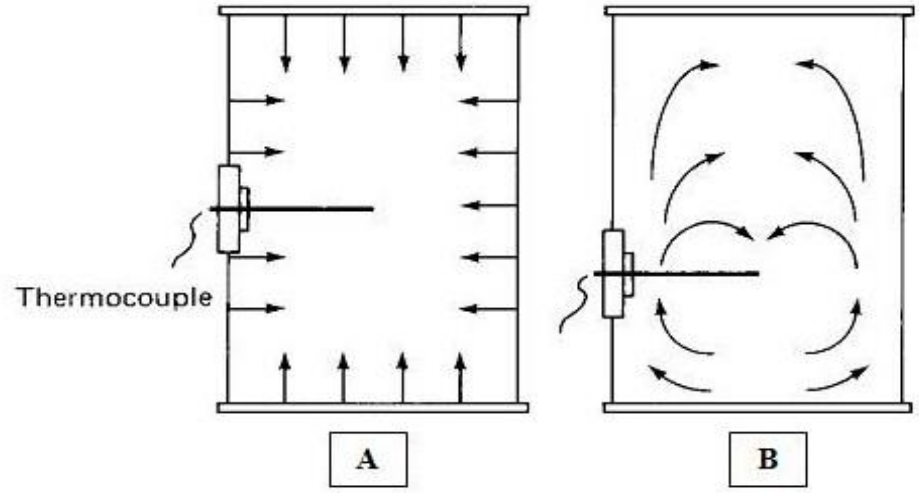

Fig. 9.6 Heat transfer into containers by conduction (A) and convection (B)

Cooling

Immediately after processing, cans are cooled to room temperature in cold water bath or water tank. Once cooling is carried out, the outer surface is dried and labeled.

CHEMICAL PRESERVATION OF FOOD

Introduction

Preservative for food may be defined as any chemical compound and/or process, when applied to food, retard alterations caused by the growth of microorganisms or enable the physical properties, chemical composition and nutritive value to remain unaffected by microbial growth. Some chemicals have been used traditionally since several decades as direct or indirect inhibitors of microbial growth and are still widely used despite their limitations

The majority of food preservation operations used today also employ some kind of chemical additive to reduce spoilage. Of the many dozens of chemical additives available, all are designed either to kill or retard the growth of pathogens or to prevent or retard chemical reactions that result in the oxidation of foods.

Some familiar examples of the former class of food additives are sodium benzoate and benzoic acid; calcium, sodium propionate, and propionic acid;calcium, potassium, sodium sorbate, and sorbic acid; and sodium and potassium sulfite. Examples of the latter class of additives include calcium, sodium ascorbate, and ascorbic acid (vitamin C); butylatedhydroxyanisole (BHA) and butylatedhydroxytoluene (BHT); lecithin; and sodium and potassium sulfite and sulphur dioxide.

Classification of Preservatives

According to FSSA rules → class I and class II preservatives

Class I preservatives

a. Common salt

b. Sugar

c. Dextrose

d. Glucose

e. Spices

f. Vinegar or acetic acid

g. Honey

h. Edible vegetable oil

Addition of class I preservatives in any food is not restricted, unless otherwise provide in the rule.

Class II preservatives

a. Benzoic acid including salts their of

b. Sulphurous acid including salts theirof

c. [Nitrates of] nitrites of sodium or potassium

d. Sorbic acid including its sodium, potassium and calcium salts

e. Nicin

f. Propionic acid including salts theirof

g. Methyl or propyl para-hydroxy benzoate

h. Sodium diacetate

i. Sodium, potassium and calcium salts of lactic acid

Use of class II preservatives is restricted. They shall be added to only specified product and at a concentration not exceeding the proportion specified for the product

Use of more than one class II preservative is prohibited. No person shall use in or upon a food more than one class II preservative

Benzoicacid and its salt

Widely use as an antimicrobial agent. Benzoate is more effective against yeasts and bacteria than molds. Antimicrobial activity is achieved by inhibition in enzymatic system of microbial cells, affecting acetic acid metabolism, citric acid cycle and oxidative phosphorylation.

Antimicrobial activity is affected by pH of medium The maximum inhibition occurs at pH value of 2.5 to 4.0 and it decreases when pH rises above 4.5.

The food products preserved with the benzoate include fruit juices and drinks, salads, jams and jellies, pickles, dried fruits and preserves, ketch up and sauce, syrup, carbonated beverages, bakery items, salad dressings, margarine and other fat spreads, spices.

Sulphurdioxideandsulfites

Sulphur dioxide (SO_2) gas is one of the oldest antimicrobial agents. It is a colourless, nonflammable gaseous compound or liquid under pressure with a suffocating pungent odour. When dissolved in water of foods, it yields sulphurous acid and its ions, owing to its solubility in water.

Sulphite salts such as sodium sulphite, sodium bisulphite, potassium sulphite, potassium bisulphite, sodium metabisulphite, potassium metabisulphite used as preservatives. When dissolved in water, form sulphurous acid, bisulphite and ions. Sulphurous acid formed from these compounds is an active antimicrobial substance. The effectiveness of sulphurous acid is enhanced at low pH values. Antimicrobial activity of sulfites against yeasts, molds and bacteria is selective, with certain species being more sensitive to inhibition them others. Bacteria are generally more sensitive to inhibition than yeasts and molds. In addition to antimicrobial action, they are also used, to prevent enzymatic and non enzymatic changes as well as discoloration in some foods. Sulphur dioxide and sulphites are used in fruit products such as fruit juice concentrate, squashes, pickles and chutneys.

Sorbicacidanditssalts

Sorbic acid and its salts (calcium, potassium or sodium salts) are effective antimicrobial agents against yeast and molds, as well as bacteria. They are less effective against bacteria. Sorbate has an upper pH limit for activity around 6.0-6.5. The food products preserved with sorbates are carbonated beverages, salad dressings, tomato products, jams, jellies, syrup, candy and chocolate syrup, cheese, sausages, smoked fish, fruit juices, grains, breads and cakes.

32.2.4 Propionic acid and its salts

Propionic acid & its salts (Ca& Na) are used most extensively in the prevention of mold growth and rope development in baked goods and for mold inhibition in many cheese foods and spreads. They are more effective against molds as compared to yeasts and bacteria. Propionates has an upper pH limit for activity around 5 to 6.

32.2.5 Lactic acid and its salts

Lactic acid is formed during fermentation of lactose by lactic acid bacteria. Lactic acid & its salts are not very common & not easily available. It can be used in pickles (with acetic acid), fermented dough crispy biscuits, some beverages, dairy products & meat & meat products. Calcium lactate is used as a firming agent in pickles, fruits & vegetables. Na & K lactate are also recommended with sodium diacetate for control of food poisoning & other bacteria in meat product.

Aceticacid

Acetic acid has antimicrobial properties. The action tends to be static rather than cidal. It is more effective against bacteria & yeast then molds. A 5 to 10 % solution of acetic acid is known as Vinegar. Acetic acid in the form of vinegar is used in mayonnaise, pickles, sauce, pickled sausage etc.

Sodiumchloride(commonsalt)

Antimicrobial action of NaCl arises from its lowering water activity (aw) of the food product. This reduces available water in food to the extent which renders condition unfavorable for microbial growth. At higher concentration it has a pronounced bacteriostatic action. The 10% NaCl inhibits the growth of most bacteria. Delaying action upon microorganisms- Creates dehydration of microbial cell—by osmosis—altering results into plasmosis of the cell. Reduction in solubility of oxygen in water decreases oxygen level in food—reduce growth of aerobic microorganisms. It is more effective against bacteria & mold compare to yeast.

One of the traditional method of food preservation. Mainly used to preserve pickles, meat & fish. Fish is usually salted by immersing in brine or by mixing with dry salt. High important as a preservative for cheese & table butter. Depending upon type of cheese salt content varied from 1 to 5 %. In table butter salt is added at a max concentration as 3%.

Sterilization

Sterilization can be defined as any process that effectively kills or eliminates transmissible agents (such as fungi, bacteria, viruses and prions) from a surface, equipment, foods, medications, or biological culture medium. In practice sterility is achieved by exposure of the object to be sterilized to chemical or physical agent for a specified time. Various agents used as steriliants are: elevated temperature, ionizing radiation, chemical liquids or gases etc. The success of the process depends upon the choice of the method adopted for sterilization.

Pharmaceutical Importance of Sterilization

• Moist heat sterilization is the most efficient biocidal agent. In the pharmaceutical industry it is used for: Surgical dressings, Sheets, Surgical and diagnostic equipment, Containers, Closures, Aqueous injections, Ophthalmic preparations and Irrigation fluids etc.

• Dry heat sterilization can only be used for thermo stable, moisture sensitive or moisture impermeable pharmaceutical and medicinal. These include products like; Dry powdered drugs, Suspensions of drug in non aqueous solvents, Oils, fats waxes, soft hard paraffin silicone, Oily injections, implants, ophthalmic ointments and ointment bases etc. • Gaseous sterilization is used for sterilizing thermolabile substances like; hormones, proteins, various heat sensitive drugs etc.

• U.V light is perhaps the most lethal component in ordinary sunlight used in sanitation of garments or utensils.

• Gamma-rays from Cobalt 60 are used to sterilize antibiotic, hormones, sutures, plastics and catheters etc.

• Filtration sterilizations are used in the treatment of heat sensitive injections and ophthalmic solutions, biological products, air and other gases for supply to aseptic areas. They are also used in industry as part of the venting systems on fermentors, centrifuges, autoclaves and freeze driers. Membrane filters are used for sterility testing.

1. The dryness of devices to be processed
2. The temperature and humidity of the processing area
3. Whether or not the devices were properly prepared and loaded into the sterilizer
4. Whether or not the sterilizing agent is properly delivered into the system
5. The sterilizer's condition and maintenance protocol 6. Whether or not the correct sterilization method and cycle were used

Methods of Sterilization The various methods of sterilization are:

1. Physical Method
 a. Thermal (Heat) methods
 b. Radiation method
c. Filtration method
2. Chemical Method a. Gaseous method

KARPAGAM ACADEMY OF HIGHER EDUCATION

CLASS: II B.Sc MB
COURSE CODE: 18MBU301

COURSE NAME: FOOD AND DAIRY MICROBIOLOGY
BATCH-2018-2021

UNIT 2						
S.NO	QUESTIONS	OPTION A	OPTION B	OPTION C	OPTION D	ANSWER
1	Which of the following factors will affect food spoilage?	infestation by rodents	light	enzymes and chemical reactions	all	all
2	Which is not an adverse effect on food by microbes?	good quality	colour	flavour	appearance	good quality
3	The process of treating and handling food to stop or greatly slow down the spoilage is	canning	exhausting	food preservation	drying	food preservation
4	The principle of food preservation in which destruction or inactivation of food enzymes is	antioxidant	by heat	asepsis	blanching	blanching
5	Which of the following will not come under physical method of food preservation?	souring	high pressure	irradiation	cooling	souring
6	Fermentation is a biological process of food preservation which is used for ___	cheese	cultured milk	butter	both a and b	both a and b
7	Temperature for pasteurization of milk for about 30 min is	71degree celcius	65deg celsius	90 deg celcius	130 deg celcius	65deg celcius
8	The principle of freezing and refrigeration preservation is___	killing microbes	slows down microbial activity	reduces water activity	inhibits chemicalreaction	slows down microbial activity

Prepared by R.Dineshkumar, Assistant Professor, Dept of Microbiology, KAHE.

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9	___ refers to the atmosphere surrounding a material or solution	water activity	relative humidity	vapour pressure	flash pasteurizaton	relative humidity
10	The radiation used for food preservation is normally from___	radioactive isotopes	machine generated x-rays	electron beams	all the above	all the above
11	Preservation of food through radiation causes___	extension of shelf-life	destroy food borne pathogens	insect disinfestation	all the above	all the above
12	The radionuclides used for food preservation is	cobalt 60	cesium 137	mercury 129	both a and b	both a and b
13	The quantity of radiation energy absorbed by the food as it passes through the radiation field during processing is___	gray	rad	radiation dose	Gy	radiation dose
14	In aseptic packaging for high acid products the package should withstand heat upto_	127deg celsius	150 deg celcius	100deg celcius	67 deg celcius	100deg celcius
15	In packaging ,low acid products should withstand pHlevel upto__	below 4.5	above 4.5	7	above 8.4	above 4.5
16	In microwave processing the oscillator tube used for the generation of microwaves is	kystron	magnetron	keltron	both b and c	both b and c
17	The mechanism of microwave heating is	dielectric	retorting	ionic	both a and c	both a and c

KARPAGAM ACADEMY OF HIGHER EDUCATION

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BATCH-2018-2021

18	A cylindrical diode with a ring of resonant cavities which produces electromagnetic radiation is	keltron	magnetron	kystron	all	magnetron
19	A vaccum tube in which the oscillation are generated by alternatively slowing down and speeding upon electron beam is	kystron	keltron	magnetron	none	keltron
20	Of the following which will not be done by the microwave processing?	thawing	lower capacity	smell free	speedy	lower capacity
21	Which of the following are used in the baking industry as a process of microwave processing	enzyme inactivation	freeze drying	solvent removal	all	all
22	Microwave processing technique doesn't involves the process of___	sterilization of milk	heat treatment of whey protein	plasticizing of fruits and vegetables	cooking of cut curd cubes	plasticizing of fruits and vegetables
23	Temperature in ultra pasteurization of milk is	1s at 89deg celcius	0.1 at 96deg celcius	0.01s at 100deg celcius	all the above	all the above
24	High pressure processing decimally can reduce the growth of	Salmonella typhimurium	Bacillus	Clostridium botulinum	Neisseria sp	Salmonella typhimurium
25	Which one is odd about the high pressure processing?	gel formation	protein construction	enzyme activation	microbes inactivation	protein construction
26	A type of high pressure eqipment which can be used for any kinds of food in in flexible packages, such asscups or bulk bags is	continuous type	batch type	PET	pressure vessel	batch type

KARPAGAM ACADEMY OF HIGHER EDUCATION

CLASS: II B.Sc MB
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COURSE NAME: FOOD AND DAIRY MICROBIOLOGY
BATCH-2018-2021

27	Monoblock is a pressure vessel made from a high tensile steel alloy can have a pressure of about	300-850MPa	165-354MPa	400-600MPa	248-350MPa	400-600MPa
28	Which is one is odd about high pressure processing?	isostatic pressure	adiabatic temperature	high energy consumption	retention of flavour of product	high energy consumption
29	The amount of aminoacid level in cheddar cheese made after 3 days wil be___	21.3mg/g	26.5mg/g	42.8mg/g	19.2mg/g	26.5mg/g
30	Who is the father of canning process?	Nicholas Appert	Pasteur	Weizmann	Koch	Nicholas Appert
31	The process of sealing fruits and vegetables or any other food stuff in airtight containers and sterilizing them by heat for long storage is called	food preservation	exhausting	canning	high presure sterilisation	canning
32	Nicholas Appert invented canning process in the year of	1964	1924	1902	1904	1904
33	The thickness of tin metal coating inside the cans is of	1.54mm	2.50mm	0.25mm	4.02mm	0.25
34	A type of can filling which is a low mettaloid steel ,used for moderate acid food	type L	type MR	type MC	none	type MR
35	A can filling type ,of high purity steel with low metaloid used for highly acidic food is	type L	type MR	type MC	none	type L

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36	A type of can filling ,similar to MRtype but has high phosphorous content and used forlow acid foods	type L	type MR	type MC	none	type MC
37	The process of coating of inner side of the can to prevent discolouration of the product is	coating	lacquering	syruping	brining	lacquering
38	Which of the following is not packed in acid resistant cans?	corns	raspberry	strawberry	red plum	corns
39	which of the following will be packed in sulphur resistant cans?	coloured grapes	beans	red plum	raspberry	beans
40	The strength of syrup is measured by ___	salometer	hydrometer	refractometer	both b and c	both b and c
41	The strength of brine is measured using	salinometer	refractometer	salometer	both a and c	both a and c
42	The process of heating the can and can contents before sealing is	processing of cans	exhausting	can filling	sterilisation	exhausting
43	The process of heating of canned foods(foodstuff) to inactivate bacteria is known as	retorting	syruping	processing of cans	both a and c	both a and c
44	The time neede to destroy 90% of the microbes is refferred to as	F value	z value	D value	none	D value
45	The time required to acheive a specified reduction in microbial numbers at a given temperature is called___	F value	z value	D value	none	F value

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46	D value of Bacillus cereus will be	3.0min	3.9min	4.1min	0.7min	3.9min
47	Contamination of low acid foods is by__	Clostridium sporogenes	Bacillus cereus	Psychrophilic	thermophilic	Psychrophilic
48	z value of Clostridium botulinum toxins is	*7.2*	5.5	36	10	5.5
49	Rate of heat penetration will be influenced by	agitation of the container	type of container	type of product	all the above	all the above
50	The chemical which will retard the growth of pathogens is	sodium propionate	lecithin	pottasium sulfite	sulfur dioxide	sodium propionate
51	The chemmical which will retard chemical reactions that result in oxidation of foods	ascorbic acid	sodium benzoate	propionic acid	sodium sorbate	ascorbic acid
52	which of the following is a class 1 preservative ,is not prohibited by FSSA_	nicin	sodium diacetate	honey	sorbic acid	honey
53	Which is a class 2 preservative ,prohibited by FSSA_	vinegar	sugar	propionic acid	spices	propionic acid
54	____is more effective to yeasts and molds	benzoic acid	vinegar	spices	sugar	benzoic acid
55	A suffogating pungent odour gas which is used in fruit juice concentrate,pickles is	sorbia acid	SO2	acetic acid	lactic acid	SO2

Fermented Milk Products

The primary function of fermenting milk was, originally, to extend its shelf life. With this came numerous advantages, such as an improved taste and enhanced digestibility of the milk, as well as the manufacture of a wide variety of products. Historically the fermentation of milk can be traced back to around 10 000 B.C. It is likely that fermentation initially arose spontaneously from indigenous microflora found in milk. Fortunately, the bacteria were lactococci and lactobacilli which typically suppress spoilage and pathogenic organisms effectively. The evolution of these products likely came as a result of the climate of the region in which they were produced: thermophilic lactic acid fermentation favours the heat of the sub-tropics; mesophilic lactic acid fermentation occurs at cooler temperatures. Today the fermentations are controlled with specific starter cultures and conditions. Some of the many fermented milk products are: acidophilus milk, crème fraîche, cultured buttermilk, kefir, koumiss, filmjölk, sour cream, and viili. Yogurt and cheese are also fermented milk products. More detail on yogurt and cheese can be found under their specific ingredient profiles.

Fermented milk products can be classified into 3 categories:

- viscous products
- beverage products
- carbonated products

Within these categories, the fermented milk products may be fresh, or have an extended shelf life. The fresh products contain live starter culture bacteria, including probiotics, while the extended shelf life products contain no live microorganisms.

Product	Typical Shelf Life (4°C)*
Acidophilus Milk	2 wks
Cultured Buttermilk	10 d
Sour Cream	4 wks

Kefir	10-14 d
Koumiss	10-14 d
Filmjölk	10-14 d
Viili	14 d
Crème Fraîche	10 d

***The shelf life may vary with manufacturers.**

There are numerous factors which affect the outcome of the product including the chemical composition of the milk, additives and starter cultures used, as well as the processing of the product. They affect the ultimate flavour, texture, and consistency of the final product. It is not uncommon for the manufacturer to add stabilizers such as pectins and gums, in order to avoid the sedimentation of milks solids and the separation of whey in the package, while improving the mouthfeel of the product.

The general process by which fermented milk products are made begins with a preliminary treatment of milk which may include clarification, fat separation and standardization, and evaporation. Processing follows next, with de-aeration, homogenization, and pasteurization. The milk is then cooled to the appropriate fermentation temperature and starter cultures are added.

Starter cultures differ for each product. They consist of microorganisms added to the milk to provide specific characteristics in the finished fermented milk product in a controlled and predictable manner. The primary function of lactic acid starters is to ferment lactose into lactic acid, but they may also contribute to flavour, aroma and alcohol production, while inhibiting spoilage microorganisms. A single strain of bacteria may be added, or a mixture of several microorganisms may be introduced. The bacteria, yeasts and moulds work at different temperatures as well. Thermophilic lactic acid fermentation favour hot temperatures (40-45°C) while mesophilic lactic acid fermentation occurs at cooler temperatures (25 and 40°C).

As the starter cultures grow within the milk, fermentation takes place. Fermentation is the chemical conversion of carbohydrates into alcohols or acids. In fermented milk products both alcohol and lactic acid may be produced, like in kefir and koumiss, or just lactic acid, like in sour cream. The bacteria ingest the lactose (milk sugar), and release lactic acid as waste causing the acidity to increase. This rise in acidity causes the milk proteins to denature (unfold) and tangle themselves into masses (curds) while also inhibiting the growth of other organisms that are not acid tolerant. Following the completion of fermentation, flavourings can be added and the products are packaged, labeled and put into cold storage before being sent to stores.

Characteristics

- **Kefir** is a milk product traditionally fermented by "kefir grains". The grains are curds which act as a starter culture in each batch of kefir. These grains contain active microorganisms and when added to fresh milk, they produce kefir. Kefir grains have a complex microbial composition consisting of 83-90% lactic acid bacteria and 10-17% yeast, as well as acetic acid bacteria and possibly mould. Commercial starter cultures have been developed that allow production to be made more efficient and may also provide a longer shelf life for the product. The fermentation of the lactose by the microorganisms yields a sour, carbonated, slightly alcoholic beverage with the consistency of thin yogurt. It is white or yellowish in colour with a yeasty aroma. The taste is acidic, but refreshing with compounds including lactic acid, diacetyl, carbon dioxide and ethanol influencing its sensory properties. Kefir is sometimes commercially available without carbonation and alcohol (when yeast is not added to the starter culture), resulting in a product that is very similar to yogurt. Its composition and flavour is dependent on milk type and lactic acid content in the final product. Typical milks used for kefir include cow, goat, and sheep, with each eliciting varying nutritional and sensory qualities.

- **Koumiss** (koumiss, kumiss, kumis, kymis, kymmyz) is a fermented drink traditionally made from the milk of horses by people in Central Asia and from camel's milk in Mongolia. The word *koumiss* is thought to derive from the name of the Turkic Kumyks people. The capital of Kyrgyzstan, Bishkek, is named after the paddle used to churn the fermenting milk, showing the importance of the drink in the national culture. It would have been originally fermented in a horse hide bag which would have contained the microflora from the previous batch. Koumiss is similar to kefir, but is not produced using "grains", but using a liquid starter culture composed of lactobacilli and non-lactose-fermenting yeasts instead.

- As mare's milk has higher sugar content than cow's and goat's milk, the resulting koumiss has a slightly higher alcohol content than kefir. Today, cow's milk is generally used for koumiss, with the addition of sugar to better approximate the composition of mare's milk.

Koumiss is a milky white liquid with a grayish cast and is very light in body compared to most dairy beverages. It has a slightly sour flavour from lactic acid, and ethyl alcohol, and a fizziness from carbon dioxide.

- **Filmjölk** is Swedish fermented milk. Fermented milk products have a long history in the Scandinavian countries, dating back to the Vikings. Traditional fermented milks of the Nordic countries are fermented at lower temperatures by mesophilic bacteria (specifically). Filmjölk is the modern variant of the traditional surmjölk. It is the most common fermented milk in Sweden and is frequently consumed for breakfast or lunch. Filmjölk is similar to yogurt or kefir, but it is fermented using different strains of bacteria, giving it a unique flavour. Filmjölk is a spoonable, semi-solid product made with standardized fat contents. It has a mild, slightly acidic flavour, with aromas from diacetyl and carbon dioxide.

- **Viili** is traditional Finnish fermented milk made from unhomogenized milk. As the milk begins to ferment a layer of cream rises to the surface and a surface growing mould, *Geo trichum candidum*, forms a thin velvety surface. Viili is inoculated with a starter culture containing *Laco bacillus lactis* subsp. *cremoris* that creates its ropy character. It is advised that viili be eaten with a tablespoon so that it can be cut into portions. If it is mixed or eaten with a teaspoon the texture becomes ropy, making it difficult to consume. Viili has a mild acidic flavour and aroma with a thick consistency that maintains its shape without collapsing when placed on a plate.

- **Acidophilus milk** is typically low fat or nonfat milk to which active cultures of *Lactobacillus acidophilus* have been added. The milk can be refrigerated to prevent further growth of the harmless bacteria producing sweet acidophilus milk. It can also be incubated at 38°C until a curd forms. *Bifido bacterium bifidum* may also be included.

- **Cultured Buttermilk** has been produced as long as butter has been made. Traditionally butter was made by churning milk or cream, but an improved method for fermenting milk became the preferred method for cultured buttermilk production. Cultured buttermilk is pasteurized skim milk fermented by a lactic acid bacteria culture (*Lactobacillus lactis* sub sp. *lactis*, *Lactobacillus lactis* sub sp. *cremoris*, and *Lactobacillus lactis* sub sp *lactis* biovar. *diacetylactis*, and *Leuconostoc mesenteroides* sub sp. *cremoris*) and by aroma bacteria. It possesses a mild acid flavour with a diacetyl overtone and a smooth texture. Cultured buttermilk has a soft white colour and may contain added butter flakes, fruit condiments, or flavourings.

- **Sour Cream** is an extremely viscous product that has been used for many years in a great number of countries. Traditionally, cream was left to sour, but today sour cream is made by lactic acid fermentation of cream using *Streptococcus lactis*, with or without the addition of rennet to create a thicker product. Stabilizers may be added to improve and maintain the consistency. Sour cream has a mild, subtle, tangy flavour and aroma which is similar to cultured buttermilk. It has a smooth, thick body and typically has a fat content of 10-14%. Lower fat varieties are also produced. Sour cream has a limited shelf life due to yeast and mould growth. The shelf life can be extended by a heat treatment after the fermentation has taken place.

- **Crème fraîche** is French for fresh cream. It is mild in taste and slightly acidic, with a smooth, rich, thick texture. It is made in the same manner as sour cream, and used for many of the same applications. It is higher in fat content (usually 30-40% fat) and as a result crème fraîche can be whisked into whipped cream. It also has a high enough fat content and low enough protein content that it can be cooked directly without curdling.

Varieties

- **Kefir** is made most often from partially skimmed cow's milk. It can be packaged either as natural or plain kefir with no added fruit or flavours or as flavoured kefir. The final product contains live bacteria and yeasts that produce carbon dioxide gas. This gas production gives kefir a "sparkling" sensation on the tongue when eaten. Kefir has been referred to as the champagne of fermented dairy products.

- **Koumiss:** Mare's milk has higher sugar content than cow's and goat's milk, and as a result koumiss has a slightly higher alcohol content than kefir. Today, cow's milk is generally used for koumiss, with the addition of sugar to better approximate the composition of mare's milk.

- **Cultured Buttermilk** may contain added butter flakes, fruit condiments, or flavourings. It is also available with different fat contents.

- **Viili** comes in a wide range of varieties, including products of different fat content, lactose-reduced varieties and flavoured versions. Viili can be made from homogenized milk and without mould growing on the surface.

- **Sour cream** comes in full fat (minimum 14% fat), low fat and fat free varieties.

- **Filmjölk** has fruit flavoured variants and can have the addition of beneficial probiotic bacteria such as *Bifido bacterium lactis* and many species of lactobacilli.

Composition

Based on 100 g	Kefir (100 g)			Sour Cream		
	2%	0%	3.80%	Full Fat	Low Fat	Fat-Free
Fat	2.0 g	0 g	3.2 g	20.1 g	10.6 g	0 g
Protein	3.4 g	3.2 g	3.2 g	3.1 g	3.5 g	3.1 g
Carbohydrates	4.6 g	4.8 g	7.2 g	4.3 g	7.1 g	15.6 g
Sugar	3.4 g	4 g	4 g	0.16 g	0.22 g	0.39 g
Calcium	220 mg	165 mg	165 mg	116 mg	141 mg	125 mg

Based on 100 g	Cultured Buttermilk		Acidophilus milk (2%)	Crème Fraîche
	Low Fat	Fat Free		
Fat	2.0 g	0.88 g	3.8 g	38.7 g
Protein	4.1 g	3.3 g	1 g	1.8 g
Carbohydrates	5.3 g	4.8 g	5.4 g	2.5 g
Sugar	5.3 g	4.8 g	5 g	2.5 g
Calcium	143 mg	116 mg	125 mg	60 mg

Based on 100 g	Koumiss (mare's milk)	Koumiss (cow's milk)
Fat	1.1 g	3.9 g
Protein	3.5 g	3.3 g
Carbohydrates	6.1 g	4.7 g
Sugar	6.1 g	4.7 g
Calcium	90 mg	~120 mg

Viili and filmjölk likely have compositions similar to kefir depending on the level of milk fat used to prepare them.

Various Uses

Kefir and **Koumiss** can be used in smoothies, salad dressings, and sauces. They can be added to baked goods such as pancakes, waffles, and breads, or in soups and desserts as a replacement for other milk products such as yogurt or buttermilk. They are also delicious mixed with fresh fruit or cereal as a breakfast, lunch or snack. They all make refreshing beverages on their own or mixed with fruits, honey, maple syrup, iced coffees and teas as well as other sweeteners and flavours **Filmjölk** is eaten in the same way as yogurt, usually from a bowl using a spoon. It is sometimes drunk as a thick beverage. Many people add sugar, jam, applesauce, cinnamon or berries. Cereals, corn flakes or muesli are often added to filmjölk. In northern regions of Sweden, crushed crisp bread is sometimes put into it. It could be used in smoothies, salad dressings and sauces, as well as in baked goods.

Cultured Buttermilk is a versatile ingredient in baking. It works very well in biscuits, breads, and desserts. Cultured buttermilk is often used in salad dressings and sauces, stirred into mashed potatoes and soups and it has even been used to make tangy buttermilk ice cream. It is also considered a refreshing beverage.

Sour Cream has numerous applications. It is commonly used as a base for dips, salad dressings and sauces. It is eaten as a condiment on potatoes, chili, or with smoked salmon, as well as many other foods. Sour cream can be used in soups and works well in baked products like breads, cakes, pies and cookies. Sour cream has significantly less calories than mayonnaise and performs many similar functions. In Russian cuisine, sour cream is often added to borscht and other soups. In Tex-Mex cuisine, it is often added to tacos, nachos, burritos, taquitos or guacamole. Hungarian cooks use it as an ingredient in sauces and in recipes such as ham-filled crepes.

Crème Fraîche has similar uses to sour cream, however it's sweeter flavour makes it particularly well suited to desserts, as a topping, or as a base for other flavours. Crème fraîche works well in dips, dressings and sauces or as an addition to soups.

Viili is consumed fresh and chilled, in the same way as yogurt, and can be topped with fruits, nuts, or cereal, as well as other flavourings like spices, sugar and honey. Viili may be added to smoothies, or used in baked goods. It may also be flavoured like yogurt.

Acidophilus milk is consumed as a beverage by the glass, or added to cereal. It has been used to make egg nog. Acidophilus milk also works well in sauces and desserts.

Functional Properties

Fermented milk products have numerous functional properties:

- **Preservation:** bacteria are inhibited from growing through pH reduction when lactic acid is formed, and shelf life is increased
- **Flavour Enhancement:** the sour characteristic of fermented milk products comes from fermentation products (lactic acid, diactyl, carbon dioxide, ethanol); these products act as excellent flavour carriers for herbs, spices and other flavourings
- **Texture Enhancement:** some fermented milk products (sour cream or crème fraîche) can add body and thickness to sauces, dips or vinagrettes
- **Reducing Caloric Content:** many fermented milk products come in low fat or fat free varieties and can be used to substitute for higher fat ingredients
- **Emulsification:** milk proteins help stabilize fat emulsions in salad dressings, soups and cakes
- **Foaming and Whipping:** crème fraîche is capable of being whipped like whip cream
- **Nutritional benefits:** fermented milk products may contain probiotics (bacteria that are beneficial to health) as well as many vitamins and minerals.

Microbial pathogens of major concern

Fermented products are rarely associated with food-borne disease as their pH is too low and the lactic acid concentration too high to permit growth of vegetative pathogens and death of non-growing cells is likely to be rapid. However, consumption of yoghurt containing large numbers of yeasts can lead to digestive disturbances. The limited outbreaks of food-borne illness that have been reported typically have involved *S. aureus*, *C. botulinum* and *E. coli* 0157:H7. Slow growth by the starter culture provides an opportunity for growth of pathogens that contaminate the milk or ingredients, for example, staphylococcal toxin may accumulate in the ingredients where too much sugar inhibited the growth of starters but not the growth of S. aureus, resulting in illness. In yoghurt outbreak, under processing of canned hazel-nut puree used to flavor the yoghurt caused growth and toxigenesis of *C. botulinum* spores in the puree. In addition the sugar in the ingredients was replaced by aspartame, leading to an increase in water activity to a level allowing growth of the pathogen. From a number of microbiological surveys of cultured and fermented milk products identified in the literature, only one reported the positive identification of a pathogen (*Y. enterocolitica* in fermented cow's milk)

Yoghurt

Yoghurt and fermented milk products are prepared by fermentation of milk or milk products using specific micro-organisms that reduce the pH and coagulate milk proteins. Yoghurt is characterized by fermentation with thermoduric *S. salivariu* subsp. *thermophilus* and *L. delbrueckii* subsp. *bulgaricus* with or without other lactic acid producing bacteria. Fermented milk products include yoghurt, cultured buttermilk, cream (sour cream) and acidophilus milk.

Cheese

The term cheese covers over 1,000 varieties of fermented dairy products with significant variations in their flavors, texture and appearance. The process of converting liquid milk into cheese involves a series of steps that are modified to produce a cheese of the desired characteristics. Starter culture and rennet are added to milk resulting in the production of a cheese curd through a process of coagulation and acidification. The curds are usually cut and with mild (38-43°C) heating there is separation of the whey which is drained from the curds. The curds are salted before they are pressed into moulds and then stored under controlled conditions to ripen the cheese. Cheese may be grouped according to manufacturing or processing procedures, consistency or rheology, country of origin, general appearance, sources of milk and chemical analysis.

Microbial pathogens of major concern in cheeses

Cheese has been the vehicle in a number of outbreaks of food-borne illness, involving pathogenic micro-organisms such as *Bacillus* spp., *Brucella* spp., *C. botulinum, E. coli, L. monocytogenes, Salmonella, Shigella* and *S. aureus*. Evidence from outbreak investigations suggests that illness resulting from consumption of cheese is often the result of faulty controls in cheese production; use of contaminated starter cultures or contaminated ingredients; post-pasteurization contamination; or mishandling during transportation and/or distribution. In microbiological surveys conducted overseas and a number of potential pathogens have been detected in cheeses made from pasteurized milk, namely *L. monocytogenes* and *S. aureus*. Additional pathogens have been detected in raw milk cheese (*B, cereus, Brucella spp., pathogenic E. coli* and *Y. enterocolitica). Bacillus* spp. and *L. monocytogenes* have been detected in pasteurized milk cheeses.

Indigenous Dairy Products

Khoa

Khoa a partially dehydrated milk product is prepared from whole milk by continuous heating in an iron cauldron ('karahi') over a direct fire or in a steam kettle. It is consistently stirred and scraped with a spatula during heating till a semi-solid (doughy) consistency is obtained. The desirable consistency is achieved when the product shows sign of leaving the bottom and sides of karahi. After removing from the fire, the contents are worked up in a solid mass which is now called khoa or mawa. Depending on the method of preparation three varieties of khoa are available, viz. 1) pindi, 2) dhap and 3) danedar. These varieties differ in composition and texture and are made use of in preparing different sweets, viz., burfi and peda (from pindi); gulabjamun and pantoa (from dhap) and kalakand (from danedar).

Microbiological quality of khoa

Khoa, like other indigenous products such as chhana, kheer, dahi, etc., can serve as a favourable medium for the growth of a variety of microorganisms because of high moisture content and good nutritive value. The market khoa keeps well for 48 hours under usual Indian conditions of handling and storage. However, storage beyond this period often results into deterioration due to microbial action. These microorganisms gain access into this product as contaminants from different sources. Various groups of bacteria (acid producers, proteolytic, chromogenic, lipolytic, aerobic spore formers, psychrotrophs, thermophiles and pathogens), yeast and moulds grow profusely on khoa. The rapid spoilage of khoa is attributed to contamination with moulds from external sources.

Pathogen sof major concern

A number of pathogens like *E. coli, S. typhi, S. dysenteriae* and *V. cholerae* are able to survive for long periods during storage of khoa. Subsequently, a number of related studies have revealed the occurrence of *staphylococci*, especially those of coagulase positive types in khoa. The *staphylococcus* has been known to produce heat stable enterotoxin in this product which causes food poisoning. Since the product is manufactured by traditional method without any regard to quality of raw material used and hygienic storage, the shelf life of the product is adversely affected by the thermoduric organisms and organisms acquired during storage.

High nutritional value and high water activity (aw = 0.96) of khoa is conducive to the growth of bacteria. Microbial content of heat dried dairy product is temperature dependent and time of preheating evaporation process is also an predisposing factor contamination and growth during storage also affect microbial population of heat dried dairy products. Psychrotrophic bacteria may also affect quality and flavour of heat-treated product, some heat tolerant enzymes produced by some psychrotrophic species cause spoilage both before and after heating. Microbes produce undesirable effects like change in odour, colour, taste and texture of food. Besides, this contamination of products with pathogenic bacteria can result into outbreaks of gastrointestinal infection and thus threat to consumer. A plethora of studies carried out in different part of India evidenced that pathogenic organism as *B. cereus, S. aureus* often contaminate khoa. Probably the microbe's access to khoa is mainly by improper handling of workers and contaminated utensils used during processing. In a study total fifty samples of khoa were brought from different localities of Chambal region at random and processed. Bacterial colony counts were also performed. Staphylococcus species and Streptococcus species were the predominant isolates. The viable counts obtained ranged from 1.3×104 to 2.1×106 CFU/g. Contamination of khoa by pathogenic bacteria could be an important factor of gastrointestinal infections including food poisoning and food borne illness. E.coli was isolated from milk products like mawa/ khoa, cream, dahi, cheese, butter and gulabjamun.

12 (60%) of mawa/ khoa samples were contaminated with *E. coli* in contrast to 11 (55%) of dahi followed by 8 (40%) gulabjamun samples. Microbiological quality of market milk sweets in twin cities of Hyderabad and Secunderabad and observed 90% of peda, 75% of kalakand and 100% of rasagolla samples were contaminated with yeasts and moulds. That peda in general had more bacterial contamination than burfi contaminated with *E. coli, P. aerogenes, S. flexneri, S. schottmuelleri* and hemolytic *streptococci.* Investigated 50 samples of peda randomly collected from various shops of Amravati city and analysed for bacteriological quality. Out of 92 strains of bacteria identified, the prominent were *P. aerogenosa* (23.91%), *S. aureus* (17.39%), *S. typhi*(16.30%), *E. coli* (14.13%), *E. aerogenes* (11.9%), S*higella flexneri* (8.69%), *Proteus vulgaris* (7.6%),etc.

Paneer

Paneer is an important indigenous coagulated milk product prepared by the combined action of acid coagulation and heat treatment of cow or buffalo milk or a combination thereof (milk solids and suitably processed may be used). The phenomenon of precipitation involves the formation of large structural aggregates of proteins in which milk fat and other colloidal and soluble solids are entrapped along with whey. According to PFA Rules, 1955 paneer is a product obtained from cow or buffalo milk or a combination thereof by precipitation with sour milk, lactic acid or citric acid. It shall not contain more than 70% moisture and the milk fat content shall not be less than 50% of the dry matter. Skim milk is also recommended for the preparation of paneer where cow or buffalo milk is precipitated with sour milk, lactic acid or citric acid. The product shall not contain more than 70% moisture and milk fat content shall not be more than 13% of the dry matter.

Microbial pathogens of major concern

Microbiological quality of Paneer, like other indigenous milk products, chiefly depends on the condition of manufacture, subsequent handling, storage and sale of the product. The possible sources of contamination might be air, water, utensils, cutting knife, muslin cloth as well as persons handling the product. Hence the number and types of microorganisms and their distribution in the product may vary depending on the location of the sweetmeat maker (halwai) shop, extent of exposure of the product to the atmosphere, temperature and period of storage, etc. Despite a higher final temperature (62°C) the duration of heating employed in the manufacture of Indian cheese (Paneer) was not sufficient to inactivate *E. coli* O157:H7. In a study 60 market dairy food samples, one sample each of raw milk, paneer and ice cream were found to be positive for *E. coli* O157:H7 with respective RT-PCR counts of 6.7, 6.2 and 5.9 log CFU respectively. Paneer is used in the preparation of certain curries and about 5% of the milk produced is converted to paneer. It may contain as high as 70% moisture which is conducive to microbial growth. Studies carried out on microbial quality of paneer have indicated that it is often contaminated with S. aureus and coliforms. The HACCP has been applied to identify the Critical Control Point for coliforms and Staphylococcus contamination.

Chhana

Chhana is one of the two chief bases (the other being khoa) for preparing a variety of indigenous sweetmeats. Chhana is also called paneer in certain parts of the country. However, the only difference between paneer and chhana preparation is that pressing is avoided in the latter which gives a loose texture to chhana unlike paneer. The PFA and ISI definitions of paneer also apply to chhana.

Microflora of major concern

Chhana samples showed an average bacterial count of 1.6 ×104 per gram. However, during storage at 37°C, the count increased to 31×106 and 110 × 106 at the end of 24 and 48 hours, respectively. The spoilage of product was chiefly due to thermoduric bacteria. Among the bacterial types isolated from chhana *micrococci* predominated and constituted 45% of the total microflora followed by spore formers (34%).

Casein, Whey Products and Other Functional Milk Derivatives

An increasing awareness of the nutritional and health benefits of dairy products has driven the development of markets for a wide array of functional and nutritional ingredients derived from milk. Improvements in fractionation technologies have allowed the manufacture of these on a commercial basis from surplus milk and other dairy by-products.

Microflora of major concern

Pathogens of concern in the production of skim milk and skim milk powder include *Salmonella, L. monocytogenes, B. cereus, C. perfringens* and *E. sakazakii*. Casein and whey products produced from skim milk might contain spores of bacilli and *clostridia* and cells of other pathogens might survive extended periods in the dried products if present, although growth will not occur. A microbiological survey of dairy products conducted overseas detected *B. cereus* in whey powder. Products formed from severely temperature-abused milk might contain *S. aureus* enterotoxin, which is exceptionally heat stable, but this is unlikely to occur in a well-regulated processing environment. Fat-enriched milk fractions e.g. anhydrous milk-fat (AMF) may protect pathogenic microorganisms such as *E. coli, Salmonella* or *Listeria*, if present. However this is unlikely given the low moisture content of the product.

IDLY

Microflora associated with fermentation of IDLY

1. The micro-organism developing during the initial soaking of ingredients are sufficient to carry out fermentation.
2. Both bacteria and yeast play important role in fermentation. Bacteria are responsible for acid and gas production where as yeast is responsible for organoleptic quality.
3. Gram dal is effective substrate for maximum number of fermentation organism and it has high number of nutrients that support growth of lactic acid bacteria.
4. Bacteria associated are *Leucono stocmesenteroides, Lactobacillus coryniformis, Lactobacillus delbrueckii, Lactobacillus fermentum, Lactobacillus lactis.*
5. Yeast associated with fermentation are *Saccharomyces cerevisiae, Torulopsis candida, Trichosporon pullulans, Debaryomycestamarii.*
6. The role of lactic acid bacteria is to reduce pH of batter to level 4.4 to 4.5 and this pH is optimum for yeast activity

Biochemical changes

1. There are two major changes and that are Leaving and acidification. In the process of leaving during fermentation the volume of batter increases from 1 to 3 times of original. Acidification in this process the lactic acid is produced.
2. During the fermentation the volume of idli batter takes place. The idli batter increase to 1.6 to 3.1 than original volume.
3. The pH value decreases from 6 to 4.3 – 5.3. Theirs is a slight increase in level of soluble salts and non-protein nitrogen.
4. The level of soluble nitrogen and free amino – acid gets increased. The essential amino-acid increase like choline, methionine, cystine, vitamin C

Sauerkraut fermentation

The first stage of sauerkraut fermentation involves anaerobic bacteria, which is why the shredded cabbage and salt need to be packed in an airtight container. At this stage the surrounding environment is not acidic, just cabbagey. The bacteria, mostly *Leuconostoc* species, produce carbon dioxide (replacing the last vestiges of oxygen in the jar) and lactic acid, which is a natural byproduct of anaerobic respiration. Eventually, the conditions within the jar become too acidic for these bacteria to survive and they die out, replaced with bacteria that can better handle the acidic conditions such as *Lactobacillus* species.

The *lactobacillus* further ferment any sugars remaining in the cabbage, using anaerobic respiration. This produces more lactic acid, until the sauerkraut reaches a pH of about 3. These bacteria are inhibited by high salt concentrations (so most sauerkraut contains around 2-3% salt) and low temperatures, which is why the fermenting jars should be left at room temperature rather than in the fridge. At pH3 the l*actobacillus* stop fermenting and the sauerkraut can be stored until needed.

All the these bacteria help to create the tangy acidic taste, however there are ways that microbial growth can go wrong. Overgrowth of the *lactobacillus*, for example if the jar is stored at too high a temperature during fermentation, can cause the sauerkraut to form the wrong consistency. Likewise if the sauerkraut gets too acidic too early the *lactobacillus* get in on the action early leading to soft sauerkraut. Although the finished sauerkraut is far too acidic for pathogens to live in, fungal spores may settle on the surface and spread, spoiling the food.

Although sauerkraut is a German word, the dish is thought to have originated in China with cabbage fermented in rice wine or brine. This spread to Europe by way of Ghengis Khan's invaders where the cabbage was dry cured with salt. As sauerkraut keeps for long periods, and is a source of vitamin C, it was favoured by the Dutch sailors, who took it with them when they travelled to America. Captain Cook also travelled with it to Australia, as sauerkraut contains a range of vitamins and minerals that are difficult to obtain when travelling for long periods at sea.

As the bacteria required for sauerkraut fermentation are found on the cabbage leaves, it's a very easy and healthy dish to produce. All you need is cabbage! By exploiting the actions of bacteria simple ingredients such as cabbage and salty water can be used to produce a healthy dish that can be stored long past the time when raw fruit and vegetables will have begun to spoil.

Soy sauce

Soy sauce is a liquid condiment of Chinese origin, made from a fermented paste of soybeans, roasted grain, brine, and Aspergillus oryzae or Aspergillus soja emolds. Soy sauce in its current form was created about 2,200 years ago during the Western Han dynasty of ancient China, and spread throughout East and Southeast Asia where it is used in cooking and as a condiment. They contain

- *Aspergillus*: a genus of fungus that is used for fermenting various ingredients (the cultures are called *koji* in Japanese). Three species are used for brewing soy sauce:
  - *A. oryzae*: Strains with high proteolytic capacity are used for brewing soy sauce.
  - *A. sojae*: This fungus also has a high proteolytic capacity.
  - *A. tamarii*: This fungus is used for brewing tamari, a variety of soy sauce.
- *Saccharomyces cerevisiae*: the yeasts in the culture convert some of the sugars to ethanol which can undergo secondary reactions to make other flavor compounds
- Other microbes contained in the culture:
  - *Bacillus spp*. (genus): This organism is likely to grow soy sauce ingredients, and to generate odors and ammonia.
  - *Lactobacillus species*: This organism makes a lactic acid that increases the acidity in the feed

Chemical composition

The chemical composition of soy sauce can be affected easily by raw materials, fermentation methodologies, fermenting molds and strains, and post-fermentation treatments.

- Although the formation mechanism of chemical composition in soy sauce is complex, it has been widely accepted that free amino acids, water soluble peptides and Maillard reaction products in soy sauce are considered as essential chemical composition and to provide core sensory effects.

The primary fermentation of lactic-acid-fermenting halophiles has lower the pH of the moromi, and this has directly resulted in an acidic pH range (4.4–5.4) of soy sauce products. The secondary fermentation conducted by hetero fermentative microbes provides soy sauce with a wide range of flavor and odorant compounds by breaking down macro-nutrients. Soy proteins and grain proteins are hydrolyzed into short peptide chain and free amino acids, which adds umami taste to the product. Based on the result of free amino acid analysis, the most abundant amino acids in Chinese soy sauce product are glutamic acid, aspartic acid, alanine and leucine.

- Starch is hydrolyzed into simple sugars which contribute to the sweet flavor in soy sauce. Legume fats may also have been decomposed into short chain fatty acids, and the interaction among lipid and other macronutrients also result in richer flavor in the final product.
- Non-enzymatic browning also contributes significantly to the property development of soy sauce. The hydrolysis of protein and large carbohydrates has provided free amino acids and simple sugars as reagents for Maillard reaction
  - **Probiotics**
  - **Probiotics** are live microorganisms intended to provide health benefits when consumed, generally by improving or restoring the gut flora. Probiotics are considered generally safe to consume, but may cause bacteria-host interactions and unwanted side effects in rare cases.
  - The original theory, similar to the modern concept, but not the term, is generally attributed to Nobel laureate Élie Metchnikoff, who postulated that yoghurt-consuming Bulgarian peasants lived longer lives because of that custom. In 1907, he wrote: "The dependence of the intestinal microbes on the food makes it possible to adopt measures to modify the microbiota in our bodies and to replace the harmful microbes by useful microbes.

A growing probiotics market has led to the need for stricter requirements for scientific substantiation of putative benefits conferred by microorganisms claimed to be probiotic. Although numerous claimed benefits are marketed towards using consumer probiotic products, such as reducing gastrointestinal discomfort, improving immune health, relieving constipation, or avoiding the common cold, such claims are not supported by scientific evidence, and are prohibited as deceptive advertising in the United States by the Federal Trade Commission. As of 2019, numerous applications for approval of health claims by European manufacturers of probiotic dietary supplements have been rejected by the European Food Safety Authority for insufficient evidence of beneficial mechanism or efficacy.

In a clinical setting, some probiotics have been found to be useful in treating antibiotic-associated diarrhea in children and *Clostridium difficult* infection in adults.

What are the most common probiotics?

Common species of probiotics

The most commonly consumed probiotics are strains of two main species. These species are also the most studied of probiotics:

Bifido bacteria: This species of bacteria is commonly used in foods and supplements. They're thought to:

- support the immune system
- limit the growth of harmful bacteria in the intestine
- help in breaking down lactose into nutrients the body can use

Lactobacillus: This species of bacteria produces lactase, the enzyme that breaks down lactose, or milk sugar. These bacteria also produce lactic acid. Lactic acid helps control the population of bad bacteria. It also serves as muscle fuel and increases the body's absorption of minerals. *Lactobacillus* bacteria are found naturally in the:

- mouth
- small intestine
- vagina

Common strains of probiotics

Probiotic strains are genetic subtypes of species. Each probiotic strain has a different effect in the body. You will see the probiotic strain names on food or supplement labels, combined with the species name. For example, the *Bifido bacteria* or *Lactobacillus* species are often abbreviated as *B.* or *L.* and combined with the individual strain name, such as *acidophilus*. This gives you the probiotic *L. acidophilus*. This is how the name will appear on food or supplement labels.

Here are six common strains of probiotics that you'll find on food and supplement labels.

B. animalis: This strain is an ingredient in Dannon yogurt's Activia product. It's helpful in aiding digestion and fighting food-borne bacteria. It's also thought to boost your immune system.

B. breve: This strain lives in your digestive tract and in the vagina. In both places, it fights off infection-causing bacteria, or yeast. It helps your body absorb nutrients by fermenting sugars. It also breaks down plant fiber to make it digestible.

B. lactis: This is derived from raw milk. It's an ingredient in Nestle's probiotic infant formula, called Good Start Natural Cultures. It also serves as a starter for:

- buttermilk
- cottage cheese
- other cheeses

B. longum: This strain lives in your gastrointestinal tract. It helps break down carbohydrates and also can be an antioxidant.

L. acidophilus: This strain is found in the small intestine and in the vagina. It helps digestion and may help fight off vaginal bacteria. You can find it in yogurt and fermented soy products, such as miso.

L. reuteri: This strain is found in the intestine and mouth. One study showed that it decreased the oral bacteria that cause tooth decay. It's also thought to help the digestive system.

Adding probiotics to your diet

How do you decide whether to add probiotics to your diet? A first step is to talk with your doctor to make sure they're right for you. Probiotics are generally considered safe to consume, unless you have a compromised immune system or you're seriously ill. Also, ask your doctor or pharmacist about dosage.

You may want to begin taking probiotics simply by adding some items with natural probiotics to your diet. You may want to keep a diary of what probiotics you introduce, and record over time whether you see any changes in your digestion or overall health. Some easily available food choices are:

- yogurt
- fermented cheeses, such as:
    - gouda
    - cheddar
    - Swiss
    - parmesan
- fermented vegetable products, such as:
    - miso
    - sauerkraut
    - pickles

If you want to take a probiotic dietary supplement, there are plenty of commercial products to choose from. Look for supplements that have:

- Live cultures: Check the expiration date on the label. To be effective, the probiotic should be "live" when you take it.
- Multiple bacteria strains: A combination of probiotics is usually more effective than a single one.
- Large enough quantities of bacteria to form colonies: This is measured in colony-forming units called CFUs.

It's important to remember that probiotics are considered to be dietary supplements, which are not regulated by the Food and Drug Administration (FDA). Also, probiotic manufacturers do not have to prove claims of effectiveness, nor does the FDA monitor these claims. The FDA is currently developing a method for determining the presence of potentially harmful contaminants in probiotics

Health Benefits of Probiotics

Probiotics are live microorganisms that can be consumed through fermented foods or supplements .
More and more studies show that the balance or imbalance of bacteria in your digestive system is linked to overall health and disease.
Probiotics promote a healthy balance of gut bacteria and have been linked to a wide range of health benefits.
These include benefits for weight loss, digestive health, immune function and more.

This is an overview of the key health benefits linked to probiotics.

1. Probiotics Help Balance the Friendly Bacteria in Your Digestive System

Probiotics include "good" bacteria. These are live microorganisms that can provide health benefits when consumed.
These benefits are thought to result from the ability of probiotics to restore the natural balance of gut bacteria.
An imbalance means there are too many bad bacteria and not enough good bacteria. It can happen due to illness, medication such as antibiotics, poor diet and more.

Consequences can include digestive issues, allergies, mental health problems, obesity and more.

Probiotics are usually found in fermented foods or taken as supplements. What's more, they appear to be safe for most people.

BOTTOM LINE: Probiotics are live microorganisms. When taken in sufficient amounts, they can help restore the natural balance of gut bacteria. As a result, health benefits may follow.

2. Probiotics Can Help Prevent and Treat Diarrhea

Probiotics are widely known for their ability to prevent diarrhea or reduce its severity.

Diarrhea is a common side effect of taking antibiotics. It occurs because antibiotics can negatively affect the balance of good and bad bacteria in the gut.

Several studies suggest probiotic use is associated with a reduced risk of antibiotic-associated diarrhea.

In one study, researchers found that taking probiotics reduced antibiotic-associated diarrhea by 42%.

Probiotics can also help with other forms of diarrhea not associated with antibiotics.

A large review of 35 studies found certain strains of probiotics can reduce the duration of infectious diarrhea by an average of 25 hours.

Probiotics reduced the risk of travelers' diarrhea by 8%. They also lowered the risk of diarrhea from other causes by 57% in children and 26% in adults.

Effectiveness varies, depending on the type and dose of the probiotic taken.

Strains such as *Lactobacillus rhamnosus*, *Lactobacillus casei* and the yeast *Saccharomyces boulardii* are most commonly associated with a reduced risk of diarrhea.

3. Probiotic Supplements Improve Some Mental Health Conditions

An increasing number of studies link gut health to mood and mental health.

Both animal and human studies find that probiotic supplements can improve some mental health disorders.

A review of 15 human studies found supplementing with *Bifido bacterium* and *Lacto bacillus*s trains for 1–2 months can improve anxiety, depression, autism, obsessive-compulsive disorder (OCD) and memory.

One study followed 70 chemical workers for 6 weeks. Those who consumed 100 grams of probiotic yogurt per day or took a daily probiotic capsule experienced benefits for general health, depression, anxiety and stress

.

4. Certain Probiotic Strains Can Help Keep Your Heart Healthy

Probiotics may help keep your heart healthy by lowering LDL ("bad") cholesterol and blood pressure.

Certain lactic acid-producing bacteria may reduce cholesterol by breaking down bile in the gut.

Bile, a naturally occurring fluid mostly made of cholesterol, helps digestion.

By breaking down bile, probiotics can prevent it from being reabsorbed in the gut, where it can enter the blood as cholesterol.

A review of 5 studies found that eating a probiotic yogurt for 2–8 weeks reduced total cholesterol by 4% and LDL cholesterol by 5%.

Another study conducted over 6 months found no changes in total or LDL cholesterol. However, the researchers did find a small increase in HDL ("good") cholesterol.

Consuming probiotics may also lower blood pressure. A review of 9 studies found that probiotic supplements reduce blood pressure, but only modestly

In order to experience any benefits related to blood pressure, supplementation had to exceed 8 weeks and 10 million colony-forming units (CFUs) daily

BOTTOM LINE: Probiotics may help protect the heart by reducing "bad" LDL cholesterol levels and modestly lowering blood pressure.

5. Probiotics May Reduce the Severity of Certain Allergies and Eczema

Certain probiotic strains may reduce the severity of eczema in children and infants.

One study found eczema symptoms improved for infants fed probiotic-supplemented milk, compared to infants fed milk without probiotics.

Another study followed children of women who took probiotics during pregnancy. Those children had an 83% lower risk of developing eczema in the first two years of life.

However, the link between probiotics and reduced eczema severity is still weak and more research needs to be done.

Some probiotics may also reduce inflammatory responses in people with milk or dairy allergies. However, the evidence is weak and further studies are needed.

BOTTOM LINE: Probiotics may reduce the risk and severity of certain allergies, such as eczema in infants. However, more research is needed.

6. Probiotics Can Help Reduce Symptoms of Certain Digestive Disorders

Over one million people in the US suffer from inflammatory bowel disease, including ulcerative colitis and Crohn's disease.

Certain types of probiotics from the *Bifido bacterium* and *Lactobacillus* strains have improved symptoms in people with mild ulcerative colitis.

Surprisingly, one study found that supplementing with the probiotic *E. coli Nissle* was just as effective as drugs in maintaining remission in people with ulcerative colitis.

However, probiotics appear to have little effect on symptoms of Crohn's disease.

Nevertheless, probiotics may have benefits for other bowel disorders. Early research suggests they may help with symptoms of irritable bowel syndrome (IBS).

They have also been shown to reduce the risk of severe necrotizing enterocolitis by 50%. This is a fatal bowel condition that occurs in premature infants.

BOTTOM LINE: Probiotics may help reduce the symptoms of bowel disorders like ulcerative colitis, IBS and necrotizing entero colitis.

7. Probiotics May Help Boost Your Immune System

Probiotics may help give your immune system a boost and inhibit the growth of harmful gut bacteria.

Also, some probiotics have been shown to promote the production of natural antibodies in the body. They may also boost immune cells like the IgA-producing cells, T lymphocytes and natural killer cells.

A large review found that taking probiotics reduced the likelihood and duration of respiratory infections. However, the quality of the evidence was low.

Another study including over 570 children found that taking *Lactobacillus GG* reduced the frequency and severity of respiratory infections by 17%.

The probiotic *Lactobacillus crispatus* has also been shown to reduce the risk of urinary tract infections (UTIs) in women by 50%.

BOTTOM LINE: Probiotics may help boost your immune system and protect against infections.

8. Probiotics May Help You Lose Weight and Belly Fat

Probiotics may help with weight loss through a number of different mechanisms.

For example, some probiotics prevent the absorption of dietary fat in the intestine.

The fat is then excreted through feces rather than stored in the body.
Probiotics may also help you feel fuller for longer, burn more calories and store less fat. This is partly caused by increasing levels of certain hormones, such as GLP-1.

They may also help with weight loss directly. In one study, dieting women who took *Lactobacillus rhamnosus* for 3 months lost 50% more weight than women who didn't take a probiotic.

Another study of 210 people found that taking even low doses of *Lactobacillus gasseri* for 12 weeks resulted in an 8.5% reduction of belly fat .

However, it's important to be aware that not all probiotics aid in weight loss.

Surprisingly, some studies found certain probiotics, such as *Lactobacillus acidophilus*, can even lead to weight gain.

More studies are needed to clarify the link between probiotics and weight.

BOTTOM LINE: Certain probiotics may help you lose weight and belly fat. However, other strains have been linked to weight gain.

The Best Way to Benefit From Probiotics

You can get probiotics from a variety of foods or supplements.

If you want to buy a probiotic supplement, then there is an excellent selection on Amazon with thousands of customer reviews.

Live probiotic cultures are often found in fermented dairy products such as yogurts and milk drinks. Fermented foods like pickled vegetables, temperature, miso, kefir, kimchi, sauerkraut and soy products may also contain some lactic acid bacteria.

You can also take probiotics as tablets, capsules and powders that contain the bacteria in dried form.

However, be aware that some probiotics can be destroyed by stomach acid before they even reach the gut — meaning that you get none of the intended benefits.

If you want to experience any of the health benefits discussed above, it's important that you consume adequate amounts.

List of probiotics available in the market

Yogurt

Yogurt is one of the best sources of probiotics, which are friendly bacteria that can improve your health.

It is made from milk that has been fermented by friendly bacteria, mainly lactic acid bacteria and bifid bacteria.

Eating yogurt is associated with many health benefits, including improved bone health. It is also beneficial for people with high blood pressure.

In children, yogurt may help reduce the diarrhea caused by antibiotics. It can even help relieve the symptoms of irritable bowel syndrome (IBS).

Additionally, yogurt may be suitable for people with lactose intolerance. This is because the bacteria turn some of the lactose into lactic acid, which is also why yogurt tastes sour.

However, keep in mind that not all yogurt contains live probiotics. In some cases, the live bacteria have been killed during processing.

For this reason, make sure to choose yogurt with active or live cultures.

Also, make sure to always read the label on yogurt before you buy it. Even if it is labeled low-fat or fat-free, it may still be loaded with high amounts of added sugar.

Kefir

Kefir is a fermented probiotic milk drink. It is made by adding kefir grains to cow's or goat's milk.

Kefir grains are not cereal grains, but rather cultures of lactic acid bacteria and yeast that look a bit like cauliflower.

The word kefir allegedly comes from the Turkish word *keyif*, which means "feeling good" after eating.

Indeed, kefir has been linked to various health benefits.

It may improve bone health, help with some digestive problems and protect against infections.

While yogurt is probably the best known probiotic food in the Western diet, kefir is actually a better source. Kefir contains several major strains of friendly bacteria and yeast, making it a diverse and potent probiotic.

Like yogurt, kefir is generally well tolerated by people who are lactose intolerant

Kefir is a fermented milk drink. It is a better source of probiotics than yogurt, and people with lactose intolerance can often drink kefir with no problems.

Sauerkraut

Sauerkraut is finely shredded cabbage that has been fermented by lactic acid bacteria.

It is one of the oldest traditional foods and is popular in many countries, especially in Europe.

Sauerkraut is often used on top of sausages or as a side dish. It has a sour, salty taste and can be stored for months in an airtight container.

In addition to its probiotic qualities, sauerkraut is rich in fiber as well as vitamins C, B and K. It is also high in sodium and contains iron and manganese.

Sauerkraut also contains the antioxidants lutein and zeaxanthin, which are important for eye health.

Make sure to choose unpasteurized sauerkraut, as pasteurization kills the live and active bacteria. You can find raw types of sauerkraut online.

Sauerkraut is finely cut, fermented cabbage. It is rich in vitamins, minerals and antioxidants. Make sure to choose unpasteurized brands that contain live bacteria.

4. Temperature

Temperature is a fermented soybean product. It forms a firm patty whose flavor is described as nutty, earthy or similar to a mushroom.

Temperature is originally from Indonesia but has become popular worldwide as a high-protein meat substitute.

The fermentation process actually has some surprising effects on its nutritional profile.

Soybeans are typically high in phytic acid, a plant compound that impairs the absorption of minerals like iron and zinc.

However, fermentation lowers the amount of phytic acid, which may increase the amount of minerals your body is able to absorb from temperature.

Fermentation also produces some vitamin B12, a nutrient that soybeans do not contain (Vitamin B12 is mainly found in animal foods, such as meat, fish, dairy and eggs.

This makes temperature a great choice for vegetarians as well as anyone looking to add a nutritious probiotic to their diet.

Temperature is a fermented soybean product that serves as a popular, high-protein substitute for meat. It contains a decent amount of vitamin B12, a nutrient found mainly in animal products.

5. Kimchi

Kimchi is a fermented, spicy Korean side dish.

Cabbage is usually the main ingredient, but it can also be made from other vegetables.

Kimchi is flavored with a mix of seasonings, such as red chili pepper flakes, garlic, ginger, scallion and salt.

Kimchi contains the lactic acid bacteria *Lactobacillus kimchii*, as well as other lactic acid bacteria that may benefit digestive health.

Kimchi made from cabbage is high in some vitamins and minerals, including vitamin K, riboflavin (vitamin B2) and iron. Find kimchi online.

Kimchi is a spicy Korean side dish, usually made from fermented cabbage. Its lactic acid bacteria may benefit digestive health.

6. Miso

Miso is a Japanese seasoning.

It is traditionally made by fermenting soybeans with salt and a type of fungus called koji.

Miso can also be made by mixing soybeans with other ingredients, such as barley, rice and rye.

This paste is most often used in miso soup, a popular breakfast food in Japan. Miso is typically salty. You can buy it in many varieties, such as white, yellow, red and brown.

Miso is a good source of protein and fiber. It is also high in various vitamins, minerals and plant compounds, including vitamin K, manganese and copper.

Miso has been linked to some health benefits.

One study reported that frequent miso soup consumption was associated with a lower risk of breast cancer in middle-aged Japanese women.

Another study found that women who ate a lot of miso soup had a reduced risk of stroke.

Miso is a fermented soybean paste and a popular Japanese seasoning. It is rich in several important nutrients and may reduce the risk of cancer and stroke, especially in women.

7. Kombucha

Kombucha is a fermented black or green tea drink.

This popular tea is fermented by a friendly colony of bacteria and yeast. It is consumed in many parts of the world, especially Asia. You can even purchase it online.

The internet abounds with claims about the potential health effects of kombucha.

However, high-quality evidence on kombucha is lacking.

The studies that exist are animal and test-tube studies, and the results may not apply to humans.

However, because kombucha is fermented with bacteria and yeast, it does probably have health benefits related to its probiotic properties.

Kombucha is a fermented tea drink. It is claimed to have a wide range of health benefits, but more research is needed.

8. Pickles

Pickles (also known as gherkins) are cucumbers that have been pickled in a solution of salt and water.

They are left to ferment for some time, using their own naturally present lactic acid bacteria. This process makes them sour.

Pickled cucumbers are a great source of healthy probiotic bacteria which may improve digestive health.

They are low in calories and a good source of vitamin K, an essential nutrient for blood clotting.

Keep in mind that pickles also tend to be high in sodium.

It is important to note that pickles made with vinegar do not contain live probiotics.

Pickles are cucumbers that have been pickled in salty water and fermented. They are low in calories and high in vitamin K. However, pickles made using vinegar do not have probiotic effects.

Traditional Buttermilk

The term buttermilk actually refers to a range of fermented dairy drinks.

However, there are two main types of buttermilk: traditional and cultured.

Traditional buttermilk is simply the leftover liquid from making butter. Only this version contains probiotics, and it is sometimes called “grandma's probiotic.”

Traditional buttermilk is mainly consumed in India, Nepal and Pakistan.

Cultured buttermilk, commonly found in American supermarkets, generally does not have any probiotic benefits.

Buttermilk is low in fat and calories but contains several important vitamins and minerals, such as vitamin B12, riboflavin, calcium and phosphorus.

Traditional buttermilk is a fermented dairy drink mainly consumed in India, Nepal and Pakistan. Cultured buttermilk, found in American supermarkets, does not have any probiotic benefits.

Natto

Natto is another fermented soybean product, like temperature and miso.
It contains a bacterial strain called *Bacillus subtilis*.

Natto is a staple in Japanese kitchens. It is typically mixed with rice and served with breakfast.

It has a distinctive smell, slimy texture and strong flavor. Natto is rich in protein and vitamin K2, which is important for bone and cardiovascular health.

A study in older Japanese men found that consuming natto on a regular basis was associated with higher bone mineral density. This is attributed to the high vitamin K2 content of natto

Other studies suggest that natto may help prevent osteoporosis in women

Natto is a fermented soy product that is a staple in Japanese kitchens. It contains a high amount of vitamin K2, which may help prevent osteoporosis and heart attacks.

Some Types of Cheese

Although most types of cheese are fermented, it does not mean that all of them contain probiotics.

Therefore, it is important to look for live and active cultures on the food labels.

The good bacteria survive the aging process in some cheeses, including Gouda, mozzarella, cheddar and cottage cheese

Cheese is highly nutritious and a very good source of protein. It is also rich in important vitamins and minerals, including calcium, vitamin B12, phosphorus and selenium

Moderate consumption of dairy products such as cheese may even lower the risk of heart disease and osteoporosis.

KARPAGAM ACADEMY OF HIGHER EDUCATION

CLASS: II B.Sc MB
COURSE CODE: 18MBU301

COURSE NAME: FOOD AND DAIRY MICROBIOLOGY
BATCH-2018-2021

UNIT 3						
S.NO	QUESTIONS	OPTION A	OPTIIN B	OPTION C	OPTION D	ANSWERS
1	Which of the following toxin causing botulism is less toxic to human being?	type A	type B	type C	type D	type B
2	The Staphylococal intoxication refers to presence of	an enterotoxin	neurotoxin	mycotoxin	exotoxin	an enterotoxin
3	The method of succesful treatment of botulism prior to appaearance of botulism symptoms involve administration of	antibiotic	analgesic	antitoxin	antipyretic	antitoxin
4	Salmonellosis is aused by ____	enterotoxin of Salmonella sp.	endotoxin of Salmonella sp.	neurotoxin of Salmonella sp.	exoenterotoxin of Salmonella sp.	endotoxin of Salmonella sp.
5	The application of gamma rays destroy botulism toxin.The dose on gamma rays required for this purpose is __	73Gy	73Rad	7.3Mrad	173Rad	7.3Mrad
6	Whichof thefollowing is a food infection ?	Salmonellosis	botulism	Staphylococcal intoxication	tetanus	Salmonellosis
7	A bacterial food intoxication refers to____	illness caused by presence of pathogens	foodborne ilness caused by the presence of a bacterial toxin formed in food	both a and b	food poisoning	foodborne illness caused by presence of a bacterial toxin formed in food
8	Botulism is caused by the presence of toxin developed by	Cl.tyrobutyricum	Cl.sporogenes	Cl.botulinum	Bacillus	Cl.botulinum

Prepared by R.Dineshkumar, Assistant Professor, Dept of Microbiology, KAHE.

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9	Group 1 Cl.botulinum strain generally includes in	all types of strains(proteolytic) A,B,F	all types of strains(non proteolytic)E,F	all typesof strains (proteolytic)C,D,F	none	all types of strains(proteolytic) A,B,F
10	The Bacillus cereus causes gastroenteritis by the production of an exoentero toxin which is released in food as a resultof	cell growth	cell autolysis	cell permeation	cell damage	cell autolysis
11	Staphylococcal intoxication is caused by the toxin in the food from___	Staphylococcal aureus	S.cerevisiae	S.thermophilus	none	S.aureus
12	Common food poisoning microbes are_	Cl.and Salmonella	Cl.and E.coli	E.coli andSalmonella	Cl.and Streptococcus	Cl.and Salmonella
13	Cl.perferenges poisoning is associated with	meat products	vegetables	canned foods	fish products	meat products
14	Which of the following statements are true regarding Staphylococcal food poisoning	is an enterotoxin	cause gastroenteritis	is produced by Cl.botulinum	both a andb	both a and b
15	The major carrier of Salmonellosis are	meat and egg	meat and fish	egg and fish	egg and fruit	meat and egg
16	Botulism is caused by	Cl.botylinum	All Cl.sp.	Cl.tetani	Cl.subtilis	Cl.botulism
17	What is the main type of microorganism responsible for food poisoning?	bacteria	mold	virus	parasite	bacteria
18	Botulism prevention involves ____	proper heat sterilisation before food canning	addition of chemical preservatives	proper low temperature treatment before food canning	freezing	proper heat sterilisation before food canning

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19	Cl.perferenges poison is a ___	exotoxin	enterotoxin priduced during sporulation	endotoxin	enterotoxin produced during vegetative phase	enterotoxin produced during sporulation
20	Salmonellosis involves_ __	an enterotoxin and exotoxin	an enterotoxin andcytotoxin	is produced by Staphylococcus aureus	endotoxin	enterotoxin and cytotoxin
21	Aflatoxin is produced by	Salmonella sp.	Fusarium sp.	Streptococcal sp.	Aspergillus	Aspergillus
22	Human beings and animals are directly or indirectly the source of the contamination of food with -	Salmonella	Staphylococcus	Bacillus	E.coli	Salmonella
23	The incubation period of Vibrio parahaemolyticus infection is -	2-48hrs	5-24hrs	40hrs	37hrs	2-48hrs
24	The sore and throat symptom caused by etiologic agent	Streptococcus pyogenes	Staphylococcus aureus	Bacillus anthrax	E.coli	Streptococcus pyogenes
25	The symptoms such as nausea and dehydration is caused by	Shigella sonnei	Yersinia	Arizona	E.coli	Streptococcus pyogenes
26	The etiological infection of Arizona infection is	Vibrio	E.coli	Arizona	Streptococcus	Arizona
27	Yersinia enterocolitica is a small shaped bacteria	cocci	chain	rod	bacilli	rod
28	The term heat tolerant is a monomer and refers to growth at ___ temperature	37deg celcius	40deg celcius	42deg celcius	25deg celcius	42deg celcius
29	Miller and Kolurger examined forty environmental isolates of P.shigelloides in the year -	1987	1982	1980	1986	1986

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30	The toxin patulin is produced by fungi	Penicillium expansum	Fusarium	Aspergillus flavus	Mucor	Penicillium expansum
31	In the early ___numerous surveys have been conducted on the detection aflatoxins in foods	1980s	1940s	1950s	1960s	1960s
32	The mode of transmission of poliomyelitis is	food	air	contaminated water	all of these	contaminated water
33	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
34	The disease gastroenteritis is caused by C.perferingens was first reported in the year -	1952	1961	1978	1945	1945
35	The etiologic agent of diarrhoel syndrome is	Shigellosis	Yersiniosis	Bacillus cereus	Vibrio	Bacillus cereus
36	The control measure of foods that cause disease by Vibrio parahaemolyticus infection is due to __-	reheat leftover	sanitize eqipment	control files	pasteurization	sanitize eqipment
37	Enteropathogenic E.coli infection is involved in foods	vegetables	apple cider	ice creams	cheese	cheese
38	The optimal temperature for growth of Shigellosis is -	27deg celcius	37deg celcius	40deg celcius	50deg celcius	37deg celcius
39	Nursery epidemmics diarrhoeal disease in infants was implicated in the year__-	1950	1940	1962	1980	1940
40	is associated with warm blooded	C.jejuni	C.botulinum	C.perferingens	E.coli	C.jejuni

	anim					
41	Aeromonas hydrophilia is a gram negative rods which are ubiquitous in	air	soil	water	land	water
42	The mold Penicillium islandicum produces toxin	Luteoskyrin	aflatoxin	penicillic acid	Roquefortine	Luteoskyrine
43	The _____ virus enters a person through oral route in the faecal contamination of food	Poliomyelitis	Hepatitis	Adeno	Herpes	Hepatitis
44	The pH near ____ favours C.botulinum	neutrality	alkalinity	acidic	both b and c	neutrality
45	The growth of Staphylococcus aureus on solid media is usually ___ in colour	red	brown	pink	yellow	yellow
46	Depending on the food and serotype the ____values from 0.06 to 11.3 min	D50C	D30c	D40c	D60c	D60c

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47	Pathogenecity involves the release of a ___ endotoxin which affects the intestinal mucosa	lipopolysaccharides	monosaccharides	polysaccharides	peptidoglycan	lipopolysaccharides
48	Theoptimal pH for enteropathogenic E.coli is	4.0to5.0	7.0to7.5	3.0to4.0	8.0to9.0	7.0to7.5
49	Typhoid fever is caused by____	Salmonella enteritidis	Salmonella infantis	Salmonella typhi	Salmonella typhimurium	Salmonella typhi
50	The FDA and USDA cooperative is a surveillance program	Pseudomonas	E.coli	Salmonella	Vibrio	Salmonella
51	_____ agencies aprove the good house keeping institute	commercial	state	federal	private	private
52	A_____ refers to food borne illnesses caused by the entrance of bacteria into the body through ingestion of contaminated food	food infection	food poisoning	food intoxication	contamination	food infection
53	The incubation priod of Streptococcus faecalis is	5to 10	2 to 10	2to 18	8 to 12	2 to 18
54	_____ organisms can be isolated from seafoods and sea water	Vibrio cholera	V.vulnificus	V.parahaemolyticus	all	V.vulficans
55	The term ____ is used to distinguish strains of different antigenic complements	biovars	serovar	herbivore	none	serovar
56	Strains used for the brewing of soy sauce is	A.oryzae	A.sojae	A.tamarii	all these	all these
57	The food and drug administration act was amended in the year	1983	1980	1953	1964	1980

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58	___ involves the identification of ingredients and products that have effect on food safetty	hazard analysis	CCP	fishery service	HACCP	hazard analysis
59	Which of the following is not a probiotic?	B.longum	L.reuteri	B.lactis	S.typhi	S.typhi
60	The antioxidants present in the sauerkraut is	lutein	zeaxanthin	both a and b	GLP	both a and b

Food borne Intoxications

Food borne intoxication is caused by consumption of food containing systemic disorders. Staphylococcal intoxication, emetic poisoning of *Bacillus cereus*, botulism, toxigenic molds, poisonous mushrooms, and biogenic amines are discussed in this chapter. The intoxications are included in the chapter, based on relative importance of a disease, characteristics of the microorganism, predominant types of food, characteristics of disease, prevention and control of pathogen, and analysis of agent. Staphylococcal food poisoning (SFP) is caused by enterotoxins that are produced by *S. aureus*. Infant botulism is caused by consuming the spores of the botulinum bacterium, which then grow in the intestines and release toxin. Toxigenic molds produce mycotoxins as secondary metabolites that are toxic to humans. Consumption of foods containing mycotoxins causes mycotoxicosis. The mushroom toxins can be recovered from poisonous mushroom, water, stomach contents, serum, and urine.

Staphylococcal food poisoning is an acute intoxication that occurs when food contaminated with enterotoxin produced by this bacterium is consumed. Although precise data regarding the exact number of cases is lacking, staphylococcal food poisoning is considered to be among the most common causes of gastroenteritis worldwide. The presence of staphylococcal enterotoxin in food is usually due to cross contamination of ready to eat food with either raw food or, most likely, contamination from a food handler that is carrying *Staphylococcus aureus*. To prevent food becoming contaminated, good food safety practices should be followed, such as practicing frequent hand washing, wearing gloves when handling foods, and ensuring separation between the areas where raw and cooked products are handled.

Definition

Illness caused by *Staphylococcus aureus* is an acute intoxication that develops after the ingestion of food contaminated with the enterotoxin produced by this bacterium. *S. aureus* is also associated to other health problems ranging from skin infections to severe invasive infections of the lungs or the heart. Drug resistant strains are common, especially in hospital settings. This summary refers solely to staphylococcal food poisoning.

Symptoms

Symptoms include:

- vomiting
- nausea
- diarrhea, usually watery but sometimes with blood
- cramps
- other symptoms may include mild fever, weakness, dizziness and chills.

Symptoms usually start 1 to 10 hours after exposure and go away in 1 to 2 days. In some cases, the illness may be more severe. If you have serious symptoms, you should see your doctor.

Causes

For staphylococcal food poisoning to occur following the ingestion of a given food, two conditions are necessary. First, *S. aureus* has to be present in the food; second, foods stored at incorrect temperatures and time allow growth of this pathogen and the production of enterotoxin.

Although *S. aureus* can be found in food-producing animals and raw foods, humans are considered the main reservoir for this pathogen. *S. aureus* can be present in healthy individuals, usually on the skin and mucous membranes, for example in the nasal cavity. Food can become contaminated during preparation if the food handler is a carrier of *S.aureus* and this is transferred to the food through direct contact with contaminated skin or by coughing and sneezing.

The growth of *S. aureus* in food to a sufficient level as to allow enterotoxin production is possible only under certain conditions. For example, it needs temperatures of between 7°C and 48°C to be able to grow, with an optimum temperature of 37°C. Enterotoxin production will only take place once the levels of this microorganism are large (greater than 10,000 *S. aureus* per gram of food).

The foods that have been most frequently implicated in cases of staphylococcal food poisoning are poultry and cooked meat products such as ham or corned beef. Other foods implicated were milk and milk products, canned food and bakery products.

Complications

Staphylococcal food poisoning is usually self-limiting, resolving within one or two days. In a small percentage of cases it can be more severe, especially in infants, the elderly and immunocompromised patients.

Tests and diagnosis

Staphylococcal food poisoning can be confirmed if the enterotoxin or large numbers of *S. aureus* are found in the food. *S. aureus* can also be detected in stool samples from patients.

Treatment and drugs

Most people recover without treatment. The administration of fluids is recommended if the diarrhoea or vomiting is severe. Antibiotics are not indicated as the symptoms are caused by the enterotoxin and not the bacteria.

Prevention

Control measures should be applied first to avoid contaminating the food with *S. aureus* and also to prevent growth and the formation of enterotoxin in the food.

To avoid contaminating the food with S. aureus, handle and prepare food safely:

- Ensure raw foods of animal origin are obtained following good hygienic practices, to reduce the possibility of *S. aureus* contamination.
- Food handlers should use appropriate protective clothing (e.g. gloves) and thoroughly wash hands.
- Food handlers with skin lesions should have them properly covered prior to handling food. If this is not possible, they should not work while handling food until the lesions have healed.
- Avoid cross-contamination by keeping work surfaces clean and ensuring separation between areas where raw and cooked foods are manipulated.

To prevent growth of S. aureus and the formation of enterotoxin:

- Ensure food is maintained either at a temperature above 60°C or refrigerated below 4°C.
- Cool cooked foods that will not be immediately consumed to below 4°C within 6 hours.
- When reheating food, ensure that the temperature reaches at least 74°C.

Clostridium botulinum

Botulism is a serious illness caused by the botulinum toxin. The toxin causes paralysis. Paralysis starts in the face and spreads to the limbs. If it reaches the breathing muscles, respiratory failure can result.
The toxin is produced by *Clostridium botulinum (C. botulinum)*, a type of bacterium.

All types of botulism eventually lead to paralysis, so any case of botulism is treated as a medical emergency.
In the past, it was often fatal, but antitoxins have significantly improved the outlook.
In 2015, the United States saw the biggest outbreak of botulism in 40 years. It stemmed from improperly home-canned potatoes that were shared at a potluck meal.

Symptoms

Botulism is a serious disease caused by the botulinum toxin.
The signs and symptoms depend on the type of botulism.

In food-borne botulism, signs and symptoms include nausea, vomiting, and diarrhea followed by constipation and abdominal distention. There may be weakness and difficulty breathing. Symptoms normally appear between 18 and 36 hours after consuming the contaminated food, but this can vary between 3 hours and 8 days.

In wound botulism, the nerves that connect the brain to the spine, known as the cranial nerves, experience the first symptoms. This then spreads to the rest of the body. The incubation period is from 4 days to 2 weeks.

Neurological signs and symptoms of adult, food-borne, and wound botulism are the same, but the symptoms of wound botulism ones may take longer to appear.

The patient may experience double or blurred vision, the eyelids may droop, there will be facial weakness, a dry mouth, dysphagia, or difficulty swallowing, and speech slurring. Muscles will become weak.

Next, paralysis will set in. Without treatment, the patient's breathing muscles will eventually become paralyzed, resulting in respiratory failure and death.

The patient remains conscious during this process.

In infant botulism, signs and symptoms may include:

- constipation
- poor feeding
- bad temper
- excessive drooling when feeding
- sagging eyelids
- flat facial expression
- lethargy and listlessness
- respiratory difficulties
- slow or improper reflexes
- weak crying weakly
- floppiness and poor muscle tone
- no gag reflex
- unfocused eyes
- weak sucking

The incubation period for infant botulism varies from 3 days to 30 days.

Causes

The botulinum toxin, a poison produced by the bacterium *Clostridium botulinum (C. botulinum)*, is common in soil and exists in untreated water. It can survive in these environments as a resistant spore.

C. botulinum produces spores that can survive in poorly preserved or canned foods. Here, they produce a toxin. When consumed, even minimal amounts of the toxin can cause severe poisoning.

There are several types of botulism.

Foodborne botulism is caused by consuming foods containing the botulinum toxin.

Wound botulism can occur if the organism enters an open wound and produces toxins within the wound. Injection drug users are at risk for this type of botulism.

Infant botulism happens when an infant consumes the bacteria or their spores, and these grow in the gut. Infant botulism in the U.S. mostly comes from eating honey or corn syrup. The bacterium may also occur naturally in the stool of an infant.

Adult intestinal colonization is a rare form of botulism that occurs when the bacterium colonizes the digestive tract of an adult.

Latrogenic botulism can occur through an overdose of botulism toxin, or botox. Cases of this form of botulism have developed following therapeutic administration of botox.

Prevention

To reduce the risk of wound botulism, people are advised to seek urgent medical attention for any infected wounds and also to avoid injecting street drugs.

To ensure food safety, it is important to practice good food hygiene.

The toxin can thrive in improperly canned food.

- Follow any instructions carefully when canning food at home, or avoid canning food at home
- Boil home-processed foods for at least 10 minutes before eating, even if no signs of food spoilage are evident
- Do not taste canned food items to see if they are still good. Throw away any cans that are bulging, leaking, or appear damaged
- Keep potatoes that have been baked in foil hot until eaten
- Not give honey or corn syrup to infants under 12 months of age
- Ensure all foods are well-cooked
- Keep oils infused with garlic or herbs in a refrigerator

Boiling can destroy both the vegetative, or non-spore, form of the bacterium, and the toxin it produces.

However, while boiling for 10 minutes can kill the toxin, to destroy the spore form requires heating to at least 248 degrees Fahrenheit, or 120 degrees Celsius, under pressure, for at least 30 minutes in an autoclave or a pressure cooker.

This is because the spores are highly resistant to harsh environments, and they can remain viable even after several hours of normal boiling. The spores can be killed by very high temperatures such as those used in commercial canning.

The World Health Organization's (WHO) "Five keys to safer food" stresses the importance of:

- keeping clean
- separating raw and cooked food
- cooking thoroughly

- keeping food at safe temperatures
- using safe water and raw materials

This is important when people are traveling, especially to countries where access to clean water, hygiene, and refrigeration facilities may be limited.

Botulism cannot always be prevented. The toxin may be present in house dust, even after cleaning. Parents should be aware of any signs that a child is sick, and take early action as appropriate.

Food sources

The most commonly tainted foods are:

- home-canned vegetables
- cured pork and ham
- raw or smoked fish
- honey
- corn syrup

For example, Home-canned foods and fermented fish and aquatic game from Alaska can be sources of the toxin.

Botulism does not grow in acidic foods with a pH of 4.5 or less.

Diagnosis

Diagnosis of infant botulism is confirmed after testing a stool or specimen of enema. If the doctor suspects botulism, treatment with an anti-toxin should begin immediately, without waiting for test results to come back.

A lab can confirm the presence of botulism.

If the patient's history and physical examination suggest botulism, a doctor may consider it, but as other conditions share similar symptoms, a test will be needed to rule these out. Conditions with similar symptoms to botulism include stroke, myasthenia gravis, and Guillain-Barre syndrome.
Diagnostic tests may include:

- a brain scan
- cerebrospinal fluid examination
- electromyography
- edrophonium chloride test for myasthenia gravis

If the toxin is identified in the food, stomach, vomit, feces, or intestinal contents, a definitive diagnosis can be made.

In very acute cases the toxin might be detected in the blood.

Treatment

Patients with botulism will need to be hospitalized.
Infants will be given Botulism Immune Globulin Intravenous-Human, also known as BIG-V or BabyBIG.
Those with respiratory problems will be on a ventilator, and they may need the ventilator for weeks or months, as well as intensive nursing. Over time, the paralysis may improve.
A patient with suspected botulism will immediately be given injections of antitoxins, even before diagnostic test results have returned.

If the infection results from a wound, the wound needs to be treated surgically. The area around the wound is removed, in a process known as debridement. Antibiotics may also be prescribed to prevent any secondary infection.

Complications

In most cases, infant botulism has no long-term effects. According to the NIH, fewer than 1 percent of infant cases in the U.S. are fatal. About 50 years ago, half of all patients with botulism died, compared to between 3 percent and 5 percent today.

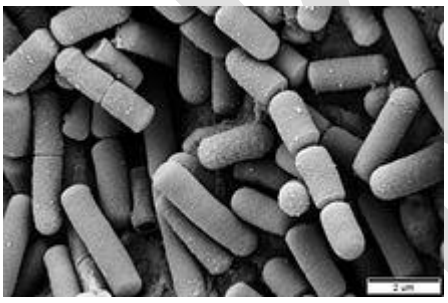
Respiratory failure caused by botulism can result in death.

Patients with severe symptoms may need a breathing machine and sometimes intensive medical and nursing care for several months. Fatigue and shortness of breath may linger for many years.

Other illnesses may develop as a result of the patient's condition, and these are sometimes fatal.

A person who experiences paralysis may recover from botulism with the help of antitoxins, antibodies that can neutralize the toxin, but antitoxins will not cure any paralysis that has already occurred.

Bacillus cereus



Electron micrograph of *Bacillus cereus*

Bacillus cereus is a Gram-positive, rod-shaped, facultatively anaerobic, motile, beta-hemolytic, spore forming, bacterium commonly found in soil and food. The specific name, *cereus*, meaning "waxy" in Latin refers to the appearance of colonies grown on blood agar. Some strains are harmful to humans and cause foodborne illness, while other strains can be beneficial as probiotics for animals.[1][2] The bacteria is classically contracted from fried rice dishes that have been sitting at room temperature for hours.[3][4] *B. cereus* bacteria are facultative anaerobes, and like other members of the genus *Bacillus*, can produce protective endospores. Its virulence factors include cereolysin and phospholipase C.

The *Bacillus cereus* group comprises seven closely related species: *B. cereus sensustricto* (referred to herein as *B. cereus*), *B. anthracis*, *B. thuringiensis*, *B. mycoides*, *B. pseudomycoides*, *B. weihenstephanensis*, and *B. cytotoxicus.*[

Reproduction[edit]

At 30 °C (86 °F), a population of *B. cereus* can double in as little as 20 minutes or as long as 3 hours, depending on the food product.[12]

Food	**Minutes to double, 30 °C (86 °F)**	**Hours to multiply by 1,000,000**
Milk	20–36	6.6 - 12
Cooked rice	26–31	8.6 - 10.3
Infant formula	56	18.6

Pathogenesis

B. cereus is responsible for a minority of foodborne illnesses (2–5%), causing severe nausea, vomiting, and diarrhea.[13] Bacillus foodborne illnesses occur due to survival of the bacterial endospores when infected food is not, or inadequately, cooked.[14] Cooking temperatures less than or equal to 100 °C (212 °F) allow some B. cereus spores to survive.[15] This problem is compounded when food is then improperly refrigerated, allowing the endospores to germinate.[16] Cooked foods not meant for either immediate consumption or rapid cooling and refrigeration should be kept at temperatures below 10 °C (50 °F) or above 50 °C (122 °F).[15] Germination and growth generally occur between 10 °C and 50 °C,[15] though some strains are psychrotrophic.[17] Bacterial growth results in production of enterotoxins, one of which is highly resistant to heat and acids (pH levels between 2 and 11);[18] ingestion leads to two types of illness, diarrheal and emetic (vomiting) syndrome.[19]

The diarrheal type is associated with a wide range of foods, has an 8.0- to 16-hour incubation time, and is associated with diarrhea and gastrointestinal pain. Also known as the 'long-incubation' form of B. cereus food poisoning, it might be difficult to differentiate from poisoning caused by Clostridium perfringens.[18] Enterotoxin can be inactivated after heating at 56 °C (133 °F) for 5 minutes, but whether its presence in food causes the symptom is unclear since it degrades in stomach enzymes; its subsequent production by surviving B. cereus spores within the small intestine may be the cause of illness.[20]

The 'emetic' form is commonly caused by rice cooked for a time and temperature insufficient to kill any spores present, then improperly refrigerated. It can produce a toxin, cereulide, which is not inactivated by later reheating. This form leads to nausea and vomiting 1-5 hours after consumption. Distinguishing from other short-term bacterial foodborne intoxications such as by Staphylococcus aureus can be difficult.[18] Emetic toxin can withstand 121 °C (250 °F) for 90 minutes.[20]

The diarrhetic syndromes observed in patients are thought to stem from the three toxins: hemolysin BL (Hbl), nonhemolytic enterotoxin (Nhe), and cytotoxin K (CytK).[21] The nhe/hbl/cytK genes are located on the chromosome of the bacteria. Transcription of these genes is controlled by PlcR. These genes occur in the taxonomically related B. thuringiensisand B. anthracis, as well. These enterotoxins are all produced in the small

intestine of the host, thus thwarting digestion by host endogenous enzymes. The Hbl and Nhe toxins are pore-forming toxins closely related to ClyA of E. coli. The proteins exhibit a conformation known as "beta-barrel" that can insert into cellular membranes due to a hydrophobic exterior, thus creating pores with hydrophilic interiors.

The effect is loss of cellular membrane potential and eventually cell death. CytK is a pore-forming protein more related to other hemolysins.

The timing of the toxin production was previously thought to be possibly responsible for the two different courses of disease, but in fact the emetic syndrome is caused by a toxin, cereulide, found only in emetic strains and is not part of the "standard toolbox" of B. cereus. Cereulide is a cyclic polypeptide containing three repeats of four amino acids: D-oxy-Leu—D-Ala—L-oxy-Val—L-Val (similar to valinomycin produced by Streptomyces griseus) produced by nonribosomal peptide synthesis. Cereulide is believed to bind to 5-hydroxytryptamine 3 (5-HT3) serotonin receptors, activating them and leading to increased afferent vagus nerve stimulation.[22] It was shown independently by two research groups to be encoded on multiple plasmids: pCERE01[23] or pBCE4810.[24] Plasmid pBCE4810 shares homology with the Bacillus anthracis virulence plasmid pXO1, which encodes the anthrax toxin. Periodontal isolates of B. cereus also possess distinct pXO1-like plasmids. Like most of cyclic peptides containing nonproteogenic amino acids, cereulid is resistant to heat, proteolysis, and acid conditions.[25]

B. cereus is also known to cause difficult-to-eradicate chronic skin infections, though less aggressive than necrotizing fasciitis. B. cereus can also cause keratitis.[26]

Diagnosis

In case of foodborne illness, the diagnosis of B. cereus can be confirmed by the isolation of more than 105 B. cereus organisms per gram from epidemiologically implicated food, but such testing is often not done because the illness is relatively harmless and usually self-limiting.[27]

Identification

For the isolation and enumeration of B. cereus there are two standardized methods by International Organization for Standardization (ISO), ISO7931 and ISO21871. Thanks to B. cereus ability to produce lecithinase and its inability to ferment mannitol there are some proper selective media for its isolation and identification such as mannitol-egg yolk-polymyxin (MYP) and polymyxin-pyruvate-egg yolk-mannitol-bromothymol blue agar (PEMBA). B. cereus colonies on MYP have a violet-red background and are surrounded by a zone of egg-yolk precipitate. [28]

Below is a list of differential techniques and results that can help to identify Bacillus cereus from other bacteria and Bacillus species.[29]

Anaerobic growth: Positive

VogesProskauer test: Positive

Acid produced from

D-glucose: Positive

L-arabinose: Negative

D-xylose: Negative

D-mannitol: Negative

Starch hydrolysis: Positive

Nitrate reduction: Positive

Degradation of tyrosine: Positive

Growth at

>50 °C: Negative

Use of citrate: Positive

The Central Public Health Laboratory in the United Kingdom tests for motility, hemolysis, rhizoid growth, susceptibility to γ-phage, and fermentation of ammonium salt-based glucose but no mannitol, arabinose, or xylose.

Vibrio parahaemolyticus

Vibrio parahaemolyticus is a curved, rod-shaped, Gram-negative bacterium found in brackish,[1] saltwater, which, when ingested, causes gastrointestinal illness in humans.[1] V. parahaemolyticus is oxidase positive, facultatively aerobic, and does not form spores. Like other members of the genus Vibrio, this species is motile, with a single, polar flagellum.[

Vibrio parahaemolyticus is spread

Vibrio parahaemolyticus infection can be acquired by eating raw or undercooked shellfish or drinking contaminated water. Eating raw oysters is the most common way the infection is spread as the organism naturally lives in the warm tidal waters where oysters grow. Eating raw or undercooked fish and crustaceans, such as crabs and lobsters, has also been associated with food-borne outbreaks of this infection.

Less commonly, the organism causes wound infections when seawater contaminates open wounds.

V. parahaemolyticus does not usually spread from person to person, however, person-to-person spread is possible if there is poor personal hygiene.

Signs and symptoms

Vibrio parahaemolyticus infection causes symptoms of gastro including:

- watery diarrhoea (occasionally bloody diarrhoea)
- abdominal cramps
- nausea
- vomiting
- fever
- Headache.

Symptoms usually occur within 24 hours of eating the contaminated food.

Usually symptoms are mild to moderate in severity and lasts around 3 days (range from 8 hours to 12 days). However, the infection can be severe in people with immunosuppression, such as people receiving cancer treatment.

Where *V. parahaemolyticus* infects a wound, symptoms around the wound may include:

- pain
- redness
- warmth
- Pus or discharge.

Diagnosis

Diagnosis is made by testing of faeces, wound swab or other clinical specimens.

Incubation period

(time between becoming infected and developing symptoms)

Usually around 24 hours but can be between 4 to 96 hours.

Infectious period

(time during which an infected person can infect others)

V. parahaemolyticus does not usually spread from person to person.

Treatment

Antibiotic treatment is not usually needed for *V. parahaemolytiticus* gastro, however, in cases with prolonged diarrhoea, antibiotic therapy may be needed.

The following are general recommendations for the treatment of gastro:

- Give plenty of fluids. Oral rehydration solution is highly recommended for children and adults with mild to moderate dehydration. It is available at pharmacies and should be administered following the instructions on the packaging.
- Give mildly unwell children their usual fluids more often; however avoid carbonated (fizzy) drinks or undiluted juice.
- Do not give medicines to prevent vomiting or diarrhoea (especially in children), except where specifically advised by a doctor.
- Continue to breastfeed babies throughout their illness.
- Children on formula or solid diets should restart their normal diet (including full strength lactose containing milk) following rehydration with oral rehydration solution.
- Give children who are hungry their usual foods, but avoid foods high in sugar or fat.

Seek medical advice if wound infection is suspected. Wound infections should be treated with antibiotics. Also seek medical advice if any of the following symptoms develop:

Adults

- signs of dehydration, such as being thirsty, decreased urination, lethargy, dry mouth, feeling faint on standing
- fever
- severe abdominal pain
- bloodydiarrhoea.

Children

- signs of dehydration, such as thirst and decreased urination, lethargy, dry mouth, sunken eyes, feeling faint on standing
- fever
- abdominal pain
- bloody diarrhoea
- any symptoms in a child less than 12 months of age.

Prevention

Infections with *V. parahaemolyticus* can be prevented by the following measures:

- Exclude people with *Vibrio parahaemolyticus* infection from childcare, preschool, school and work until there has been no diarrhoea for 24 hours. If working as a food handler in a food business, the exclusion period should be until there has been no diarrhoea or vomiting for 48 hours. People with *Vibrio parahaemolyticus* wound infections do not require exclusion.
- Avoid consumption of raw or undercooked seafood such as oysters, especially during warm summer periods or if at increased risk of severe diseases (such as people with immune suppression).
- Keep raw seafood separated from ready to eat foods when preparing or storing food.
- Wash hands with soap and clean water before and after handling raw seafood.
- Wash hands after going to the toilet, after changing a nappy and after handling rubbish.
- Avoid using seawater for cooking.
- Avoid exposing open wounds to seawater. If wounds are exposed then wash with soap and clean water.

Escherichia coli

Escherichia coli (E. coli) is a bacterium that is commonly found in the gut of humans and warm-blooded animals. Most strains of *E. coli* are harmless. Some strains, however, such as Shiga toxin-producing *E. coli* (STEC), can produce powerful toxins and cause severe foodborne disease. The most recognisedserogroup of STEC is *E.coli* O157:H7. Other strains e.g. *E. coli* O104:H4 may also cause serious disease and outbreaks.

Clinical features

Symptoms of STEC infection include abdominal cramps and diarrhoea that may in some cases progress to bloody diarrhoea. Fever and vomiting may also occur. In serious cases, the infection may lead to a life-threatening complication named haemolyticuraemic syndrome (HUS) which is a type of kidney failure. People of any age can become infected. Very young children and the elderly are more likely to develop severe illness, but even healthy older children and adults can become seriously ill.

Mode of transmission

STEC is transmitted to humans primarily through consumption of contaminated foods, such as raw or undercooked ground meat products, contaminated fruits and vegetables, unpasteurised dairy products, contaminated water, and direct contact with animals or their environment. Direct person-to-person transmission through the faecal-oral route can also occur. Exposure to recreational water sources like swimming in contaminated water is also a route of infection.

Incubation period

Can range from about 2 – 10 days, usually 3 – 4 days.

Management

Clinical management for STEC infection is usually supportive. Fluid and electrolyte replacement is important when there is severe diarrhoea. Patients with kidney failure may require specific supportive treatment and transfusion.

Prevention

Preventive measures for STEC infection are similar to those recommended for other foodborne diseases. Public are urged to observe good personal and food hygiene:

- Adopt the 5 Keys to Food Safety in handling food, i.e. Choose (Choose safe raw materials); Clean (Keep hands and utensils clean); Separate (Separate raw and cooked food); Cook (Cook thoroughly); and Safe Temperature (Keep food at safe temperature) to prevent foodborne diseases.
- Wash hands properly with liquid soap and water before handling food, after handling raw meat or poultry and before eating, and after going to toilet or changing diapers.
- Cook food and boil water thoroughly before consumption. When cooking or reheating, the core temperature of the food should reach at least 75℃.
- Avoid consumption of unpasteurised milk or undercooked food.
- Consult your doctor immediately if you have symptoms of STEC infection, particularly bloody diarrhoea.

Salmonella infection

Salmonella infection (salmonellosis) is a common bacterial disease that affects the intestinal tract. Salmonella bacteria typically live in animal and human intestines and are shed through feces. Humans become infected most frequently through contaminated water or food.

Typically, people with salmonella infection have no symptoms. Others develop diarrhea, fever and abdominal cramps within eight to 72 hours. Most healthy people recover within a few days without specific treatment.

In some cases, the diarrhea associated with salmonella infection can be so dehydrating as to require prompt medical attention. Life-threatening complications also may develop if the infection spreads beyond your intestines. Your risk of acquiring salmonella infection is higher if you travel to countries with poor sanitation.

Symptoms

Salmonella infection is usually caused by eating raw or undercooked meat, poultry, eggs or egg products. The incubation period ranges from several hours to two days. Most salmonella infections can be classified as stomach flu (gastroenteritis). Possible signs and symptoms include:

- Nausea
- Vomiting
- Abdominal cramps
- Diarrhea
- Fever
- Chills
- Headache
- Blood in the stool

Signs and symptoms of salmonella infection generally last two to seven days. Diarrhea may last up to 10 days, although it may take several months before bowels return to normal.

A few varieties of salmonella bacteria result in typhoid fever, a sometimes deadly disease that is more common in developing countries.

Request an Appointment at Mayo Clinic

Causes

Salmonella bacteria live in the intestines of people, animals and birds. Most people are infected with salmonella by eating foods that have been contaminated by feces. Commonly infected foods include:

- **Raw meat, poultry and seafood.** Feces may get onto raw meat and poultry during the butchering process. Seafood may be contaminated if harvested from contaminated water.
- **Raw eggs.** While an egg's shell may seem to be a perfect barrier to contamination, some infected chickens produce eggs that contain salmonella before the shell is even formed. Raw eggs are used in homemade versions of mayonnaise and hollandaise sauce.
- **Fruits and vegetables.** Some fresh produce, particularly imported varieties, may be hydrated in the field or washed during processing with water contaminated with salmonella. Contamination also can occur in the kitchen, when juices from raw meat and poultry come into contact with uncooked foods, such as salads.

The Food and Drug Administration also indicates that some salmonella outbreaks have been traced to contaminants in spices. The agency is seeking ways to increase the safety of spices.

Many foods become contaminated when prepared by people who don't wash their hands thoroughly after using the toilet or changing a diaper. Infection also can occur if you touch something that is contaminated, including pets, especially birds and reptiles, and then put your fingers in your mouth.

Risk factors

Factors that may increase your risk of salmonella infection include activities that may bring you into closer contact with salmonella bacteria and health problems that may weaken your resistance to infection in general.

Increased exposure

- **International travel.** Salmonella infection, including varieties that cause typhoid fever, is more common in developing countries with poor sanitation.
- **Owning a pet bird or reptile.** Some pets, particularly birds and reptiles, can carry salmonella bacteria.

Stomach or bowel disorders

Your body has many natural defenses against salmonella infection. For example, strong stomach acid can kill many types of salmonella bacteria. But some medical problems or medications can short-circuit these natural defenses. Examples include:

- **Antacids.** Lowering your stomach's acidity allows more salmonella bacteria to survive.
- **Inflammatory bowel disease.** This disorder damages the lining of your intestines, which makes it easier for salmonella bacteria to take hold.
- **Recent use of antibiotics.** This can reduce the number of "good" bacteria in your intestines, which may impair your ability to fight off a salmonella infection.

Immune problems

The following medical problems or medications appear to increase your risk of contracting salmonella by impairing your immune system.

- AIDS
- Sickle cell disease
- Malaria
- Anti-rejection drugs taken after organ transplants
- Corticosteroids

Complications

Salmonella infection usually isn't life-threatening. However, in certain people — especially infants and young children, older adults, transplant recipients, pregnant women, and people with weakened immune systems — the development of complications can be dangerous.

Dehydration

If you can't drink enough to replace the fluid you're losing from persistent diarrhea, you may become dehydrated. Warning signs include:

- Decreased urine output
- Dry mouth and tongue
- Sunken eyes
- Reduced production of tears

Bacteremia

If salmonella infection enters your bloodstream (bacteremia), it can infect tissues throughout your body, including:

- The tissues surrounding your brain and spinal cord (meningitis)
- The lining of your heart or valves (endocarditis)
- Your bones or bone marrow (osteomyelitis)
- The lining of blood vessels, especially if you've had a vascular graft

Reactive arthritis

People who have had salmonella are at higher risk of developing reactive arthritis. Also known as Reiter's syndrome, reactive arthritis typically causes:

- Eye irritation
- Painful urination
- Painful joints

Prevention

The Department of Agriculture has created a Salmonella Action Plan, which involves updating the poultry slaughter inspection system and enhancing sampling and testing programs for poultry and meat. The plan's purpose is to cut the number of salmonella infections in the United States.

You can also take care to avoid spreading bacteria to others. Preventive methods are especially important when preparing food or providing care for infants, older adults and people with weakened immune systems. Be sure to cook food thoroughly and refrigerate or freeze food promptly.

Wash your hands

Washing your hands thoroughly can help prevent the transfer of salmonella bacteria to your mouth or to any food you're preparing. Wash your hands after you:

- Use the toilet
- Change a diaper
- Handle raw meat or poultry
- Clean up pet feces
- Touch reptiles or birds

Keep things separate

To prevent cross-contamination:

- Store raw meat, poultry and seafood away from other foods in your refrigerator
- If possible, have two cutting boards in your kitchen — one for raw meat and the other for fruits and vegetables
- Never place cooked food on an unwashed plate that previously held raw meat

Avoid eating raw eggs

Cookie dough, homemade ice cream and eggnog all contain raw eggs. If you must consume raw eggs, make sure they've been pasteurized

Shigella infection or, 'shigellosis,' is an intestinal disease caused by a family of bacteria known as, 'shigella.' The main sign of shigella infection is diarrhea, which is often times bloody. Shigella may be passed through direct contact with the bacteria in the stool.

Shigellosis, (Bacillary dysentery or Marlow Syndrome), is defined as a foodborne illness caused by infection by bacteria of the genus Shigella. The causative organism is frequently found in water polluted with human feces, and is transmitted via the fecal-oral route. The usual mode of transmission is directly person-to-person hand-to-mouth, in the setting of poor hygiene among children. Signs and symptoms of Shigellosis can range from mild abdominal discomfort to full-blown dysentery characterized by cramps, diarrhea, with slimy-consistent stools, fever, blood, pus, or mucus in stools or tenesmus.

For example; this may happen in a child care setting when staff members do not wash their hands well enough after changing diapers, or helping toddlers with toilet training. Shigella bacteria can also be passed in contaminated food, or by drinking or swimming in contaminated water. Children between the ages of two and four are most likely to experience a shigella infection. A mild case commonly clears up on its own within a week. When treatment is required, a doctor will generally prescribe antibiotics.

Symptoms of a Shigella Infection

Signs and symptoms of shigella infection usually start a day or two after contact with shigella, yet might take up to a week to develop. The signs and symptoms can include the following:

- Fever
- Abdominal pain or cramps
- Diarrhea, often times containing mucus or blood

While some people experience no symptoms after they have been infected with shigella, their feces might continue to be contagious for up to a few weeks. It is important to contact a doctor or pursue urgent care if you or your child has bloody diarrhea, or diarrhea severe enough to cause weight loss and dehydration. Contact a doctor if you or your child had diarrhea and a fever of 101F or higher.

Causes of Shigella Infection

A shigella infection occurs when a person accidentally swallows shigella bacteria. Examples of causes of a shigella infection include the following.

Direct Person-To-Person Contact: Person-To-Person contact is the most common way shigella is spread.

Swallowing Contaminated Water: Water may become contaminated either from sewage, or from a person with shigella infection swimming in it.

Touching Your Mouth: If you do not wash your hands well after changing the diaper of a child who has shigella infection, you might become infected as well.

Eating Contaminated Food: Infected people who handle food may transmit the bacteria to others who consume the food. Food may also become contaminated if it grows in a field containing sewage.

Risk Factors for Shigella Infection

One of the risk factors for a shigella infection is simply being a toddler. Shigella infection is most common in children who are between the ages of two and four. Another risk factor is living or traveling in areas lacking sanitation. People who live or travel to developing countries are more likely to contract shigella infection. Additional risk factors include:

Being a Sexually Active Gay Male: Men who have sex with men are at increased risk because of direct or indirect oral-anal contact.

Living in Group Housing: Living in group housing or participating in group activities are risk factors. Close contact with others spreads the bacteria from person to person. Shigella outbreaks are more common in community wading pools, child care centers, jails, nursing homes and military barracks.

Complications of a Shigella Infection

A shigella infection usually clears up without complications, although it might take weeks or even months before your bowel habits return to usual. Complications of a shigella infection may include:

Rectal Prolapse: In this condition, straining during bowel movements might cause the mucous membrane or lining of the rectum to move out through the anus.

Dehydration: Persistent diarrhea may cause dehydration. Symptoms may include lightheadedness, dizziness, a lack of tears in children, dry diapers and sunken eyes. Severe dehydration can lead to shock and death.

Hemolytic Uremic Syndrome: Hemolytic uremic syndrome is a rare complication of shigella, more commonly caused by bacteria called, 'E. Coli,' which may lead to a low red blood cell count, low platelet count and acute kidney failure.

Seizures: Some children who run high fevers with a shigella infection experience seizures. It is not known whether the convulsions are a result of the fever, or the shigella infection itself. If your child experiences a seizure, contact a doctor at once.

Reactive Arthritis: Reactive arthritis develops in response to infection. Signs and symptoms include joint pain and inflammation, usually in the person's feet, ankles and hips; itching, redness and discharge in one or both eyes, as well as painful urination.

Toxic Megacolon: Toxic megacolon is a rare complication that happens when a person's colon becomes paralyzed, preventing them from having a bowel movement or passing gas. Signs and symptoms include abdominal swelling and pain, fever and weakness. If the person does not receive adequate treatment for toxic megacolon, their colon might rupture, causing peritonitis, a life-threatening infection requiring emergency surgery.

Treating Shigella Infection

Diarrhea and bloody diarrhea may result from a number of different diseases. Confirming shigellosis involves taking a sample of a person's stool to be tested in a laboratory for the presence of shigella bacteria, or their toxins. Shigella infection usually runs its course in five to seven days. Replacing lost fluids from diarrhea might be all the treatment a person needs, especially if their general health is good and their shigella infection is mild. Avoid drugs intended to treat diarrhea such as loperamide or atropine because they might worsen the condition.

For severe shigella infection, antibiotics may shorten the duration of the illness. Some shigella bacteria; however, have become drug resistant. It is better not to take antibiotics unless your shigella infection is severe. Antibiotics might also be necessary for infants, seniors, or people who have HIV infection, as well as in situations where there is a high risk of spreading the disease.

For adults who are generally healthy, drinking water might be enough to counteract the dehydrating effects of diarrhea. Children may benefit from an oral rehydration solution such as Pedialyte. Children and adults who are severely dehydrated need treatment in an emergency room, where they can receive fluids and salts intravenously instead of by mouth. Intravenous hydration provides the body with water and essential nutrients more rapidly than oral solutions do.

Preventing Shigella Infection

Even though the World Health Organization has been working on a shigella vaccine, nothing is available at this time. To prevent the spread of shigella, wash your hands often and thoroughly. Supervise small children when they wash their hands, and dispose of soiled diapers appropriately. Disinfect diaper-changing areas after use. Do not prepare food for others if you have diarrhea.

Keep children with diarrhea home from child care, school, or play groups. Avoid swallowing water from lakes, ponds or untreated pools. Avoid sexual activities with anyone who has diarrhea, or who recently recovered from diarrhea

Yersinia enterocolitica

bacillus-shaped bacterium, belonging to the family Enterobacteriaceae. It is motile at temperatures of 22–29° C (72-84°F), but becomes nonmotile at normal human body temperature.[1][2] *Y. enterocolitica* infection causes the disease yersiniosis, which is an animal-borne disease occurring in humans, as well as in a wide array of animals such as cattle, deer, pigs, and birds. Many of these animals recover from the disease and become carriers; these are potential sources of contagion despite showing no signs of disease.[3] The bacterium infects the host by sticking to its cells using trimericautotransporteradhesins.

The genus *Yersinia* includes 11 species: *Y. pestis*, *Y. pseudotuberculosis*, *Y. enterocolitica*, *Y. frederiksenii*, *Y. intermedia*, *Y. kristensenii*, *Y. bercovieri*, *Y. mollaretii*, *Y. rohdei*, *Y. aldovae*, and *Y. ruckeri*. Among them, only *Y. pestis*, *Y. pseudotuberculosis*, and certain strains of *Y. enterocolitica* are of pathogenic importance for humans and certain warm-blooded animals, whereas the other species are of environmental origin and may, at

best, act as opportunists. However, *Yersinia* strains can be isolated from clinical materials, so they have to be identified at the species level.

Y. enterocolitica is a heterogeneous group of strains, which are traditionally classified by biotyping into six biogroups on the basis of phenotypic characteristics, and by serotyping into more than 57 O serogroups, on the basis of their O (lipopolysaccharide or LPS) surface antigen. Five of the six biogroups (1B and 2–5) are regarded as pathogens. However, only a few of these serogroups have been associated with disease in either humans or animals. Strains that belong to serogroups O:3 (biogroup 4), O:5,27 (biogroups 2 and 3), O:8 (biogroup 1B), and O:9 (biogroup 2) are most frequently isolated worldwide from human samples. However, the most important *Y. enterocolitica* serogroup in many European countries is serogroup O:3followed by O:9, whereas the serogroup O:8 is mainly detected in the United States.

Y. enterocolitica is widespread in nature, occurring in reservoirs ranging from the intestinal tracts of numerous mammals, avian species, cold-blooded species, and even from terrestrial and aquatic niches. Most environmental isolates are avirulent; however, isolates recovered from porcine sources contain human pathogenic serogroups. In addition, dogs, sheep, wild rodents, and environmental water may also be a reservoir of pathogenic *Y. enterocolitica* strains. Human pathogenic strains are usually confined to the intestinal tract and lead to enteritis/diarrhea

How *Yersinia* infection is spread

Many domesticated and wild animals carry *Yersinia* in their intestines. Spread to people occurs by eating food or water contaminated by infected human or animal faeces. Contact with infected pets and domestic stock may also cause infection.

Yersinia is able to multiply at temperatures in normal refrigerators, so sometimes if meat is kept without freezing large numbers of the bacteria may be present.

Yersinia is also occasionally transmitted by blood transfusion as it is able to multiply in stored blood products. This is why people are asked not to donate blood if they have had diarrhoea recently.

Signs and symptoms

Symptoms vary with age and are commonest in young children. They include:

- fever
- diarrhoea, often bloody in young children
- abdominal pain and cramps
- symptoms similar to appendicitis in older children and adults
- joint pain occurs in half of affected adults.

Diagnosis

The diagnosis is usually made by a faecal specimen or by detecting *Yersinia* using a PCR (polymerase chain reaction) test in a pathology laboratory.

Incubation period

(time between becoming infected and developing symptoms)

Symptoms typically develop 4 to 7 days after exposure.

Infectious period

(time during which an infected person can infect others)

Usually 2 to 3 weeks. If not treated with antibiotics, the organism may be shed in the faeces for 2 to 3 months.

Treatment

Effective antibiotic treatment is available.

Prevention

- Exclude people with Yersinia infection from childcare, preschool, school and workuntil there has been no diarrhoea for 24 hours. If working as a food handler in a food business, the exclusion period should be until there has been no diarrhoea or vomiting for 48 hours.
- Infants, children and adults with Yersinia infection should not swim until there has been no diarrhoea for 24 hours.

- Cook all meat thoroughly.
- Good food handling procedures should be followed.
- Follow good hand washing and keeping areas clean procedures.
- Wash hands after contact with farm animals, pets, animal faeces or animal environments.
- Do not drink unpasteurised milk.
- anyone with diarrhoea should avoid swimming in pools
- babies and small children without diarrhoea who are not toilet trained should wear tight fitting waterproof pants or swimming nappies in swimming pools and changed regularly in the change room. When faecal accidents occur, swimming pools should be properly disinfected.

Listeria,

Listeriosis is a food-borne infection caused by *Listeria* bacteria. The majority of people who become infected might barely notice the illness. However, those at risk can be severely affected, and mortality rates are relatively high.

Listeriosis, also called *Listeria*, can be a serious infection; it strikes pregnant women, newborns, the elderly, and anyone with a weakened immune system.

In this article, we will look at the symptoms, diagnosis, and treatment of listeriosis. We will also discuss how the bacteria works, the best ways to avoid infection, and recent research into preventing the disease.

Fast facts on listeriosis

Here are some key points about listeriosis. More detail and supporting information is in the main article.

- Listeriosis is an infection caused by *Listeria monocytogenes*
- An estimated 260 Americans die of listeriosis yearly.
- Only immunosuppressed individuals and pregnant women are at risk of a serious case of listeriosis.
- Listeriosis can lead to septicemia or meningitis.
- Pregnant women are 10 times more likely to be infected with *Listeria* than the general population.

What is it?

Listeriosis is an infection caused by *Listeria* bacteria, named after Joseph Lister, the surgeon and pioneer of antiseptic surgery. There are 10 distinct species of *Listeria*; the variant that most commonly impacts humans is *Listeria monocytogenes*.

Listeria is responsible for around 1,600 illnesses and 260 deaths in the United States yearly, exceeding the fatality rates of *Salmonella* and *Clostridium botulinum*. This rate of infection has remained relatively stable over recent years.

Normally caused by eating contaminated food, around 20-30 percent of listeriosis cases are fatal.

Symptoms

Symptoms of listeria include fever.

The initial symptoms of listeriosis might not become apparent for some time; the incubation period is variable and can be anything from 11-70 days after consuming food with *Listeria*.

The following symptoms of *Listeria* infection are likely to last 1-3 days:

- muscle aches
- fever
- flu-like symptoms
- nausea
- diarrhea

For many people, a *Listeria* infection will pass unnoticed. However, in some individuals, the infection will spread to the nervous system where symptoms might include:

- headache
- confusion
- stiff neck
- tremors and convulsions
- loss of balance

In susceptible individuals, listeriosis can lead to a serious blood infection (septicemia) or inflammation of the membranes around the brain (meningitis).

If the listeriosis infection spreads to the brain, the outcomes can be severe and may include:

- Cranial nerve palsies: Paralysis and tremors.
- Encephalitis: Inflammation of the brain.
- Meningitis: Inflammation of the membranes covering the brain and spinal cord.
- Meningoencephalitis: A combination of meningitis and encephalitis.
- Cerebral abscesses: Localized pus build-up within the brain.

Symptoms during pregnancy or for newborn infants

Pregnant women are 10 times more likely to develop listeriosis than the general population. The incidence of listeriosis during pregnancy is 12 per 100,000, compared with 0.7 per 100,000 in the general population.

While a mother with a *Listeria* infection may not show any outward symptoms, an unborn child might be severely affected.

Listeriosis can result in miscarriage or premature birth. There is a possibility that a newborn might suffer a life-threatening infection in the days and weeks after birth.

The symptoms in a newborn child can be subtle but may include:

- irritability
- fever
- vomiting
- loss of interest in feeding

Causes

Listeriosis is caused by *Listeria*, a type of bacteria that is commonly found in water, soil, and feces. Humans are infected when they consume foods that harbor the bacteria.

The most common foods to cause listeriosis outbreaks are deli meats and unpasteurized dairy products. However, many other foods have also been found to spark outbreaks, including caramel apples, cantaloupe, and cabbages fertilized by sheep manure.

Adults who are healthy and have strong immune systems are less at risk of listeriosis. The following are associated with an increased risk of *Listeria* infection:

- age over 65 years
- AIDS (acquired immune deficiency syndrome)
- existing kidney disease
- chemotherapy
- cirrhosis
- diabetes
- surgical removal of the spleen
- anti-rheumatoid arthritis medication and immunosuppressant drugs

Diagnosis

Listeriosis is diagnosed by a blood test. Urine or spinal fluid might also be tested.

Treatment

For minor infections, medication might not be required. For more serious cases of listeriosis, antibiotics are the most common treatment choice; ampicillin can be used alone or in conjunction with another antibiotic (often gentamicin).

If septicemia or meningitis occur, the individual will be given intravenous antibiotics and require up to 6 weeks of care and treatment.

Prevention

Simple methods of listeria prevention include washing hands and scrubbing fruits or vegetables thoroughly before cooking.

Although listeriosis is rare, there are a number of ways to further reduce the chances of becoming infected; these precautions are especially important during pregnancy:

- **Cleanliness** - wash hands with warm soapy water before preparing food. Clean utensils and work surfaces in the same manner.
- **Raw vegetables** - scrub clean under warm water with a brush.
- **Cook thoroughly** - ensure that meat and egg dishes are heated thoroughly and throughout. A food thermometer can be useful.
- **Cheese** - avoid soft cheeses including Brie, feta, Camembert, blue-veined cheeses, or Mexican-style cheeses such as queso fresco, panela, and quesoblanco; unless the label clearly specifies the product was made with pasteurized milk.
- **Meat** - avoid cold meats, especially deli meats and hot dogs, unless cooked at a high temperature before eating. Be careful to wash anything that comes into contact with raw and cold cooked meat.
- **Smoked seafood** - avoid refrigerated smoked seafood unless it is cooked thoroughly before consumption.

Listeria monocytogenes

L. monocytogenes is one of the most virulent food-borne pathogens. It can flourish with or without oxygen and, unlike many other bacteria, can thrive and reproduce at temperatures as low as 0°C.

Listeria has been found in at least 42 species of wild and domesticated animals, and 17 species of birds. The bacterium has been isolated from oysters, fish, crustaceans, ticks, and flies.

Some studies suggest that up to 10 percent of human gastrointestinal tracts contain *L. monocytogenes*. In short, *Listeria* is a successful organism.

Its hardy characteristics, combined with its relative ubiquity make Listeria a serious, ongoing concern.

L. monocytogenes typically enters the host through the intestines and infects the liver first. In the liver, the bacteria multiplies until the host's immune system tackles it; at this stage, the vast majority of infections end. However, in immunocompromised or other at-risk individuals, the infection may continue and eventually move to the brain.

The Listeria bacterium is able to enter and survive within immune cells such as macrophages. *L. monocytogenes* is also capable of hijacking cellular machinery and tricking cells into drawing the bacterium inside.

Within the cell, the bacteria can multiply and spread to neighboring cells, safe from the immune system. This ability to live within human cells makes it unusual, dangerous, and very difficult to treat

Campylobacter jejuni

Campylobacter jejuni (/ˈkæmpɪloʊˌbæktər dʒəˈdʒuːni/) is one of the most common causes of food poisoning in Europe and in the United States. The vast majority of cases occur as isolated events, not as part of recognized outbreaks.[1] Active surveillance through the Foodborne Diseases Active Surveillance Network (FoodNet) indicates that about 14 cases are diagnosed each year for each 100,000 persons in the population.[2] The European Food Safety Authority estimated in 2011 that there are approximately nine million cases of human campylobacteriosis per year in the European Union.[3]

Campylobacter jejuni is in a genus of bacteria that is among the most common causes of bacterial infections in humans worldwide. Campylobacter means "curved rod", deriving from the Greek *kampylos* (curved) and *baktron* (rod). "There is wide diversity in the genus. The species are metabolically and genetically different to the extent that one can question whether one genus is adequate to house all of the species."[4] Of its many species, *C. jejuni* is considered one of the most important from both a microbiological and public health perspective.[5]

C. jejuni is also commonly found in animal feces. *Campylobacter* is a helical-shaped, non-spore-forming, Gram-negative, microaerophilic, nonfermenting bacterium forming motile rods with a single polar flagellum, which are also oxidase-positive and grow optimally at 37 to 42 °C.[6][7][8][9] When exposed to atmospheric oxygen, *C. jejuni* is able to change into a coccal form.[10] This species of pathogenic bacteria is one of the most common

causes of human gastroenteritis in the world. Food poisoning caused by *Campylobacter* species can be severely debilitating, but is rarely life-threatening. It has been linked with subsequent development of Guillain–Barré syndrome, which usually develops two to three weeks after the initial illness.[11] Individuals with recent *C. jejuni* infections develop Guillain-Barré syndrome at a rate of 0.3 per 1000 infections, about 100 times more often than the general population

How *Campylobacter* infection is spread

Eating contaminated food is the most frequent cause of this infection. *Campylobacter* is commonly found in raw or undercooked poultry meat. Occassionally other sources of infection include:

- infected individuals, particularly infants
- household pets, especially puppies and kittens
- domestic stock
- raw milk
- contaminated water.

Signs and symptoms

Symptoms may include:

- diarrhoea which may sometimes be bloody
- fever
- stomach cramps.

Vomiting is not common. The most severe infections occur in the very young, the elderly and malnourished people.

Rarely, *Campylobacter* infection may lead to Guillain-Barré syndrome, a condition which causes muscular paralysis.

Diagnosis

Diagnosis is made by growing *Campylobacter* bacteria from a faecal specimen or by detecting the bacteria in a faecal sample using a PCR (polymerase chain reaction) test in a pathology laboratory.

Incubation period

(time between becoming infected and developing symptoms)

Usually 2 to 5 days, with a range of 1 to 10 days.

Infectious period

(time during which an infected person can infect others)

A person is infectious for as long as the *Campylobacter* bacteria are in their faeces, which may be for an average of 2 to 3 weeks after symptoms are gone. The risk of infecting others decreases when diarrhoea is no longer present.

Treatment

Antibiotic treatment is not usually needed for *Campylobacter* infection. Recovery from symptoms usually occurs within a few days.

The following are general recommendations for the treatment of gastroenteritis:

- Give plenty of fluids. Oral rehydration solution is highly recommended for children with mild to moderate dehydration. It is available at pharmacies and should be administered following the instructions on the packaging.
- Mildly unwell children should be given their usual fluids more often. Carbonated (fizzy) drinks or undiluted juice should be avoided.
- Medicines to prevent vomiting or diarrhoea should not be given (especially in children), except where specifically advised by a doctor.
- Breastfed babies should continue to be breastfed throughout their illness.
- Children on formula or solid diets should restart their normal diet (including full strength lactose containing milk) following rehydration with oral rehydration solution.
- Children who are hungry or ask for food should be given small portions of their usual foods, but avoid foods high in sugar or fat.

When to seek medical advice

Seek medical advice if there are any of the following symptoms:

Adults

- Signs of dehydration, such as thirst and decreased urination, lethargy, dry mouth, feeling faint on standing
- fever
- severe abdominal pain
- bloodydiarrhoea.

Children

- Signs of dehydration, such as thirst and decreased urination, lethargy, dry mouth, sunken eyes, feeling faint on standing
- fever
- abdominal pain
- bloody diarrhoea
- any symptoms in a child less than 12 months of age.

Prevention

- Exclude people with *Campylobacter* from childcare, preschool, school and work until there has been no diarrhoea for 24 hours. If working as a food handler in a food business, the exclusion period should be until there has been no diarrhoea or vomiting for 48 hours.
- Infants, children and adults with *Campylobacter* infection should not swim until there has been no diarrhoea for 24 hours.
- Wash hands after handling raw meat, especially poultry, and keep food preparation areas clean.
- Wash hands after gardening or touching animals.
- Meat, particularly poultry, should be thoroughly cooked.
- Do not store uncooked poultry or other meat near foods which will be eaten raw, such as salad items.
- If pets are sick with diarrhoeal illness, have them treated.
- Babies and small children without diarrhoea who are not toilet trained should wear tight fitting waterproof pants or swimming nappies in swimming pools and be changed regularly in the change room. When faecal accidents occur, swimming pools should be properly disinfected

Fungal infections are common throughout much of the natural world. In humans, fungal infections occur when an invading fungus takes over an area of the body and is too much for the immune system to handle.
Fungi can live in the air, soil, water, and plants. There are also some fungi that live naturally in the human body.

Like many microbes, there are helpful fungi and harmful fungi. When harmful fungi invade the body, they can be difficult to kill, as they can survive in the environment and re-infect the person trying to get better.

In this article, we take a look at who is most at risk of getting a fungal infection and what the symptoms and treatment options are for some common types.

Symptoms

Skin changes, redness, and itching are common symptoms of many fungal infections.

The symptoms of a fungal infection will depend on the type, but common symptoms include the following:

- skin changes, including red and possibly cracking or peeling skin
- itching
  Read on to find out more about some common types of fungal infection, their symptoms, and the treatment options.

Types

The following conditions are all common types of fungal infections.

Athlete's foot

Tineapedis or athlete's foot is a common fungal infection that affects the foot.

Athlete's foot is commonly associated with sports and athletes because the fungus grows perfectly in warm, moist environments, such as socks and shoes, sports equipment, and locker rooms.

In reality, anyone may be affected by athlete's foot. It is most common in warmer climates and summer months, where it can quickly multiply.

Symptoms

Athlete's foot is a common infection where the fungus grows in warm and moist environments.

The symptoms of athlete's foot may vary slightly from person to person. Classic symptoms include:

- redness or blisters on the affected area
- the infected skin may be soft, or layers may start to break down
- peeling or cracking skin
- the skin may scale and peel away
- itching, stinging, or burning sensations in the infected area

Diagnosis, treatment, and prevention

Not all itchy feet are the result athlete's foot. Doctors usually diagnose the infection by scraping scaling skin off of a person and inspecting it under a microscope for evidence of any fungus.

There are a few different fungi that can cause athlete's foot. The infection may behave differently depending on the specific fungus that is infecting the skin.

Athlete's foot is often treated with topical antifungal ointments, which are available to purchase over-the-counter or online. Severe infections can require additional oral medications as well. The feet will also need to be cared for and kept dry to help kill the fungus.

Prevention methods include allowing the feet plenty of air to breathe and keeping them clean and dry. It is a good idea to wear sandals in public showers or locker rooms.

Yeast infection

Vaginal yeast infections are a common form of *Candida* overgrowth in women, usually caused by *Candida albicans*.

An overgrowth of *Candida* disrupts the normal balance of the bacteria and yeast in the vagina. This imbalance of bacteria may be due to antibiotics, stress, and hormone imbalances, or poor eating habits, among other things.

Candida infections can also commonly cause fungal toenail infections and diaper rash.

Symptoms

A yeast infection may commonly cause fungal toenail infections.

Symptoms of a yeast infection include:

- itching and swelling around the vagina
- burning sensations or pain during urination or intercourse
- redness and soreness on and surrounding the vagina
- unusual vaginal discharge, such as gray clumps that resemble cottage cheese or a very watery discharge

A rash may develop over time in some cases. Yeast infections should be treated quickly, as the symptoms may become severe if left untreated.

Diagnosis, treatment, and prevention

The classic symptoms of a yeast infection make them easy to diagnose. Doctors may ask about the person's medical history, such as any previous yeast infections or sexually transmitted infections(STIs). They may also ask whether the person was recently taking antibiotics.

Doctors will then examine the vaginal walls and cervix for signs of infection, taking cells from the vagina if necessary for proper diagnosis.

Treatment of yeast infections depends on their severity. Standard treatments include creams, tablets, or suppositories, which are available via prescription, or over-the-counter or online. Complicated infections may require complex treatments.

Avoiding yeast infections begins with a balanced diet and proper hygiene. Wearing loose-fitting clothing made from natural fibers may also help prevent infection. Washing underwear in very hot water and changing feminine products often can also help prevent fungal growth.

Jock itch

Tineacruris, commonly known as jock itch, is another common fungal skin infection.

These fungi love warm and damp environments and thrive in moist areas of the body, such as the groin, buttocks, and inner thighs. Jock itch may be more common in summer or in warm, humid areas of the world.

Jock itch is mildly contagious and is often spread through direct contact with an infected person or an object that is carrying the fungus.

Symptoms

Thrush can affect the genital area in men as well as women.

Jock itch appears on the body as an itchy, red rash that often has a circular shape to it. Symptoms include:

- redness in the groin, buttocks, or thighs
- chafing, irritation, itching, or burning in the infected area
- a red rash with a circular shape and raised edges
- cracking, flaking, or dry peeling of the skin in the infected area

Most common fungal diseases

Fungal nail infections

Common infections of the fingernails or toenails.

Vaginal candidiasis

Caused by the yeast *Candida*, also called a "vaginal yeast infection."

Ringworm

A common fungal skin infection that often looks like a circular rash.

Candida infections of the mouth, throat, and esophagus

Caused by the yeast *Candida*, also called "thrush.

Fungal diseases that affect people who live in or travel to certain areas

Blastomycosis

Caused by the fungus *Blastomyces*, which lives in moist soil in parts of the United States and Canada.

Cryptococcus gattii infection

Caused by *Cryptococcus gattii*, which lives in tropical and sub-tropical areas of the world, the United States Pacific Northwest, and British Columbia.

Paracoccidioidomycosis

Caused by the fungus *Paracoccidioides*, which lives in parts of Central and South America and most often affects men who work outdoors in rural areas.

Coccidioidomycosis (Valley Fever)

Caused by *Coccidioides*, which lives in the southwestern United States and parts of Mexico and Central and South America.

Histoplasmosis

Caused by the fungus *Histoplasma*, which lives in the environment, often in association with large amounts of bird or bat droppings.

Fungal diseases that affect people with weakened immune systems

Weakened immune systems can't fight off infections as well, due to conditions such as HIV, cancer, organ transplants, or certain medications.

Aspergillosis

An infection caused by *Aspergillus*, a common mold that lives indoors and outdoors.

Candida auris infection

Emerging, often multidrug-resistant fungus found in healthcare settings that presents a serious global health threat.

Invasive candidiasis

A serious infection that can affect the blood, heart, brain, eyes, bones, and other parts of the body in hospitalized patients.

Pneumocystis pneumonia (PCP)

A serious infection caused by the fungus *Pneumocystis jirovecii*.

Candidiasis

Candida normally lives inside the body and on the skin without causing any problems, but can cause infections if it grows out of control or if it enters deep into the body.

*Cryptococcus neoformans*infection

Can infect the brain, causing meningitis, and is more likely to affect people with HIV/AIDS.

Mucormycosis

A rare but serious infection caused by a group of molds called mucormycetes.

Talaromycosis

Caused by *Taloromyces*, a fungus that lives in Southeast Asia, southern China, or eastern India.

Other diseases and health problems caused by fungi

Fungal eye infections

Rare infections that can develop after an eye injury or after eye surgery.

Sporotrichosis

Caused by the fungus *Sporothrix*, which lives throughout the world in soil and on plants.

KARPAGAM ACADEMY OF HIGHER EDUCATION

CLASS: II B.Sc MB
COURSE CODE: 18MBU301

COURSE NAME: FOOD AND DAIRY MICROBIOLOGY
BATCH-2018-2021

UNIT IV	OPTION 1	OPTION 2	OPTION 3	OPTION 4	ANSWER KEY
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
_____ is a term used to label foods treated with low level ionizing radiation	Radicidation	radurization	picowaved	radappertization	Picowaved
Flavoring etracts such as vanilla and lemon etracts are preserved by their content of ____	sugar	salt	alcohol	ethylene	alcohol
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
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*
_____ contains a large number of olatile compounds that may have bacteriostatic and bactericidal effect	spices	woodsmoke	formaldehyde	alcohol	woodsmoke
_____ has been used as starter culture in fermented sausages	sweating	springer	cooling	freezing	springer
_____ 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
_____ can be dried by a process called explosive puffing	meat	vegetables	fruits	juices	vegetables
_____ in 1765 preserved food by heating it in a sealed containers	Spallanzani	Ruiz-Argueso	Rodrigeuz-Navarro	Christophersen	spallanzani
Combination of _____ irradiation with chilling storage helps preserve foods	Ultraviolet	infra red	gamma	none of the above	ultraviolet
Which solvent is commonly used to determine fat	Ethyl alcohol	Hexane	Acetone	Benzene	Hexane

Prepared by R.Dineshkumar, Assistant Professor, Dept of Microbiology, KAHE.

content					
During _____ the internal temperature of bread, cake or other bakery products approaches but neve reaches 100 °C	Heating	boiling	baking	all of these	baking
Pasteurization is done to kill	Selective microorganism	All the microorganism	Yeast	Yeast and its spores	Selective microorganism
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
The simplest dryer is the _____	sun	air	heat	evaporator	evaporator
Bacteria which is present in raw or undercooked meat, eggs, sea food and unpasteurized milk is	*E.coli*	*Salmonella*	*Staphylococcus*	cyano bacteria	*salmonella*
Milk and curry left over can be turned into sour and spoiled at	high temperature	very low temperature	room temperature	constant temperature	room temperature
_____ rays are streams of electrons emitted from radioactive materials	beta	cathode	gamma	X-rays	beta
Increase in the concentration of dissolved substances like sugar and salt helps in _____ of the food material	drying	freezing	moistening	thawing	drying
Sulfur stinker spoilage of canned food is caused by	*E.coli*	*D. nigrificans*	*Bacillus*	*Clostridium*	*D. nigrificans*
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
Preservation affects the growth of microorganism by	inhibition	retardation	arresting	all the above	retardation
Souring of canned meat is caused by _____.	thermoduric cells	thermostatic cells	thermo liable cells	none of the above	thermoduric cells
Significant numbers of S. aureus in a food can be determined by examining the food	RNase	thermostable nuclease	protease	thermostable DNase	protease

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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
Gazing at ultraviolet lamps produces irritation of the ____ within few seconds	eye	ear	nose	throat	eye
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
The minimal pH for the growth of staphylococcus is about ----------	2.5	4.8	2	3.5	4.8
_____ alcohol is used as coagulant and enaturizer of cell proteins	methanol	ethanol	butanol	none of these	ethanol
The fumes of burning ____ are used to treat light colored dehydrated fruits	sulfur	ethylene	potassium	sodium	sulfur
_____ can be used to control bacterial and fungal growth in tapholes of maple tree	paraformaldehyde	benzaldehyde	formaldehyde	all of these	paraformaldehyde
Christophersen classified microroganisms on the basis of sensitivity to freezing in the year_____	1984	1989	1973	1981	1973
The percentage fat constituent of double toned milk is	0.5	1.5	3	4.5	1.5
---------- is mostly used preservative to prevent mold growth	sodium propionate	springer	sorbates	acetate	sodium propionate
_____ solvent is poisonous and should not be added to foods	propylene	ethanol	methanol	glycerol	methanol
_____ drying is limited to climates with a hot sun and dry atmosphere to fruits	mechanical	solar	freeze	all of these	solar
Food should be cooked to which temperature?	5°C	75°C	100°C	60°C	75°C
The sclerotia from a species of Penicillium can survive	70 °C	90 to100 °C	50-60 °C	37 °C	90 to100 °C

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a heat treatment of ____					
The sodium salt of _____ acid has been used extensively as an antimicrobial agent in foods	propionic	benzoic	sorbic	acetic	benzoic
Fruit juice is sterilized by _____.	filteration	freezing	cooling	heating	filteration
Pasteurization is a _____	low temperature treatment	steaming treatment	high temperature treatment	low and high temperature treatment	high temperature treatment
The reddish liquid comes out from meat on thawing process is called as	drying	wilting	bleeding	leakage	bleeding
The spoilage organism bring about the spoilage of meat by	purification	oxidation	decomposition	hydrolysis	decomposition
The minimum growth temperature of Bifidobacteria range from	43 to 45	25 to 28	29 to 32	30 to 35	43 to 45
_____ acid is used in soft drinks such as colas	phosphoric	benzoic	acetic	sorbic	phosphoric
_____ freezing usually refer to freezing in air with only natural air circulation	Sharp	slow	quick	all of these	sharp
Jones and Loackhead found enterotoxin forming Staphylococci in _____food	frozen corn	cheese	bread	jam	frozen corn
_____ from retail market contain from 0 to2 million bacteria per piece	caramels	jellies	fudges	candies	candies
---------- is a storage method uses bins or boxes for equalization of moist	Sweating	Springer	Cooling	Freezing	Springer
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
_____organic acid is used in syrups, drinks, jam and jellies	lactic	acetic	propionic	citric	citric
Food preservation involves_____	increasing shelf life	ensuring	both a and b	none of these	both a and b

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	of food	safety for human consumption			
97 to 99 % of *E.coli* in air were killed in ____ seconds with a 15 watts lamp	40	10	50	30	10
_____ is used as treatment for wrappers use don butter	sodium diacetate	calcium carbonate	sodium nitrate	potassium nitrite	sodium diacetate
_____ temperature are more lethal	high freezing	frozen storage	freezing rate	thawing	high freezing
About ____ percent of the suspected samples contained viable spores	20	10	30	50	10
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
_____organic acid is used in syrups, drinks, jam and jellies	lactic	acetic	propionic	citric	citric
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
_____ 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

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47	Pathogenecity involves the release of a ___ endotoxin which affects the intestinal mucosa	lipopolysaccharides	monosaccharides	polysaccharides	peptidoglycan	lipopolysaccharides
48	Theoptimal pH for enteropathogenic E.coli is	4.0to5.0	7.0to7.5	3.0to4.0	8.0to9.0	7.0to7.5
49	Typhoid fever is caused by____	Salmonella enteritidis	Salmonella infantis	Salmonella typhi	Salmonella typhimurium	Salmonella typhi
50	The FDA and USDA cooperative is a surveillance program	Pseudomonas	E.coli	Salmonella	Vibrio	Salmonella
51	_____ agencies aprove the good house keeping institute	commercial	state	federal	private	private
52	A_____ refers to food borne illnesses caused by the entrance of bacteria into the body through ingestion of contaminated food	food infection	food poisoning	food intoxication	contamination	food infection
53	The incubation priod of Streptococcus faecalis is	5to 10	2 to 10	2to 18	8 to 12	2 to 18
54	_____ organisms can be isolated from seafoods and sea water	Vibrio cholera	V.vulnificus	V.parahaemolyticus	all	V.vulficans
55	The term ____ is used to distinguish strains of different antigenic complements	biovars	serovar	herbivore	none	serovar
56	Strains used for the brewing of soy sauce is	A.oryzae	A.sojae	A.tamarii	all these	all these
57	The food and drug administration act was amended in the year	1983	1980	1953	1964	1980

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58	___ involves the identification of ingredients and products that have effect on food safetty	hazard analysis	CCP	fishery service	HACCP	hazard analysis
59	Which of the following is not a probiotic?	B.longum	L.reuteri	B.lactis	S.typhi	S.typhi
60	The antioxidants present in the sauerkraut is	lutein	zeaxanthin	both a and b	GLP	both a and b

DIAGNOSIS AND MANAGEMENT OF FOODBORNE ILLNESSES:

A PRIMER FOR PHYSICIANS

BACKGROUND

This primer is directed to primary care physicians, who are more likely to see the index case of a potential food-related disease outbreak. It is a teaching tool to update primary care physicians about food borne illness and remind them of their important role in recognizing suspicious symptoms, disease clusters, and etiologic agents, and reporting cases of foodborne illness to public health authorities.

Specifically, this guide urges physicians to:

- Recognize the potential for a foodborne etiology in a patient's illness;
- Realize that many but not all cases of foodborne illness have gastrointestinal tract symptoms;
- Obtain stool cultures in appropriate settings, and recognize that testing for some specific pathogens, e.g. E. coli O157:H7, Vibrio spp., must be requested;
- Report suspect cases to appropriate public health officials;
- Talk with patients about ways to prevent food-related diseases; and
- Appreciate that any patient with foodborne illness may represent the sentinel case of a more widespread outbreak.

Foodborne illness is considered to be any illness that is related to food ingestion; gastrointestinal tract symptoms are the most common clinical manifestations of foodborne illnesses. This document provides detailed summary tables and charts, references, and resources for healthcare professionals. Patient scenarios and clinical vignettes are included for self-evaluation and to reinforce information presented in this primer. Also included is a CME component worth 3 credit hours.

This primer is not a clinical guideline or definitive resource for the diagnosis and treatment of foodborne illness. Safe food handling practices and technologies (e.g. irradiation, food processing and storage) also are not addressed. More detailed information on these topics is available in the references and resources listed in this document, as well as from medical specialists and medical specialty societies, state and local public health authorities, and federal government agencies.

CLINICAL CONSIDERATIONS

food-related disease threats are numerous and varied, involving biological and nonbiological agents. Foodborne illnesses can be caused by microorganisms and their toxins, marine organisms and their toxins, fungi and their related toxins, and chemical contaminants. During the last 20 years, some foods that have been linked to outbreaks include: milk (*Campylobacter*); shellfish (Norwalk-like viruses); unpasteurized apple cider (*Escherichia coli* O157:H7), eggs (*Salmonella*); fish (ciguatera poisoning); raspberries (*Cyclospora*); strawberries (hepatitis A virus); and ready-to-eat meats (*Listeria*).

While physicians have a critical role in surveillance for and prevention of potential disease outbreaks, only a fraction of the people who experience gastrointestinal tract symptoms from foodborne illness seek medical care. In those who do seek care and submit specimens, bacteria are more likely than other pathogens to be identified as causative agents. Bacterial agents most often identified in patients with foodborne illness in the United States are *Campylobacter*, *Salmonella*, and *Shigella* species, with substantial variation occurring by geographic area and season. Testing for viral etiologies of diarrheal disease is rarely done, but viruses are considered the most common cause of foodborne illness.

This section and the **Foodborne Illnesses Tables** summarize diagnostic features and laboratory testing for bacterial, viral, parasitic, and noninfectious causes of foodborne illness. For more specific guidance, consult an appropriate medical specialist or medical specialty society, as well as various resources listed in other sections of this document. Also refer to this section and the **Foodborne Illnesses Tables** when working through the **Patient Scenarios** and **Clinical Vignettes** of this primer.

RECOGNIZING FOODBORNE ILLNESSES

Patients with foodborne illnesses typically present with gastrointestinal tract symptoms (e.g. vomiting, diarrhea, and abdominal pain); however, nonspecific symptoms and neurologic symptoms may also occur. Every outbreak begins be the only one with the opportunity to make an early and expeditious diagnosis. Thus, the physician must have a high index of suspicion and ask appropriate questions to recognize that an illness may have a foodborne etiology.

Important clues to determining the etiology of a foodborne disease are the:

- Incubation period;
- Duration of the resultant illness;
- Predominant clinical symptoms; and
- Population involved in the outbreak.

Additional clues may be derived by asking whether the patient has consumed raw or poorly cooked foods (e.g. raw or undercooked eggs, meats, shellfish, fish), unpasteurized milk or juices, home canned goods, fresh produce, or soft cheeses made from unpasteurized milk. Inquire whether any of the patient's family members or close friends has similar symptoms. Inquiries about living on or visiting a farm, pet contact, day care attendance, occupation, foreign travel, travel to coastal areas, camping excursions to mountains or other areas where untreated water is consumed, and attendance at group picnics or similar outings also may provide clues for determining the etiology of the illness.

If a foodborne illness is suspected, submit appropriate specimens for laboratory testing and contact the state or local health department for advice about epidemiologic investigation. For the physician, implication of a specific source in disease transmission is difficult from a single patient encounter. Attempts to identify the source of the outbreak are best left to public health authorities.

Because infectious diarrhea can be contagious and is easily spread, rapid and definitive identification of an etiologic agent may help control a disease outbreak. An individual physician who obtains testing can contribute the necessary piece of data that ultimately leads to identification of the source of an outbreak.

DIAGNOSING FOODBORNE ILLNESSES

Differential Diagnosis

As shown in Table 1 and the **Foodborne Illnesses Tables** a variety of infectious and noninfectious agents must be considered in patients suspected of having a foodborne illness. Establishing a diagnosis can be difficult, however, particularly in patients with persistent or chronic diarrhea, those with severe abdominal pain, and when there is an underlying disease process. The extent of diagnostic evaluation depends on the clinical picture, the differential diagnosis considered, and clinical judgment.

If any of the following signs and symptoms occur, alone or in combination, laboratory testing may provide important diagnostic clues (particular attention should be given to very young and elderly patients and to immunocompromised patients, all of whom are more vulnerable):

- Bloody diarrhea
- Weight loss
- Diarrhea leading to dehydration
- Fever
- Prolonged diarrhea (3 or more unformed stools per day, persisting several days)
- Neurologic involvement such as paresthesias, motor weakness, cranial nerve palsies
- Sudden onset of nausea, vomiting, diarrhea
- Severe abdominal pain

In addition to foodborne causes, a differential diagnosis of gastrointestinal tract disease should include underlying medical conditions such as irritable bowel syndrome; inflammatory bowel diseases such as Crohn's disease or ulcerative colitis; malignancy; medication use (including antibiotic-related *Clostridium difficile* toxin colitis); gastrointestinal tract surgery or radiation; malabsorption syndromes; immune deficiencies; Brainerd diarrhea; and numerous other structural, functional, and metabolic etiologies. Consideration also should be given to exogenous factors such as the association of the illness with travel, occupation, emotional stress, sexual practices, exposure to other ill persons, recent hospitalization, child care center attendance, and nursing home residence.

The differential diagnosis of patients presenting with neurological symptoms due to a foodborne illness is also complex. Possible food-related causes to consider include recent ingestion of contaminated seafood, mushroom poisoning, and chemical poisoning. Because the ingestion of certain toxins (e.g. botulinum toxin, tetrodotoxin) and chemicals (e.g. organophosphates) can be life-threatening, a differential diagnosis must be made quickly with concern for aggressive therapy and life support measures (e.g. respiratory support, administration of antitoxin or atropine), and possible hospital admission.

Clinical Microbiology Testing

When submitting specimens for microbiologic testing, it is important to realize that clinical microbiology laboratories differ in protocols used for the detection of pathogens. To optimize recovery of an etiologic agent, physicians should understand routine specimen collection and testing procedures as well as circumstances and procedures for making special test requests. Some complex tests (e.g. toxin testing, serotyping, molecular techniques) may only be available from large commercial and public health laboratories. Contact your microbiology laboratory for more information.

Stool cultures are indicated if the patient is immunocompromised, febrile, has bloody diarrhea, has severe abdominal pain, or if the illness is clinically severe or persistent. Stool cultures are also indicated if many fecal leukocytes are present, which indicates diffuse colonic inflammation and is suggestive of invasive bacterial pathogens such as *Shigella*, *Salmonella*, and *Campylobacter*species, and invasive *E. coli*. In most laboratories, routine stool cultures are limited to screening for *Salmonella* and *Shigella* species, and *Campylobacter jejuni/coli*. Cultures for *Vibrio* and *Yersinia*species, *E. coli* O157:H7, and *Campylobacter* species other than *jejuni/coli* require additional media or incubation conditions and therefore require advance notification or communication with laboratory and infectious disease personnel.

Stool examination for parasites generally is indicated for patients with suggestive travel histories, who are immunocompromised, who suffer chronic or persistent diarrhea, or when the diarrheal illness is unresponsive to appropriate antimicrobial therapy. Stool examination for parasites is also indicated for gastrointestinal tract illnesses that appear to have a long incubation period. Requests for ova and parasite examination of a stool specimen will often enable identification of *Giardia lamblia* and *Entamoebahistolytica*, but a special request may be needed for detection of *Cryptosporidium parvum* and *Cyclosporacayetanensis*. Each laboratory may vary in its routine procedures for detecting parasites so it is important to contact your laboratory.

Blood cultures should be obtained when bacteremia or systemic infection are suspected.

Direct antigen detection tests and molecular biology techniques are available for rapid identification of certain bacterial, viral, and parasitic agents in clinical specimens. In some circumstances, microbiologic and chemical laboratory testing of vomitus or implicated food items also is warranted. For more information on laboratory procedures for the detection of foodborne pathogens, consult an appropriate medical specialist, clinical microbiologist, or state public health laboratory.

TREATING FOODBORNE ILLNESSES

Selection of appropriate treatment depends on identification of the responsible pathogen (if possible) and determining if specific therapy is available. Many episodes of acute gastroenteritis are self limiting and require fluid replacement and supportive care. Oral rehydration is indicated for patients who are mildly to moderately dehydrated; intravenous therapy may be required for more severe dehydration. Because many antidiarrheal agents have potentially serious adverse effects in infants and young children, their routine use is not recommended in this age group.

Choice of antimicrobial therapy should be based on:

- Clinical signs and symptoms;

- Organism detected in clinical specimens;
- Antimicrobial susceptibility tests; and
- Appropriateness of treating with an antibiotic (some enteric bacterial infections are best not treated).

Knowledge of the infectious agent and its antimicrobial susceptibility pattern allows the physician to initiate, change, or discontinue antimicrobial therapy. Such information also can support public health surveillance of infectious disease and antimicrobial resistance trends in the community. Antimicrobial resistance has increased for some enteric pathogens, which requires judicious use of this therapy.

SURVEILLANCE AND REPORTING OF FOODBORNE ILLNESSES

Reporting of foodborne illnesses in the United States began more than 50 years ago when state health officers, concerned about the high morbidity and mortality caused by typhoid fever and infantile diarrhea, recommended that cases of "enteric fever" be investigated and reported. The intent of investigating and reporting these cases was to obtain information about the role of food, milk, and water in outbreaks of gastrointestinal tract illness as the basis for public health actions. These early reporting efforts led to the enactment of important public health measures (e.g. the Pasteurized Milk Ordinance) that profoundly decreased the incidence of foodborne illnesses.

Often health care professionals may suspect foodborne illness either because of the organism involved or because of other available information, such as several ill patients who have eaten the same food. Health care professionals can serve as the eyes and ears for the health department by providing such information to the local or state public health authorities. Foodborne disease reporting is not only important for disease prevention and control, but more accurate assessments of the burden of foodborne illness in the community occur when physicians report foodborne illnesses to the local or state health department. In addition, reporting of cases of foodborne illness by practicing physicians to the local health department may help the health officer identify a foodborne disease outbreak in the community. This may lead to early identification and removal of contaminated products from the commercial market. If a restaurant or other food service establishment is identified as the source of the outbreak, health officers will work to correct inadequate food preparation practices, if necessary. If the home is the likely source of the contamination, health officers can institute public education about proper food handling practices. Occasionally, reporting may lead to the identification of a previously unrecognized agent of foodborne illness. Reporting also may lead to identification and appropriate management of human carriers of known foodborne pathogens, especially those with high-risk occupations for disease transmission such as foodworkers.

Table 2 lists current reporting requirements for foodborne diseases and conditions in the United States. National reporting requirements are determined collaboratively by the Council of State and Territorial Epidemiologists and the Centers for Disease Control and Prevention (CDC).

Typically, the appropriate procedure for physicians to follow in reporting foodborne illnesses is to contact the local or state health department whenever they identify a specific notifiable disease. However, it is often unclear if a patient has a foodborne illness prior to diagnostic tests, so physicians should also report potential foodborne illnesses, such as when two or more patients present with a similar illness that may have resulted from the ingestion of a common food. Local health departments then report the illnesses to the state health department and determine if further investigation is warranted. Each state health department reports foodborne

illnesses to the CDC. The CDC compiles this data nationally and disseminates information to the public through annual summary reports. The CDC assists state and local public health authorities with epidemiologic investigations and the design of interventions to prevent and control food-related outbreaks. The CDC also coordinates a national network of public health laboratories, called PulseNet, which perform "molecular fingerprinting" of bacteria (by pulsed-field gel electrophoresis) to support epidemiolgic investigations.

Thus, in addition to reporting cases of potential foodborne illnesses, it is important for physicians to report noticeable increases in unusual illnesses, symptom complexes, or disease patterns (even without definitive diagnosis) to public health authorities. Prompt reporting of unusual patterns of diarrheal/gastrointestinal tract illness, for example, can allow public health officials to initiate an epidemiologic investigation earlier than would be possible if the report awaited definitive etiologic diagnosis.

Finally, new information on food safety is constantly emerging. Recommendations and precautions for people at high risk are updated whenever new data about preventing foodborne illnesses become available. Physicians and other health care professionals need to be aware of and follow the most current information on food safety

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Foodborne Illnesses (Bacterial)

Etiology	Incubation Period	Signs and Symptons	Duration of Illness	Associated Foods	Laboratory Testing	Treatment
Bacillus anthracis	2 days to weeks	Nausea, vomiting, malaise, bloody diarrhea, acute abdominal pain.	Weeks	Insufficiently cooked contaminated meat.	Blood.	Penicillin is first choice for naturally acquired gastro-intestinal anthrax. Ciprofloxacin is second option.
Bacillus cereus (diarrheal toxin)	10-16 hrs	Abdominal cramps, watery diarrhea, nausea.	24-48 hours	Meats, stews, gravies, vanilla sauce.	Testing not necessary, self-limiting (consider testing food and stool for toxin in outbreaks).	Supportive care, self-limiting.
Bacillus cereus (preformed enterotoxin)	1-6 hrs	Sudden onset of severe nausea and vomiting. Diarrhea may be present.	24 hrs	Improperly refrigerated cooked and fried rice, meats.	Normally a clinical diagnosis. Clinical laboratories do not routinely identify this organism. If indicated, send stool and food specimens to reference laboratory for culture and toxin identification.	Supportive care.
Brucella abortus, *B. melitensis*, and *B. suis*	7-21 days	Fever, chills, sweating, weakness, headache, muscle and joint pain, diarrhea, bloody stools during acute phase.	Weeks	Raw milk, goat cheese made from unpasteurized milk, contaminated meats.	Blood culture and positive serology.	Acute: Rifampin and doxycycline daily for ≥6 weeks. Infections with complications require combination therapy with rifampin, tetracycline and an aminoglycoside.
Campylobacter jejuni	2-5 days	Diarrhea, cramps, fever, and vomiting; diarrhea may be bloody.	2-10 days	Raw and undercooked poultry, unpasteurized milk, contaminated water.	Routine stool culture; *Campylobacter* requires special media and incubation at 42°C to grow.	Supportive care. For severe cases, antibiotics such as erythromycin and quinolones may be indicated early in the diarrheal disease. Guillain-Barré syndrome can be a sequala.

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(Continued) Foodborne Illnesses (Bacterial)

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Clostridium botulinum children and adults (preformed toxin)	12-72 hrs	Vomiting, diarrhea, blurred vision, diplopia, dysphagia, and descending muscle weakness.	Variable (from days to months). Can be compli-cated by respira-tory failure and death.	Home-canned foods with a low acid content, improperly canned commercial foods, home-canned or fermented fish, herb-infused oils, baked potatoes in aluminum foil, cheese sauce, bottled garlic, foods held warm for extended periods of time (e.g. in a warm oven).	Stool, serum, and food can be tested for toxin. Stool and food can also be cultured for the organism. These tests can be performed at some State Health Department Laborato-ries and the CDC.	Supportive care. Botulinum antitoxin is helpful if given early in the course of the illness. Call 404 639-2206 or 404 639-3753 workdays, 404 639-2888 weekends and evenings.
Clostridium botulinum infants	3-30 days	In infants <12 months, lethargy, weakness, poor feeding, constipation, hypotonia, poor head control, poor gag and suck	Variable	Honey, home-canned vegetables and fruits.	Stool, serum, and food can be tested for toxin. Stool and food can also be cultured for the organism. These tests can be performed at some State Health Department laborato-ries and the CDC.	Supportive care. Botulism immune globulin can be obtained from the Infant Botulism Prevention Program, Health and Human Services, California (510 540-2646). Botulinum antitoxin is generally not recommended for infants.
Clostridium perfringens toxin	8-16 hrs	Watery diarrhea, nausea, abdominal cramps; fever is rare.	24-48 hrs	Meats, poultry, gravy, dried or precooked foods.	Stools can be tested for enterotoxin and cultured for organism. Because *Clostridium perfringens* can normally be found in stool, quantitative cultures must be done.	Supportive care. Antibiotics not indicated.

(Continued) **Foodborne Illnesses (Bacterial)**

Etiology	Incubation Period	Signs and Symptons	Duration of Illness	Associated Foods	Laboratory Testing	Treatment
Enterohemorrhagic *E. coli* (EHEC) including *E. coli* 0157:H7 and other Shigatoxin-producing *E. coli* (STEC)	1-8 days	Severe diarrhea that is often bloody, abdominal pain and vomiting. Usually, little or no fever is present. More common in children <4 years.	5-10 days.	Undercooked beef, unpasteurized milk and juice, raw fruits and vegetables (e.g. sprouts), salami, salad dressing, and contaminated water.	Stool culture; E. coli O157:H7 requires special media to grow. If E. coli O157:H7 is suspected, specific testing must be requested. Shiga toxin testing may be done using commercial kits; positive isolates should be forwarded to public health laboratories for confirmation and serotyping.	Supportive care, monitor renal function, hemoglobin, and platelets closely. Studies indicate that antibiotics may be harmful. *E. coli* O157:H7 infection is also associated with hemolytic uremic syndrome, which can cause lifelong complications.
Enterotoxigenic *E. coli* (ETEC)	1-3 days	Watery diarrhea, abdominal cramps, some vomiting.	3->7 days	Water or food contaminated with human feces.	Stool culture. ETEC requires special laboratory techniques for identification. If suspected, must request specific testing.	Supportive care. Antibiotics are rarely needed except in severe cases. Recommended antibiotics include TMP-SMX and quinolones.
Listeria monocytogenes	9-48 hrs for gastrointestinal symptoms, 2-6 weeks for invasive disease	Fever, muscle aches, and nausea or diarrhea. Pregnant women may have mild flu-like illness, and infection can lead to premature delivery or stillbirth. Elderly or immunocompromised patients may have bacteremia or meningitis.	Variable	Fresh soft cheeses, unpasteurized milk, inadequately pasteurized milk, ready-to-eat deli meats, hot dogs.	Blood or cerebrospinal fluid cultures. Asymptomatic fecal carriage occurs; therefore, stool culture usually not helpful. Antibody to listerolysin O may be helpful to identify outbreak retrospectively.	Supportive care and antibiotics; Intravenous ampicillin, penicillin, or TMP-SMX are recommended for invasive disease.
	At birth and infancy	Infants infected from mother at risk for sepsis or meningitis.				

(Continued) Foodborne Illnesses (Bacterial)

Etiology	Incubation Period	Signs and Symptons	Duration of Illness	Associated Foods	Laboratory Testing	Treatment
Salmonella spp.	1-3 days	Diarrhea, fever, abdominal cramps, vomiting. *S. typhi* and *S. paratyphi* produce typhoid with insidious onset characterized by fever, headache, constipation, malaise, chills, and myalgia; diarrhea is uncommon, and vomiting is usually not severe.	4-7 days	Contaminated eggs, poultry, unpasteurized milk or juice, cheese, contaminated raw fruits and vegetables (alfalfa sprouts, melons). *S. typhi* epidemics are often related to fecal contamination of water supplies or street-vended foods.	Routine stool cultures.	Supportive care. Other than for *S. typhi*, antibiotics are not indicated unless there is extra-intestinal spread, or the risk of extra-intestinal spread, of the infection. Consider ampicillin, gentamicin, TMP-SMX, or quinolones if indicated. A vaccine exists for *S. typhi*.
Shigella spp.	24-48 hrs	Abdominal cramps, fever, and diarrhea. Stools may contain blood and mucus.	4-7 days	Food or water contaminated with fecal material. Usually person-to-person spread, fecal-oral transmission. Ready-to-eat foods touched by infected food workers, raw vegetables, egg salads.	Routine stool cultures.	Supportive care. TMP/SMX recommended in the US if organism is susceptible; nalidixic acid or other quinolones may be indicated if organism is resistant, especially in developing countries.
Staphylococcus aureus (preformed enterotoxin)	1-6 hrs	Sudden onset of severe nausea and vomiting. Abdominal cramps. Diarrhea and fever may be present.	24-48 hrs	Unrefrigerated or improperly refrigerated meats, potato and egg salads, cream pastries.	Normally a clinical diagnosis. Stool, vomitus, and food can be tested for toxin and cultured if indicated.	Supportive care
Vibrio cholerae (toxin)	24-72 hrs	Profuse watery diarrhea and vomiting, which can lead to severe dehydration and death within hours.	3-7 days. Causes life-threatening dehydration.	Contaminated water, fish, shellfish, street-vended food.	Stool culture; *Vibrio cholerae* requires special media to grow. If *V. cholerae* is suspected, must request specific testing.	Supportive care with aggressive oral and intravenous rehydration. In cases of confirmed cholera, tetracycline or doxycycline is recommended for adults, and TMP-SMX for children (<8 years)

(Continued) Foodborne Illnesses (Bacterial)

Etiology	Incubation Period	Signs and Symptons	Duration of Illness	Associated Foods	Laboratory Testing	Treatment
Vibrio parahaemolyticus	2-48 hrs	Watery diarrhea, abdominal cramps, nausea, vomiting.	2-5 days	Undercooked or raw seafood, such as fish, shellfish.	Stool cultures. *Vibrio parahaemolyticus* requires special media to grow. If *V. parahaemolyticus* is suspected, must request specific testing.	Supportive care. Antibiotics are recommended in severe cases: tetracycline, doxycycline, gentamicin, and cefotaxime.
Vibrio vulnificus	1-7 days	Vomiting, diarrhea, abdominal pain, bacteremia, and wound infections. More common in the immunocompromised, or in patients with chronic liver disease (presenting with bullous skin lesions).	2-8 days; can be fatal in patients with liver disease and the immunocompromised	Undercooked or raw shellfish, especially oysters; other contaminated seafood, and open wounds exposed to sea water.	Stool, wound, or blood cultures. *Vibrio vulnificus* requires special media to grow. If *V. vulnificus* is suspected, must request specific testing.	Supportive care and antibiotics; tetracycline, doxycycline, and ceftazidime are recommended.
Yersinia enterocolytica and *Y. pseudotuberculosis*	24-48 hrs	Appendicitis-like symptoms (diarrhea and vomiting, fever, and abdominal pain) occur primarily in older children and young adults. May have a scarlitiniform rash with *Y. pseudotuberculosis*.	1-3 weeks	Undercooked pork, unpasteurized milk, contaminated water. Infection has occurred in infants whose caregivers handled chitterlings, tofu.	Stool, vomitus or blood culture. *Yersinia* requires special media to grow. If suspected, must request specific testing. Serology is available in research and reference laboratories.	Supportive care, usually self-limiting. If septicemia or other invasive disease occurs, antibiotic therapy with gentamicin or cefotaxime (doxycycline and ciprofloxacin also effective).

Please call the state health department for more information on specific foodborne illnesses. These telephone numbers are available at: http://www2.cdc.gov/mmwr/international/relres.html. See the reverse side for information hotlines and list of notifiable diseases.

Foodborne Illnesses (Viral)

Etiology	Incubation Period	Signs and Symptons	Duration of Illness	Associated Foods	Laboratory Testing	Treatment
Hepatitis A	30 days average (15-50 days)	Diarrhea; dark urine; jaundice; and flu-like symptoms, (i.e., fever, headache, nausea, and abdominal pain).	Variable, 2 weeks-3 months	Shellfish harvested from contaminated waters, raw produce, uncooked foods and cooked foods that are not reheated after contact with infected food handler.	Increase in ALT, bilirubin. Positive IgM and anti-hepatitis A antibodies.	Supportive care. Prevention with immunization.
Norwalk-like viruses	24-48 hrs	Nausea, vomiting, watery, large-volume diarrhea; fever rare.	24-60 hrs	Poorly cooked shellfish; ready-to-eat foods touched by infected food workers; salads, sandwiches, ice, cookies, fruit.	Clinical diagnosis, negative bacterial cultures, >fourfold increase in antibody titers of Norwalk antibodies, acute and convalescent, special viral assays in reference lab. Stool is negative for WBCs.	Supportive care. Bismuth sulfate.
Rotavirus	1-3 days	Vomiting, watery diarrhea, low-grade fever. Temporary lactose intolerance may occur. Infants and children, elderly, and immunocom-promised are especially vulnerable.	4-8 days	Fecally contaminated foods. Ready-to-eat foods touched by infected food workers (salads, fruits).	Identification of virus in stool via immuno-assay.	Supportive care. Severe diarrhea may require fluid and electrolyte replace-ment.
Other viral agents (astroviruses, calciviruses, adenoviruses, parvoviruses)	10-70 hrs	Nausea, vomiting, diarrhea, malaise, abdominal pain, headache, fever.	2-9 days	Fecally contaminated foods. Ready-to-eat foods touched by infected food workers. Some shellfish.	Identification of the virus in early acute stool samples. Serology.	Supportive care, usually mild, self-limiting.

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Foodborne Illnesses (Parasitic)

Etiology	Incubation Period	Signs and Symptons	Duration of Illness	Associated Foods	Laboratory Testing	Treatment
Cryptosporidium parvum	7 days average (2-28 days)	Cramping, abdominal pain, watery diarrhea; fever and vomiting may be present and may be relapsing.	Days to weeks	Contaminated water supply, vegetables, fruits, unpasteurized milk.	Must be specifically requested. May need to examine water or food.	Supportive care, self-limited. If severe consider paromomycin for 7 days.
Cyclospora cayetanensis	1-11 days	Fatigue, protracted diarrhea, often relapsing.	May be protracted (several weeks to several months)	Imported berries, contaminated water, lettuce	Request specific examination of the stool for *Cyclospora*. May need to examine water or food.	TMP/SMX for 7 days.
Entamoeba histolytica	2-3 days to 1-4 weeks	Bloody diarrhea, frequent bowel movements (looks like *Shigella*), lower abdominal pain.	Months	Fecal-oral; may contaminate water and food.	Examination of stool for cysts and parasites — at least 3 samples. Serology for long-term infections.	Metronidazole and iodoquinol.
Giardia lamblia	1-4 weeks	Acute or chronic diarrhea, flatulence, bloating.	Weeks	Drinking water, other food sources.	Examination of stool for ova and parasites — at least 3 samples.	Metronidazole.
Toxoplasma gondii	6-10 days	Generally asymptomatic, 20% may develop cervical lymphadenopathy and/or a flu-like illness. In immunocompromised patients: central nervous system (CNS) disease, myocarditis, or pneumonitis is often seen.	Months	Accidental ingestion of contaminated substances (e.g. putting hands in mouth after gardening or cleaning cat litter box); raw or partly cooked pork, lamb, or venison.	Isolation of parasites from blood or other body fluids; observation of parasites in patient specimens, such as broncho-alveolar lavage material or lymph node biopsy. Detection of organisms is rare, but serology can be a useful adjunct in diagnosing toxoplasmosis. Toxoplasma-specific IgM antibodies should be confirmed by a reference laboratory. However, IgM antibodies may persist for 6-18 months and thus may	Asymptomatic healthy, but infected, persons do not require treatment. Spiramycin or pyrimethamine plus sulfadiazine may be used for immuno-compromised persons or pregnant women, in specific cases.

(Continued) Foodborne Illnesses (Parasitic)

Etiology	Incubation Period	Signs and Symptons	Duration of Illness	Associated Foods	Laboratory Testing	Treatment
					not necessarily indicate recent infection. For congenital infection: isolation of *T. gondii* from placenta, umbilical cord, or infant blood. PCR of white blood cells, CSF, or amniotic fluid (reference laboratory). IgM and IgA serology (reference laboratory).	
Toxoplasma gondii (congenital infection)	In infants at birth	Treatment of the mother may reduce severity and/or incidence of congenital infection. Most infected infants have few symptoms at birth. Later, they will generally develop signs of congenital toxoplasmosis (mental retardation, severely impaired eyesight, cerebral palsy, seizures) unless the infection is treated.		Passed from mother (who acquired acute infection during pregnancy) to child.		
Trichinella spiralis	1-2 days to 2-8 weeks	Nausea, vomiting, diarrhea, abdominal discomfort followed by fever, myalgias, periorbital edema.	Months	Raw or undercooked contaminated meat, usually pork or wild game meat, e.g. bear or moose.	Positive serology or demonstration of larvae via muscle biopsy. Increase in eosinophils.	Supportive care + mebendazole.

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Foodborne Illnesses (Non-Infectious)

Etiology	Incubation Period	Signs and Symptons	Duration of Illness	Associated Foods	Laboratory Testing	Treatment
Antimony	5 min-8 hrs. usually <1 hr	Vomiting, metallic taste.	Usually self-limited	Metallic container.	Identification of metal in beverage or food.	Supportive care.
Arsenic	Few hrs	Vomiting, colic, diarrhea.	Several days	Contaminated food.	Urine. May cause eosinophilia.	Gastric lavage, BAL (dimercaprol).
Cadmium	5 min-8 hrs. usually <1 hr	Nausea, vomiting, myalgia, increase in salivation, stomach pain.	Usually self-limited	Seafood, oysters, clams, lobster, grains, peanuts.	Identification of metal in food.	Supportive care.
Ciguatera fish poisoning (ciguatera toxin).	2-6 hrs	GI: abdominal pain, nausea, vomiting, diarrhea.	Days to weeks to months	A variety of large reef fish. Grouper, red snapper, amberjack, and barracuda (most common).	Radioassay for toxin in fish or a consistent history.	Supportive care, IV mannitol. Children more vulnerable.
	3 hrs	Neurologic: paresthesias, reversal of hot or cold, pain, weakness.				
	2-5 days	Cardiovascular: bradycardia, hypotension, increase in T wave abnormalities.				
Copper	5 min-8 hrs. usually <1 hr	Nausea, vomiting, blue or green vomitus.	Usually self-limited	Metallic container.	Identification of metal in beverage or food.	Supportive care.
Mercury	1 week or longer	Numbness, weakness of legs, spastic paralysis, impaired vision, blindness, coma. Pregnant women and the developing fetus are especially vulnerable.	May be protracted	Fish exposed to organic mercury, grains treated with mercury fungicides.	Analysis of blood, hair.	Supportive care.
Mushroom toxins, short-acting (muscinol, muscarine, psilocybin, coprius artemetaris, ibotenic acid)	<2 hrs	Vomiting, diarrhea, confusion, visual disturbance, salivation, diaphoresis, hallucinations, disulfiram-like reaction, confusion, visual disturbance.	Self-limited	Wild mushrooms (cooking may not destroy these toxins).	Typical syndrome and mushroom identified or demonstration of the toxin.	Supportive care.

(Continued) Foodborne Illnesses (Non-Infectious)

Etiology	Incubation Period	Signs and Symptons	Duration of Illness	Associated Foods	Laboratory Testing	Treatment
Mushroom toxin, long-acting (amanita)	4-8 hrs diarrhea; 24-48 hrs liver failure	Diarrhea, abdominal cramps, leading to hepatic and renal failure.	Often fatal	Mushrooms.	Typical syndrome and mushroom identified and/or demonstration of the toxin.	Supportive care; life-threatening, may need life support.
Nitrite poisoning	1-2 hrs	Nausea, vomiting, cyanosis, headache, dizziness, weakness, loss of consciousness, chocolate-brown colored blood.	Usually self-limited	Cured meats, any contaminated foods, spinach exposed to excessive nitrification.	Analysis of the food, blood	Supportive care, methylene blue.
Pesticides (organophosphates or carbamates)	Few min to few hrs	Nausea, vomiting, abdominal cramps, diarrhea, headache, nervousness, blurred vision, twitching, convulsions.	Usually self-limited	Any contaminated food.	Analysis of the food, blood.	Atropine.
Puffer fish (tetrodotoxin)	<30 min	Paresthesias, vomiting, diarrhea, abdominal pain, ascending paralysis, respiratory failure.	Death usually in 4-6 hrs	Puffer fish.	Detection of tetrodotoxin in fish.	Life-threatening, may need respiratory support.
Scombroid (histamine)	1 min-3 hrs	Flushing, rash, burning sensation of skin, mouth and throat, dizziness, uriticaria, paresthesias.	3-6 hrs	Fish: bluefin, tuna, skipjack, mackerel, marlin, and mahimahi.	Demonstration of histamine in food or clinical diagnosis.	Supportive care, antihistamines.
Shellfish toxins (diarrheic, neurotoxic, amnesic)	Diarrheic shellfish poisoning (DSP)—30 min to 2 hrs	Nausea, vomiting, diarrhea, and abdominal pain accompanied by chills, headache, and fever.	Hrs to 2-3 days	A variety of shellfish, primarily mussels, oysters, scallops, and shellfish from the Florida coast and the Gulf of Mexico.	Detection of the toxin in shellfish; high pressure liquid chromatography.	Supportive care, generally self-limiting. Elderly are especially sensitive to ASP.

(Continued) Foodborne Illnesses (Non-Infectious)

Etiology	Incubation Period	Signs and Symptons	Duration of Illness	Associated Foods	Laboratory Testing	Treatment
	Neurotoxic shellfish poisoning (NSP)—few min to hrs	Tingling and numbness of lips, tongue, and throat, muscular aches, dizziness, reversal of the sensations of hot and cold, diarrhea, and vomiting.				
	Amnesic shellfish poisoning (ASP)—24-48 hrs	Vomiting, diarrhea, abdominal pain and neurological problems such as confusion, memory loss, disorientation, seizure, coma.				
Shellfish toxins (paralytic shellfish poisoning)	30 min-3 hrs	Diarrhea, nausea, vomiting leading to paresthesias of mouth, lips, weakness, dysphasia, dysphonia, respiratory paralysis.	Days	Scallops, mussels, clams, cockles.	Detection of toxin in food or water where fish are located; high pressure liquid chromatography.	Life-threatening, may need respiratory support.
Sodium fluoride	Few min to 2 hrs	Salty or soapy taste, numbness of mouth, vomiting, diarrhea, dilated pupils, spasms, pallor, shock, collapse.	Usually self-limited	Dry foods (such as dry milk, flour, baking powder, cake mixes) contaminated with sodium fluoride-containing insecticides and rodenticides.	Testing of vomitus or gastric washings. Analysis of the food.	Supportive care.
Thallium	Few hrs	Nausea, vomiting, diarrhea, painful paresthesias, motor polyneuropathy, hair loss.	Several days	Contaminated food.	Urine, hair.	Supportive care.
Tin	5 min-8 hrs. usually <1 hr	Nausea, vomiting, diarrhea.	Usually self-limited	Metallic container.	Analysis of the food.	Supportive care.
Vomitoxin	Few min to 3 hrs	Nausea, headache, abdominal pain, vomiting.	Usually self-limited	Grains, such as wheat, corn, barley.	Analysis of the food.	Supportive care.
Zinc	Few hrs	Stomach cramps, nausea, vomiting, diarrhea, myalgias.	Usually self-limited	Metallic container.	Analysis of the food, blood and feces, saliva or urine.	Supportive care.

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ROLE OF PREDICTIVE MICROBIOLOGY

Introduction

Every year thousands of new food products are added to the previous list world over. The initial microbial population of these products generally includes spoilage as well as pathogenic organisms which may grow to a higher number and may thus make the food unsafe as well as spoil it. In order to ensure their longer shelf life & safety it is important that adequate control measures are adopted to prevent the growth of microorganisms in the entire food chain i.e. from production to consumption. It is very challenging to produce these new products that are healthy (low fat, low salt), minimally processed fresh to taste, do not contain chemical preservatives and are safe.

To produce new types of foods with desirable safety, stability and acceptance quality we need to determine the influence of several factors on microbial growth such as, concentration of different ingredients, processing and storage conditions, water activity, pH under the intrinsic and extrinsic factors. For determining the safety and stability of the processed foods it may not be always possible to do the microbiological analysis of each product by the traditional methods. Thus there is a need to develop mathematical models and put into application the computers for determining the influence of a vast array of different parameters that affect the microbial growth.

Microbiologists and hygienists would like to improve their approach by using new tools for modeling and simulation. Some models have been proposed and used with the aim to describe the effect of temperature & heat treatments on microbial destruction but it is only at the end of 1980s that the first mathematical tools have been built to stimulate the complete behavior of microflora in food products under processed conditions. However, predictive microbiology started as a purely empirical (though quantitative) science. In 1922 Esty and Meyer described the thermal death of *Clostridium botulinum*type A spores by a log-linear model, which is still used to estimate the necessary heat processing of low-acid canned foods. This model simply says that, at a given temperature, the *relative* (or *specific*) death rate of the bacteria is constant with time. In other words, the percentage of the cell population inactivated in a unit time is constant.

General Principle

As food safety is a growing concern in modern society, the scientific discipline of predictive food microbiology gains more and more interest worldwide. The term 'Predictive Microbiology' describes the scientific discipline of predicting microbiological growth or decline as a function of environmental factors. Such methods may not allow us to arrive at a very definite and accurate conclusion but certainly they can be an effective tool in obtaining hostile information quite rapidly. They can be a forerunner for conducting traditional studies that are relatively feasible experimentally as well as economically.

Predictive Modeling is the detailed knowledge of the behavior (growth, survival, and inactivation) of microorganisms in food products condensed into a mathematical model that enables an objective evaluation of the microbiological safety and quality of foods.

Food processing may be described as a succession of steps, from the input of raw materials to the distribution and consumption of the processed food. Different steps can be identified as critical from the microbiological point of view. At these steps microbial contamination or multiplication can occur.. If we consider that a contamination occurs at a given initial level during one of these critical steps, predictive microbiology consists

of simulation of the behavior of these contaminations, from the starting point to a given time, taking into account variation in processing conditions. This approach allows the microbial hazard to be predicted and therefore, helps to prevent and control the risk, allows quantification of the risk, optimize experimental designs and thus reduces delay and cost. Further this approach is supportive of debate, and thus helps to improve communication between the experts under managers.

The objective of the predictive microbiology is to be a good forward microbial dynamics using mathematical models. But before that, it is important to consider the classical behavior of the microbial population.

i. **The lag phase** : This is considered as an adaptation phase between an initial physiological state and growth state wherein the cell number remains constant. This phase may get longer under unfavorable conditions.

ii. **Logarithmic growth phase** : This is characterized by a linear portion if the logarithm of the variable (biomass, number or concentration of cells) is represented versus time.

iii. **The stationary phase** : This is linked to lack of nutrients, acidity etc. that leads to stable number of cells in the growth medium.

iv. **Death phase** : The decrease in cell number takes place when the medium and the conditions become too unfavorable. This phase is usually close to an exponential decrease of the cell density.

Conventional Methods for Predicting Shelf life of Food Products

Spiking studies

In this method a food is inoculated with the microorganisms that are expected to be the major causes of loss of shelf life or safety under storage conditions. A definite but realistic number of microbial cells or spores is used as inoculum and stored under conditions at which the food would normally be placed. Afterwards it is examined for microbial growth or toxin production. However a large number of variables (extrinsic and intrinsic factors) need to be studied. This is quite time consuming, costly and cumbersome.

Storage studies

A food product is stored under normal storage conditions and microbiological analysis is done at regular intervals and extent of spoilage and the growth of pathogenic organisms/ production of toxin is assessed. The data thus generated can be useful for predicting the expected shelf life and safety of the product. However, there are certain limitations to the use of this method as it would not take into consideration the temperature of use for a short time and other analytical problems.

Accelerated tests

In this procedure the product is held at relatively higher temperature (near ambient) so as to increase the rate of growth of the organism and thereby accelerate the spoilage. This process is used particularly for foods that have relatively longer shelf life. However, there are also limitations to arriving at a logical conclusion as different organisms in the mixed flora of the food behave differently at different temperatures.

Predictive Modeling

A number of mathematical models have been developed to predict the growth of pathogenic and spoilage microorganisms in foods from the data generated by studying growth rate at different pH, water activity, temperature and preservative conditions in the laboratory media, with suitable computers help in the rapid analysis of the huge data. Two kinetic based models that take into consideration the effect of culture parameters on the growth rate of microorganisms are:

Square root model

This model is based on the linear relationship between the square root of the growth rate and temperature. This model is quite effective when one or two parameters are used. The effectivity of this model decreases if several parameters in combination are used to control the microbial growth.

Sigmoidal model

This model has been developed by the US department of Agriculture (USDA) to predict microbial growth in a food system that is controlled by several parameters. It has been tested in the laboratory media to determine the growth rate of several pathogenic microorganisms under different physical and chemical parameters. This model is extensively used because of its simplicity and effectiveness.

Predictive microbiology is quite interesting and important. With the advent of computers and subsequent developments, the processing of data has become easier and quicker. Most of the studies so far on this aspect have been carried out in laboratory media and a very limited number of studies have been carried out in food systems. Therefore, there is a limit to the effectiveness of this modeling system. The information obtained through this modeling system, therefore, needs to be used with caution.

HACCP SEVEN PRINCIPLES

Objectives

To demonstrate mastery of this module, the Inspection Program Personnel (IPP) will
1.Identify the HACCP Seven Principles
2.Define HACCP
3.Define the following terms:
a.Hazard Analysis
b.Prerequisite Program
c.Critical Control Point
d.Critical Limit
e.Monitoring
f.Verification
4.Explain the purpose of monitoring

FSIS has the overall authority and oversight to regulate meat and poultry products intended for distribution into commerce. The official establishment's responsibility is to produce safe wholesome meat and poultry products. FSIS requires all establishments that produce federally inspected meat and poultry products to design and operate HACCP (**Hazard Analysis and Critical Control Point**) systems. HACCP provides a framework for

establishments to conduct science-based process controls that can be validated as effective in eliminating, preventing, or reducing to an acceptable level the food safety hazards that are reasonably likely to occur in an official establishment's

particular production processes. Under the HACCP regulatory system, establishments assume full responsibility for producing products that are safe for consumers.

The seven principles of HACCP, which encompass a systematic approach to the identification, prevention, and control of food safety hazards include:
1.Conduct a Hazard Analysis
2.Determine Critical Control Points
3.Establish Critical Limits
4.Establish Monitoring Procedures
5.Establish Corrective Actions
6.Establish Recordkeeping and Documentation Procedures
7.Establish Verification Procedures

Principle 1: Conduct a Hazard Analysis.

A thorough hazard analysis is the key to preparing an effectively designed HACCP plan. The NACMCF identified the purpose of the hazard analysis in the guidance document as a process used to develop a list of hazards which are of such significance that they are reasonably likely to cause injury or illness if not effectively controlled. It is important to consider in the hazard analysis the ingredients and raw materials, each step in the process, product storage and distribution, and final preparation and use by the consumer. When conducting a hazard analysis, safety concerns must be differentiated from quality concerns.

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. This paper is not a regulatory document. However, it was used by FSIS when the HACCP regulation was developed and then published in the Federal Register. As regulators, you will be responsible for verifying compliance with the HACCP regulation. The HACCP guideline with the seven principles is not an enforceable document; however, it is helpful for inspection personnel to be familiar with the basis for the development of the HACCP plan is under Title 9 Code of Federal Regulation (CFR) Part 417. Later sections in this training will cover your regulatory responsibilities.

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. A "step" is a point or

activity in an operation within the production process that is essential to the proper production of the finished product. A food safety hazard that is reasonably likely to occur

Inspection Methods
16-2 is one for which a prudent establishment would establish controls because the hazard has historically occurred in the product/process or because there is a reasonable probability that the hazard would occur in the absence of these controls.

The hazard analysis and identification of associated control measures accomplish three objectives:

1. hazards and associated control measures are identified,
2. the analysis may identify needed modifications (also known as interventions) to the initial process or product so that product safety is assured, and
3. the analysis provides a basis for determining Critical Control Points (CCP) in Principle 2.

A summary of the HACCP design decisions and the rationale developed during the hazard analysis should be kept for future reference. Upon completion of the hazard analysis, the hazards associated with each step in the production of the food should be listed along with any measure(s) that are used to control the hazard(s). The term control measure is used because not all hazards can be prevented, but virtually all can be controlled. More than one control measure may be required for a specific hazard. On the other hand, more than one hazard may be addressed by a specific control measure.

Federally inspected establishments must conduct hazard analyses for their processes. The establishment can either conduct the hazard analysis itself or have an outside source conduct it. The hazard analysis is the heart of the successful food safety system. The identification of the food safety hazards in the hazard analysis must be thorough in order to ensure that the HACCP plan when executed will result in an adequate food safety system. When the hazard analysis is not well thought out, it results in a design flaw, and products that pose a food safety hazard to the consumer may be produced and shipped.

Every hazard analysis is unique, because each establishment is responsible for identifying the hazards reasonably likely to occur in its particular process, and for determining how it will control those hazards to prevent, eliminate, or reduce them to an acceptable level. Hazards identified in one facility may not be significant in another operation producing the same product. Different establishments may have identified different hazards as reasonably likely to occur and different control measures for them, even though their processes may appear to be similar. For example, differences may exist in the type of equipment, incoming product, employee training, or production practices.

The hazard analysis is the foundation of the food safety system. A thorough hazard analysis is the key to preparing an effectively designed HACCP plan. Federally inspected establishments must conduct hazard analyses for each process. During the development and design of the hazard analysis, establishments must consider all three types of hazards – biological, chemical, and physical – at each step they identify in the production process. Once the establishment has identified potential hazards, these hazards are evaluated to

determine if each one is **reasonably likely to occur (RLTO)**, or **not reasonably likely to occur (NRLTO)**. If the establishment determines that the hazard is reasonably likely to occur, a preventive measure must be identified and a critical control point must be developed to address the hazard, either at that step or later in theprocess. If the establishment determines the hazard is not reasonably likely to occur, they must provide justification for this decision. Establishments may use scientific or technical support, or they may have a variety of supporting programs as the basis for the decision that a hazard is not likely to occur.

A **Prerequisite Program** is a procedure or set of procedures that is designed to provide basic environmental or operating conditions necessary for the production of safe, wholesome food. The programs provide a **foundation for the development and implementation of an effective HACCP system**. Some programs are managed as facility-wide programs and others are specific to a certain process. An establishment may determine that a hazard is not reasonably likely to occur, using the justification that a properly designed and implemented prerequisite program is preventing the hazard from occurring.

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.

Some examples of prerequisite programs include:

Process Step	Potential hazard	Example Prerequisite Program
Receiving live cattle	SRM	Dentition program for age verification
Cooler	Pathogen growth	Temperature control program
Receiving raw beef	*E. coli* O157:H7 and other STEC	Supplier purchase specifications
Receiving	Foreign objects	Incoming product inspection

When establishments perform their hazard analysis, they identify any potential biological, physical, or chemical hazards. Then for each hazard, they ask "***Is thishazard reasonably likely to occur?***" If ***no***, then the establishment must have support for that decision. If ***yes***, the establishment must address the hazard with a CCP. A record of the hazard analysis must be kept for future verification. When completed, the hazard analysis should have·Identified hazards reasonably likely to occur before, during and after entry into the establishment, and

·Identified the associated preventive measures that can be applied to control these hazards, which provides a basis for determining the critical control points (CCPs).

Principle 2: Determine Critical Control Points

The hazards that were identified in the hazard analysis must be addressed in the HACCP plan. A hazard is controlled by one or more critical control points (CCPs).

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.

The step of the process at which the critical control point is located does not necessarily have to be at the point where the hazard is introduced. They may be placed at any location deemed adequate to prevent, eliminate, or effectively control the hazard in the product produced. The control point for a hazard may be later in the process than the point at which the hazard occurs. For example, the cooking step is a common control for biological hazards that have been introduced into the product at previous steps.

Control may actually be achieved as a cumulative effect, also known as multiple hurdles. There may be several steps in the process that together attain sufficient control, but individually do so only partially. For example, an official establishment that slaughters cattle may have a pre-evisceration organic acid rinse, a post evisceration organic acid rinse, and a wash step followed by steam pasteurization.

For ***each*** hazard that is determined to be reasonably likely to occur, the establishment must identify critical control points and corresponding critical limits that are measurable or observable. Establishments must have documentation supporting all of these decisions, and they must be able to demonstrate that their plan designs are valid and effective in operation.

Principle 3: Establish Critical Limits

The next step in the development of a HACCP plan is to establish critical limits for each critical control point. ***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. The establishment must consider the food safety standard that must be met at each CCP. Critical limits are designed to ensure applicable targets or performance standards pertaining to the specific process or product. Critical limit design should be based on applicable FSIS **regulations** or compliance guidelines, FDA tolerances, scientific and technical literature, experimental studies, or the recommendations of recognized experts in the industry, academia, or processing authorities. Critical limits should not be confused with operational limits which are established for reasons other than food safety.

Critical limits are most often based on process parameters such as temperature, time, physical dimensions, or presence of target pathogens. Critical limits must be actual values that can be **measured or quantified**. Regardless of the parameter used, the critical limit must be sufficient to prevent, eliminate, or reduce to an acceptable level the occurrence of the food safety hazard it is designed to control. The establishment must be able to provide the basis for their decision documents regarding the selection and development of the critical limits. The CLs must also be designed to work effectively given the capabilities and limitations of the establishment's processes.

Principle 4: Establish Monitoring Procedures

Once critical limits are set for each CCP during the HACCP plan development, procedures must be established to monitor the CCPs to determine whether the critical limits are being met. ***Monitoring*** is a planned sequence of observations or measurements to assess whether a CCP is under control and to produce an accurate record for future use in verification. Every CCP that is in the HACCP plan must be monitored to ensure that the

critical limits are consistently met and that the process is producing safe product. Establishments are responsible for determining the procedure used to monitor each CCP. Monitoring procedures usually involve either a measurement or an observation. If the critical limit is a numerical value, then monitoring usually involves a measurement. If the critical limit is defined as the presence or absence of an attribute, then the monitoring procedure may involve observation. Monitoring procedures should be designed to determine when deviations from the critical limit occur so that appropriate corrective actions can be initiated.

Establishments must determine how often they need to monitor CCPs. Ideally, the monitoring frequency would be continuous whenever possible. An example is the

continual recording of cooking temperatures on temperature recording charts. The advantage of continuous monitoring is that it allows an establishment to see what is occurring at a CCP throughout the production process at any given time.

When it is not possible to monitor a CCP on a continuous basis then it is monitored intermittently and the frequency must be determined. The frequency selected should be adequate to determine that the CCP is under control. Statistically designed data collection systems are used to establish the frequency when monitoring is not on a continuous basis. Establishments can select any employee to conduct monitoring activities. Assigning monitoring responsibilities is an important consideration for establishment management. HACCP monitors are often production employees or quality control personnel. Employees selected to be HACCP monitors should be adequately trained and should understand the purpose of monitoring. They should also be trained to immediately report unusual occurrences to the individual responsible for initiating corrective actions. The HACCP plan does not have to specify ***who*** will do the monitoring.

Monitoring has three objectives:

·To track control of the process.

Monitoring the process allows the establishment to identify situations in which a trend is developing that may lead to loss of process control. If monitoring detects such a trend, establishments can take appropriate measures to restore process control **before** a deviation occurs.

·To determine when there is a loss of control and a deviation occurs. Monitoring serves to determine when the process has deviated from the critical limit. This information lets the establishment know appropriate corrective actions must be taken to restore process control and to effectively address all affected product.

·To provide a written document to be used in verification.

Monitoring results must be recorded on official HACCP records, and such records serve as the basis for verification activities.

Principle 5: Establish Corrective Actions

The corrective actions must be determined for each CCP in cases where the CL is not met. The specific corrective actions depend upon the process used and type of food produced.

When there is a deviation from the critical limit, corrective actions are required to prevent potentially hazardous foods from reaching consumers. The HACCP plan must include corrective actions to be taken when a deviation from the critical limit occurs at a critical control point. 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.

HACCP plans should specify what is to take place when a deviation occurs, who is responsible for implementing corrective actions, and that corrective actions will be documented as part of the HACCP records. When designing their HACCP plans, establishments can either specify particular corrective actions they will take when a deviation occurs, or can simply state that they will address the regulatory requirements in 9 CFR Part 417.3, Corrective Action. Experts may be consulted to review the information available and to assist in determining disposition of non-compliant product.

Principle 6: Establish Recordkeeping and Documentation Procedures

When developing the HACCP plan, the establishment must ensure that the HACCP system has an effective recordkeeping system. ***Records*** are written evidence documenting the operation of the HACCP system. All measurements taken at a CCP, and any corrective actions taken, should be documented and kept on file. These records can be used to trace the production history of a finished product. If any questions arise about the product, a review of records may be the only way to determine whether the product was produced in a safe manner according to the HACCP plan.

The National Advisory Committee on Microbiological Criteria for Foods (NACMCF, 1998) recommends that the establishment maintain four types of records. *These recommendations are also regulatory requirements as outlined in 9 CFR Part 417.*

·Summary of the hazard analysis including the rationale
·HACCP plan
·Support documentation such as validation records
·Daily operational records generated during the operation of the HACCP plan

The **summary of the hazard analysis** covers the basis and justification for an establishment's HACCP plan. This includes information about decisions the establishment made during the hazard analysis process. It contains all the information about the hazard analysis, including justification for CCPs and critical limits.

The **HACCP plan** outlines the formal procedures the establishment will follow to meet the seven principles. The NACMCF recommends that HACCP plan records should contain the following.

·List of the HACCP team and assigned responsibilities.
·Description of the food, its distribution, intended use, and consumer.
·Verified flow chart for the entire manufacturing process
·HACCP Plan Summary Table that lists the following for each hazard of concern—the CCP, critical limit, the monitoring procedures and frequencies, the corrective actions, the verification procedures and frequencies, and the recordkeeping system.

The **supporting documentation** includes the rationale used to establish CCPs, critical limits, monitoring procedures and frequencies, corrective action procedures, and verification procedures and frequencies. This includes all scientific references, regulatory resources, and materials from other sources (for example, extension services, academic experts, consultants) that have been used in the development of the HACCP plan.

The **daily operational records** are what most of us think of when we think of HACCP records. These include the actual records from the implementation of the HACCP plan (monitoring, corrective actions, and verification).

The HACCP records should:

·Contain the date and time of the activity reflected on the record.
·Contain the signature or initials of the employee making the entry.
·Have the information entered on the record at the time it is being observed.
·Contain actual observations or data values obtained.

Principle 7: Establish Verification Procedures

HACCP systems must be systematically verified. In the NACMCF explanation of the verification principle, four processes are involved in the verification of the establishment's HACCP system. The establishment is responsible for the first three; FSIS is responsible for the fourth.

·The first is the scientific and technical process, known as **validation** for determining that the CCP and associated critical limits are adequate and sufficient to control likely hazards.

·The second process is to ensure, initially and on an **ongoing** basis, that the entire HACCP system functions properly.

·The third process consists of documented, periodic, **reassessment** of the HACCP plan.

·The fourth process defines FSIS's responsibility for certain actions (**government verification**) to ensure that the establishment's HACCP system is functioning adequately.

Verification ensures that the HACCP plan is being implemented as written. Verification confirms the accurate monitoring of the critical control points. The verification procedures demonstrate that the HACCP system is adequately controlling food safety hazards. After initial validation the system must be verified periodically. Periodic verification involves the use of methods, procedures, or tests in addition to those used for monitoring,

to determine whether the HACCP system is in compliance with the HACCP plan, or whether the HACCP plan needs modification and revalidation to achieve its food safety objective. Establishments must also be able to provide supporting documentation for the verification procedures and frequencies specified in the HACCP plan.

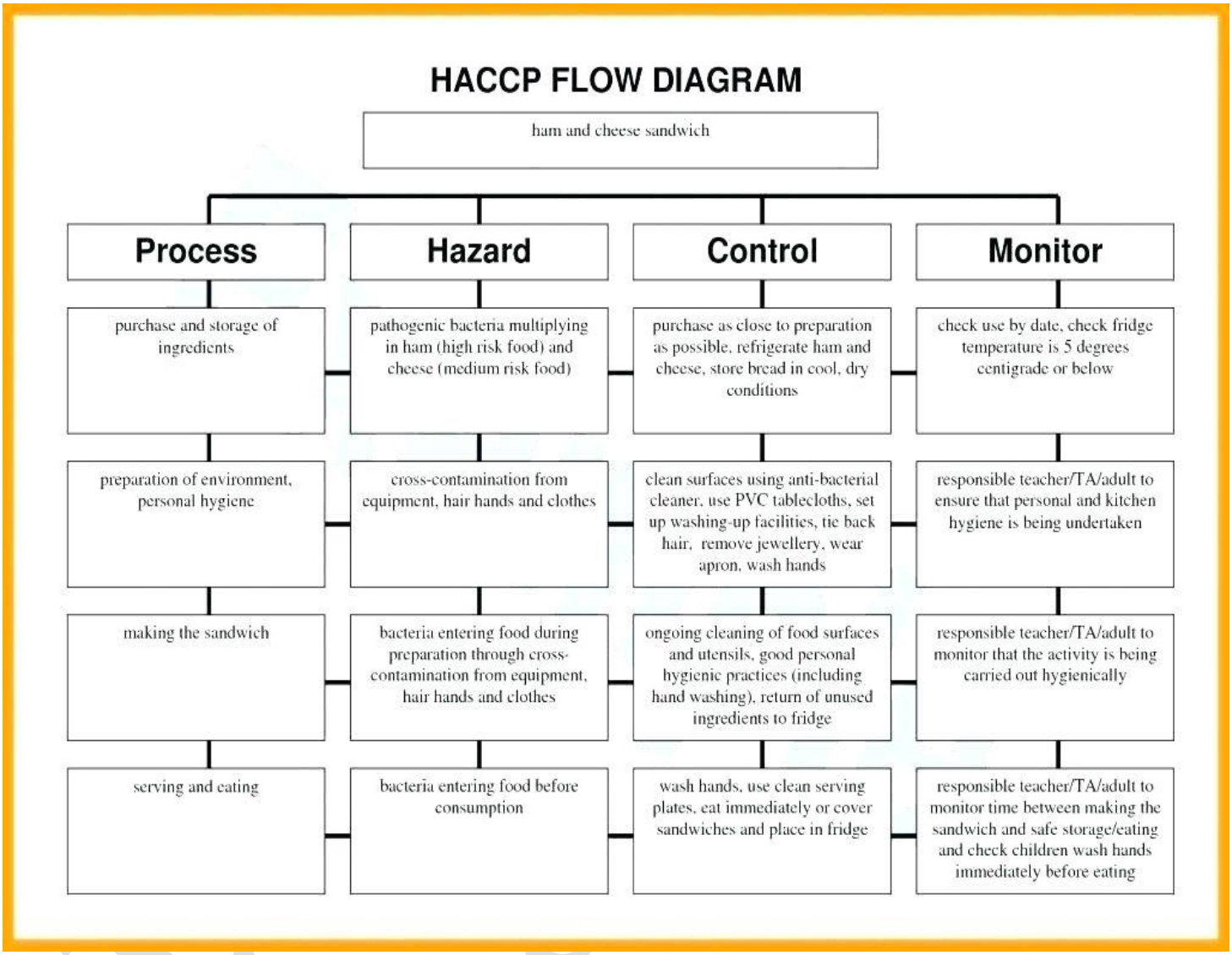
Ongoing verification activities consist at a minimum of calibration procedures (if there are instruments that require calibration), direct observations of monitoring and corrective actions, and records review. They should be described in the HACCP plan.

The goal of **calibration procedures** is to ensure that all measurements taken with process-monitoring equipment are accurate. If the findings from the procedures show that the measuring device is incorrect, then the device must be recalibrated or replaced.

The **direct observation** procedures and frequency for involve observing the monitor to determine that monitoring is being done correctly.

The purpose of **records review** is to ensure that the records were prepared correctly, that all activities were performed as required by the HACCP plan, that no activity was missed, and that all results were within the critical limits.

Not all CCPs require the calibration of process-monitoring equipment. Establishments are not limited to only these three types of verification activities. Other types of verification procedures that establishments may use include independent checks or measurements to verify the accuracy of monitoring and microbiological testing.



Food Safety and Standards Authority of India (FSSAI) is an autonomous body established under the Ministry of Health & Family Welfare, Government of India.[3] The FSSAI has been established under the Food Safety and Standards Act, 2006 which is a consolidating statute related to food safety and regulation in India.[3] FSSAI is responsible for protecting and promoting public healththrough the regulation and supervision of food safety.[3]

The FSSAI is headed by a non-executive Chairperson, appointed by the Central Government, either holding or has held the position of not below the rank of Secretary to the Government of India.[4] Rita Teotia is the current Chairperson for FSSAI and Pawan Kumar Agarwal is the current Chief Executive Officer for FSSAI.[5]

The FSSAI has its headquarters at New Delhi. The authority also has 6 regional offices located in Delhi, Guwahati, Mumbai, Kolkata, Cochin, and Chennai.[6] 14 referral laboratories notified by FSSAI, 72 State/UT laboratories located throughout India and 112 laboratories are NABL accredited private laboratories notified by FSSAI.[

History[edit]

FSSAI was established by Former Union Health Minister DrAnbumaniRamadoss,Government of India on 5 August 2011 under Food Safety and Standards Act, 2006 which was operationalized in year 2006. The FSSAI consists of a chairperson & 22 members. The FSSAI is responsible for setting standards for food so that there is one body to deal with and no confusion in the minds of consumers, traders, manufacturers, and investors.[9][10] Ministry of Health & Family Welfare, Government of India is the Administrative Ministry of Food Safety and Standards Authority of India.[11][12] The following are the statutory powers that the FSS Act, 2006 gives to the Food Safety and Standards Authority of India (FSSAI).[13]

1. Framing of regulations to lay down food safety standards
2. Laying down guidelines for accreditation of laboratories for food testing
3. Providing scientific advice and technical support to the Central Government
4. Contributing to the development of international technical standards in food
5. Collecting and collating data regarding food consumption, contamination, emerging risks etc.
6. Disseminating information and promoting awareness about food safety and nutrition in India

Location[edit]

FSSAI is located in 5 regions [14]

1. Northern Region – With head office at New Delhi
2. Eastern Region
3. North Eastern Region
4. Western region
5. Southern Region

Regulatory framework[edit]

The Food Safety and Standards Authority of India is a statutory body under Food Safety and Standards Act, 2006. The Food Safety and Standards Act (FSS), 2006 is the primary law for regulation of food products. This act also sets up the formulation and enforcement of food safety standards in India. The FSSAI appoints food safety authorities on the state level.[15]

The FSSAI functions under the administrative control of the Ministry of Health and Family Welfare.[16] The main aim of FSSAI is to

1. Lay down science-based standards for articles of food
2. To regulate manufacture, storage, distribution, sale and import of food
3. To facilitate food safety

The FSS Act is a bucket for all the older laws, rules and regulations for food safety. The FSS Act took 7 older acts into one umbrella.

1. **Prevention of Food Adulteration Act, 1954** [17]
2. **Fruit Products Order, 1955** [18]
3. **Meat Food Products Order, 1973** [19]
4. **Vegetable Oil Products (Control) Order, 1947**
5. **Edible Oils Packaging (Regulation) Order 1988** [20]
6. **Solvent Extracted Oil, De- Oiled Meal and Edible Flour (Control) Order, 1967** [21]
7. **Milk and Milk Products Order, 1992**.[22]

Departments]

1. Import Division
2. International Co-operation
3. Regulatory Compliance Division (RCD)
4. Food Safety Management System (FSMS) Division
5. Risk Assessment and R&D division (RARD)
6. Information Education Communication (IEC) Division
7. Regulation and Codex Division
8. Quality Assurance/ lab Division
9. HR Division
10. Standards Division

Research and quality assurance

Research

FSSAI has set certain guidelines for food safety research. The Research and Development division is responsible for research with the following objectives:

1. Generate new knowledge that would help in continuously updating and upgrading food safety standards which are compatible with international organizations
2. Carry out evidence based studies for improving or building policies.

Quality Assurance

FSSAI has been mandated to perform various functions related to quality and standards of food. These functions in addition to others include "Laying down procedure and guidelines for notification of the accredited laboratories as per ISO17025."[23] The FSSAI notified laboratories that are classified as:

1. FSSAI notified NABL accredited labs- 112 [24]
2. State Labs-72
3. Referral Labs-14 [25]

Standards

Standards framed by FSSAI are prescribed under Food Safety and Standards (Food Product Standards and Food Additives) Regulation, 2011, Food Safety and Standards (Packaging and Labelling) Regulation, 2011 and Food Safety and Standards (Contaminants, Toxins, and Residues) Regulations, 2011.

The FSSAI has prescribed standards for following food products:

- Dairy products and analogues [26]
- Fats, oils and fat emulsions
- Fruits and vegetable products
- Cereal and cereal products
- Meat and meat products
- Fish and fish products
- Sweets & confectionery
- Sweetening agents including honey
- Salt, spices, condiments and related products
- Beverages, (other than dairy and fruits & vegetables based)
- Other food product and ingredients
- Proprietary food
- Irradiation of food

The development of standards is a dynamic process based on the latest developments in food science, food consumption pattern, new food products and additives, changes in the processing technology leading to changed specifications, advancements in food analytical methods, and identification of new risks or other regulatory options.

Formulation of standards of any article of food under the Food Safety and Standards Act 2006, involves several stages. After consideration by the Food Authority, the draft standard is published (Draft notified), for inviting stakeholder comments. Since India is a signatory to the WTO-SPS Committee, Draft Standard is also notified in WTO. Thereafter, taking into account the comments received from the stakeholders, the Standard is finalized and notified in Gazette of India, and implemented.[27]

Consumer outreach

Consumers can connect to FSSAI through various channels. A GAMA portal for concerns regarding misleading claims and advertisements too is operated.[28]

Applicable FSSAI License

FSSAI issues three types of license based on nature of food business and turnover:

1. **Registration:** For Turnover less than ₹12 Lakh
2. **State License**: For Turnover between ₹12 Lakh to ₹20 Crore
3. **Central License**: For Turnover above ₹20 Crore

Other criteria like the location of the business, number of retail stores etc. is needed while evaluating the nature of license applicable

KARPAGAM ACADEMY OF HIGHER EDUCATION

CLASS: II B.Sc MB
COURSE CODE: 18MBU301

COURSE NAME: FOOD AND DAIRY MICROBIOLOGY
BATCH-2018-2021

UNIT 5						
S.NO	QUESTIONS	OPTION 1	OPTION 2	OPTION 3	OPTION 4	ANSWERS
1	The outbreak in unpasteurized apple cider during last 20 years is due to __	Listeria	E.coliO157:H7	Cyclospora	Campylobacter	E.coliO157:H7
2	Most food borne illness causing bacterial agent is	Campylobacter	Shigella sp.	Salmonella	all the above	all the above
3	The determmination of the etiology of a food borne disease is by___	incubation period	population involved in outbreak	duration of recovery	both a and b	both a and b
4	A chemical by ingestion causing chemical poisoning thereby foodnborne illness caused is -	botulinum toxin	organophosphates	atropine	antitoxin	organophosphates
5	In lab,sool culture screening is limited to	Salmonella sp.	Shigella sp.	Vibrio sp.	both a and b	both a and b
6	Additional incubation or selective media is needed for the screening of cultures	Yersinia sp.	Giardia lamblia	Entamoebahistolytica	Salmonella	Yersinia sp.
7	Ova and stool specimen screening is done for the identification of -	Campylobacter	Cryptosporidium	Giardia lamblia	E.coli	Giardia lamblia
8	The CDC coordinates with a public health labs,to support epidemiologic investigations by performing	pulse field gel electrophoresis	molecular finger printing	etiologic diagnosing	pulse net	molecular fingerprinting
9	Ciprofloxacin is given as a medication to gastrointestinal disorder caused by	Bacillus anthracis	Bacillus cereus	Brucella abortus	Campylobacter	Bacillus anthracis

Prepared by R.Dineshkumar, Assistant Professor, Dept of Microbiology, KAHE.

KARPAGAM ACADEMY OF HIGHER EDUCATION

CLASS: II B.Sc MB
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10	The preformed enterotoxin producer which can cause sudden onset of nausea and vommiting	Bacillus anthracis	Bacillus cereus	Brucella abortus	Campylobacter	Bacillus cereus
11	Rifampin and tetracyclin is given as medication for the bacterial disease caused by	Bacillus anthracis	Bacillus cereus	Brucella abortus	Campylobacter	Brucella abortus
12	Erythromycin treatment is given to bloody diarrhoea caused by -	Bacillus anthracis	Bacillus cereus	Brucella abortus	Campylobacter jejuni	Campylobacter jejuni
13	Hemolytic uremic syndrome causing bacteria which can be associated in undercooked beef is	Enterotoxigenic E.coli	Enterohaemorrhagic E.coli	Listeria	Clostridium sp.	Enterohaemorrhagic E.coli
14	TMP-SMX and quinolones are given to patients who are suffering due to waterydiarrhoea caused by	Enterotoxigenic E.coli	E.coliO157:H7	Cyclospora	Listeria	Enterotoxigenic E.coli
15	Intravenous ampicillin injected for the contamination of dairy products causing food vorne illness caused by	Corynebacterium	Listeria monocytogenes	Yersinia	E.coli	Listeria monocytogenes
16	Doxycycline treatment given for diarrhoea caused by___	Vibriovulnificus	Yersinia enterocolytica	Vibrio parahaemolyticus	both a andc	both a andc
17	Antibiotic therapy with gentamicin is given as a treatment for scarlitiniform with tuberculosis caused by____	Staphylococcus aureus	Yersinia pseudotuberculosis	Vibrio parahaemolyticus	Rota virus	Yersinia pseudotuberculosis
18	Metronidazole as a medication given for the bloody diarrhoea	Giardia lamblia	Toxoplasma gondii	Entamoebahistolytica	Cyclospora	Entamoebahistolytica

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19	Flatulence and bloating are treated with metronidazole which are aused by___	Toxoplasma gondii	Cryptosporidium pavam	Giardia lamblia	Trichinella spiralis	Giardia lamblia
20	Spiramycin or pyrimethamine plus sulfadiazine are used to treat cervical lymphadenopathy and flu like illness	Trichinella spiralis	Toxoplasma gondii	Entamoebahistolytica	Cyclospora cayetanensis	Toxoplasma gondii
21	In serological test,a positive result with increase in eosinophils can be treated with mebendazole are caused by ___	Entamoeba histolytica	Trichinella spiralis	Toxoplasma gondii	Cryptosporidium parvam	Trichinella spiralis
22	Radioactive assay for __by ciguatera fish poisoning in which children are more vulnerable to this	copper	ciguatera toxin	mercury	arsenic	ciguatera toxin
23	Of the following which is not a mushroom toxin?	ibotenic acid	muscarine	psilocybin	antimony	antimony
24	Nitrite poisoning happened due to the exposure of spinach to excessive nitrification can be treated using	antihistamines	methylene blue	dimercaprol	mebendazole	methylene blue
25	Tetrodotoxin detected in the puffer fish can leads to	abdominal cramos	respiratory failure	paresthesias	both b and c	both b and c
26	Diarrhoeic neurotoxin can be detected using the following method	thin layer chromatography	column chromatography	high pressure liquid chromatography	none	high pressure chromatography
27	A food borne disease called scombroid(histamine) can be found in	puffer fish	skipjack	shellfish	oysters	skipjack

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28	A chemical contamination in the dry foods which can lead to dilated pupils,salty or soapy taste,spasms is__	tin	thallium	sodium fluoride	vomitoxin	sodium fluoride
29	The first mathematical tools built to stimulate the complete behaviour of microflora in foodproductsin theyear	1980	1922	1956	1938	1980
30	The thermal death of Clostridium botulinum by a log linear method was found in the year	1945	1922	1887	1856	1922
31	Thermal death of Clostridium botulinum by log linear method was found by	Esty	Mayer	Appert	both a and b	both a a nd b
32	The linear portion ,in which the logarithm ofvariable(biomass,concentration of cells) represented vs time is	death phase	log phase	lag phase	stationary phase	log phase
33	The phase inwhich the lack of nutrients ,acidity are established then leads to stable no.of ce)s in medium is called__	lag phase	log phase	death phase	stationary phase	stationary phase
34	The phase consists of decrease in cell number when the medium and conditions are too unfavourable	log phase	lag phase	stationary phase	death phase	death phase

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35	Which of the following method will not come under conventional method for the prediction of shelf lifeof food products	spiking studies	storage studies	accelerated tests	sigmoidal model	sigmoidal model
36	In __process ,the product is held at relatively higher temperature so as to increase the rate of growth of the organism and thereby accelerate the spoilage	storage studies	accelerated tests	spiking studies	predicrive modelling	accelerated tests
37	___has the overall authority and oversight to regulate meat and poultry products intended for distribution into commerce	HACCP	FSIS	CCP	SSOP	FSIS
38	___provides a frameworkfor establishments to conduct science based process controls that can be validated as effective in eliminating or reducing ti an acceptable level the food safety hazards occur in an official establishment	FSIS	HACCP	SOP	SSOP	HACCP
39	____identified the purpose of the hazard analysis in the guidance document as a process used to develop a list of hazards to cause injury not effeectively controlled	SSOP	FSIS	HACCP	NACMCF	NACMCF

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40	___are not usually designed to control specific hazards, but are intended to provide guidelines to help establishments produce safe and wholesome products	GMP	SOO	SSOP	RLTO	GMP
41	___may address washing and sanitizing of knife and hands between carcasses to reduce potential contamination with pathogens	SOP	HACCP	SSOP	RLTO	SSOP
42	____is a process in food sources at which control can be applied ,as a result foodsafety hazard can beprevented, eliminated	SSOP	CCP	RLTO	HACCP	CCP
43	__is a maximum or minimum value to which a biological ,chemical, or reduce to an acceptable level the occurence of a food safety hazard	CCP	NRLTO	RLTO	CL	CL
44	___allows an establishment to see what isoccuring at aCCP thriughout theproduction process atany given time	CCP	NRLTO	monitoring	HACCP	monitoring
45	___are written evidence documenting the operation of the HACCP system	hazard analysis	records	supporting documentation	operatiinal records	records

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46	HACCP records consists of ____	date and time of the activity reflected	actual observations and data values	sign and initials of the employer	all the above	all the above
47	___procedures and freqencies for involve observing the monitor to determine that monitoring is being done correctly	calibration procedure	records review	direct observation	HACCP	direct observation
48	Current chair person ofFSSAI is ____	Pawan kumar	Rita Teotia	Pranab Agarwal	none	Rita Teotia
49	The current CEO of FSSAI is____	Pranab Agarwal	Rita Teotia	Pawan kumar Agarwal	Mahendar Rao	Pawan Kumar Agarwal
50	Meat food products order was amended in the year	1973	1947	1992	1955	1973
51	Milk and mlik products order was amended in the year	1954	1992	1955	1967	1992
52	Prevention of food adulteration act was propoesd in the year	1988	1947	1946	1954	1954
53	Solvent extracted oil and de oiled meal and edible flour orderwas amended in the year	1935	1948	1967	1928	1967
54	FSSAI has NABL accredited labs	14	38	112	74	112
55	FSSAI consists of referral labs	16	38	43	14	14
56	FSSAI has prescribed standards fir __of the following	cereal and cerael products	proprietary food	salt and spice related products	all the above	all the above
57	General symptomsof foodborne illnesses	weight loss	paresthesias	cranial nerve palsies	all the above	all the above

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58	Food related diseases aremostly due to ingestion of	contaminated seafood	mushroompoisoning	chemical poisoning	all	all
59	A chemical which is dete ted in beverages which will cause blue or green vomiting	mercury	copper	cadmium	arsenic	copper
60	Dimercaprol is given as a medication for poisoning	coprius	muscarine	arsenic	copper	arsenic