KARPAGAM ACADEMY OF HIGHER EDUCATION

DEPARTMENT OF BIOTECHNOLOGY
II M.Sc., BIOTECHNOLOGY – SEMESTER III
LECTURE PLAN – Food Biotechnology (18BTP303)

S.No	Lecture Duration (hr)	Topics	Support materials
1.	1	History and scope of food biotechnology	W1
2.	1	Nutritive value of food	W2
3.	1	Role of microbes in food Biotechnology -Bacteria	J1:382-386
4.	1	Role of microbes in food Biotechnology -Fungi	J1:382-386
5.	1	Role of microbes in food Biotechnology -Yeast	J1:382-386
6.	1	Types of fermented foods	W2
7.	1	Changes during fermentation	W2
8.	1	Nutritive value of fermentation foods	W2
9.	1	Revision	1
10.	1	Primary source of microorganism in food	T1:9-10
11.	1	Food born bacteria	W3
12.	1	Food borne Mold and yeast	W3
13.	1	Intrinsic factors of food affecting microbial	T1:10-15
14.	1	Extrinsic factors parameters of food affecting microbial count	T1: 20-23
15.	1	Detection of microorganism in food –SPC, membrane filters	T1:30, T2: 1-20
16.	1	Detection of microorganism in food -dry films	T2: 1-15
17.	1	Bacterial toxins-Botustism toxin Staphylococcal toxin	W4
18.	1	Fungal toxin-aflatoxin	W5
19.	1	Revision	W5
20.	1	Origin, scope and preservation of Cheese, Yoghurt, Butter	T3:283-285
21.	1	Origin, scope and preservation of miso, tempeh, kefir, koumiss	T3:372-373, T3:355-362
22.	1	Origin, scope and preservation of pickles, acidophilus milk, Pickles and vinegar	T3:372-373, T3:355-362
23.	1	Fresh juice production,- Mango, Orange and Pine apple	W6, W7, W8

24.	1	Industrial production of beer	T3:334-338
25.	1	Industrial production of Wine	T3:339-345
26.	1	Industrial production of baker's yeast	T3: 326-328
27.	1	Revision	
28.	1	Test	
29.	1	Causes of food spoilage	T3: 1-5
30.	1	Spoilage of fruits & vegetables	T3: 5-7, 196-200
31.	1	Spoilage of Meat, soft drinks, eggs	T3: 218-222
32.	1	Spoilage of dairy products	T3: 276-283
33.	1	Food preservation through chemicals, Acid, Salts	T3: 83-90
34.	1	Food preservation through Antibiotics, Ethylene oxide, Antioxidants	T3:90-98
35.	1	Methods of food preservation- Low and high temperature	T3:91-120
36.	1	Methods of food preservation- Radiations, Drying	T3:159-160 T3:115-120
37.	1	Food Packaging materials and their properties	J2
38.	1	Revision	T3: 144-149
39.	1	Food Adulteration, Responsibility for food safety	T3:496-498
40.	1	Food additives- Definition, Types and functional characteristics	T3:144-147
41.	1	Natural colours – Types, Applications	T3:146-148
42.	1	Advantages of natural colors	T3:146-148
43.		Sweeteners- Types and application	T3:150-153
44.	1	Adulteration detection systems and sensors	W9
45.	1	Food safety	T3:495
46.	1	HAACP system to food protection	T3: 496
47.	1	FSSAI guidelines	W10
48.	1	Revision	

References

T1: Fundamental of food biotechnology-second edition Byong.H.lee
T2: Membrane filtration- Teixeira J.A Vincent A.A
T3: Food microbiology (1995)- Frazier, William fourth edition
R1: Modern food microbiology (1992)- Jay, J.M. II Ed, Chapman and Hall, Newyork, USA .
J1: Indian Journal of Biotechnology 2 (2003), PP: 382-386
J2: Journal of Food Science (2007), R39 – R56
W1: WWW.ucdavies.edu
W2: https:// WWW.researchgate.net (W2)
W3: WWW.foodinsight.org
W4: http:// wikepedia.org/wiki/microbial-toxins
W5: WWW.nature.com
W6: WWW.fruitjuicemachinery.com/product-mangojuice processing line html
W7: WWW.fruitjuicemachinery.com/product-orangejuice processing line html
W8: WWW.fruitjuicemachinery.com/product-pineapplejuice processing line html
W9: https://food adulteration detection methods.html
W10: https:// archeive.fssai.gov.in/home/fss-legislations/fss regulations.html

Semester – III

18BTP303 **FOOD BIOTECHNOLOGY** **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 introduce the students to the fundamentals of food science and technology
- To integrate different aspects of technologies involved in food processing and product development.
- To emphasize on the importance of food safety, food quality, plant sanitation, packaging, marketing in food industry.

Course Outcomes:

- Upon successful completion of this course, the student will be able to:
- On the completion of the course, the students will able to get experience on food process and preservation including advanced techniques in food analysis and marketing policies.

Unit – I

Introduction: History and Scope of Food Biotechnology, Nutritive value of food, Role of microbes in food biotechnology – bacteria, fungi and yeast. Fermented foods – Types, Changes during Fermentation, Nutritive value of fermented foods.

Unit - II

Food Microbiology: Primary Sources of Microorganisms in food. Food-borne Bacteria, Molds and Yeasts. Intrinsic- and Extrinsic Parameters of food affecting microbial count. Detection of Microorganisms in food - SPC, Membrane filters, Dry films. Bacterial Toxins - Botulism and Staphylococcal toxin. Fungal Toxins - Aflatoxins.

Unit - III

Fermented Foods: Origin, scope and development and preservation- Cheese, Yoghurt, Butter, miso, tempeh, kefir, koumiss, acidophilus milk, sourkraut, pickles and vinegar. Fresh juice production –Mango, orange, and pineapple. Technological aspects of industrial production of beer, wine and baker's yeast.

Unit - IV

Food Spoilage and Preservation: Causes of Food Spoilage, Spoilage of Fruits, Vegetables, Meat, Soft Drinks, Eggs, Dairy products. Food Preservation through chemicals - Acids, Salts, Sugars, Antibiotics, Ethylene oxide, Antioxidants. Other Methods of Food Preservation - Radiations, Low and High temperature, Drying. Food packaging materials and their properties.

Unit - V

Food Adulteration and Food Safety: Adulteration, Responsibility for food safety, Food Additives - Definition, Types and Functional characteristics. Natural Colors -Types, Applications, Advantages of natural colors. Sweeteners - Types and Applications. Adulteration Detection systems and sensors. Food safety - HACCP System to food protection, FSSAI guidelines.

References

Adam, M.R., & Moss, M.O. (2003). *Food Microbiology*. New Delhi: New Age International Pub.

Frazier, W.C., & Westhoff, D.C. (2005). *Food Microbiology* (6th ed.). New Delhi: Tata Mc Graw Hill Pub. Company Ltd.

Harrigan, W. F., (1998). *Laboratory methods in Food Microbiology* (3rd ed.). NY: USA, Academic Press.

Bell, C., Neaves, P., & Williams, A.P. (2005). *Food Microbiology and Laboratory Practice*. (1 st ed.) Oxford: Blackwell Science.

Jay, J.M., Loessner, J.M., & Golden, A.D. (2005). *Modern Food Microbiology* (7th ed.). USA: Springer Science and Business Media. Inc.

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UNIT-I

SYLLABUS

Introduction: History and Scope of Biotechnology, Nutritive Value of Food, Role of microbes in Food Biotechnology - Bacteria, Fungi and Yeast. Fermented foods – Types, Changes during Fermentation, Nutritive Value of Fermented Foods.

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Introduction- History

Food Biotechnology is a branch of food science that deals with the production processes that make foods. Early scientific research into food technology concentrated on food preservation. Nicolas Appert's development in 1810 of the canning process was a decisive event. The process wasn't called canning then and Appert did not really know the principle on which his process worked, but canning has had a major impact on food preservation techniques. Louis Pasteur's research on the spoilage of wine and his description of how to avoid spoilage in 1864 was an early attempt to apply scientific knowledge to food handling. Besides research into wine spoilage, Pasteur researched the production of alcohol, vinegar, wines and beer, and the souring of milk. He developed pasteurization—the process of heating milk and milk products to destroy food spoilage and disease-producing organisms. In his research into food technology, Pasteur became the pioneer into bacteriology and of modern preventive medicine.

Scope of Food Biotechnology

Role of Micro organisms

The microorganisms that inhabit, create, or contaminate food, including the study of microorganisms that cause food spoilage. "Good" bacteria, however, such as probiotics, are becoming increasingly important in food science. In addition, microorganisms are essential for the production of foods such as cheese, yogurt, bread, beer, and wine other fermented foods.

Food safety

It is a major focus of food microbiology. Pathogenic bacteria, viruses and toxins produced by microorganisms are all possible contaminants of food. However, microorganisms and their products can also be used to combat these pathogenic microbes. Probiotic bacteria, including those that produce bacteriocins, can kill and inhibit pathogens. Alternatively, purified bacteriocins such as nisin can be added directly to food products. Finally, bacteriophages, viruses that only infect bacteria, can be used to kill bacterial pathogens. Thorough preparation of food, including proper cooking, eliminates most bacteria and viruses. However, toxins produced by contaminants may not be liable to change to non-toxic forms by heating or cooling the contaminated food.

Fermentation

Fermentation is one of the methods to preserve food and alter its quality. Yeast, especially *Saccharomyces cerevisiae*, is used to leaven bread, brew beer and make wine. Certain bacteria, including lactic acid bacteria, are used to make yogurt, cheese, hot sauce, pickles, fermented sausages and dishes such as kimchi. A common effect of these fermentations is that the food product is less hospitable to other microorganisms, including pathogens and spoilage-causing microorganisms, thus extending the food's shelf-life. Some cheese varieties also require molds to ripen and develop their characteristic flavors.

Developments in food biotechnology

Several disciplines in the food processing have contributed greatly to the food supply and have changed our world. Some of these developments are:

Instantized Milk Powder - D.D. Peebles developed the first instant milk powder, which has become the basis for a variety of new products that are rehydratable. This process increases the surface area of the powdered product by partially rehydrating spray-dried milk powder.

Freeze-drying - The first application of freeze drying was most likely in the pharmaceutical industry; however, a successful large-scale industrial application of the process was the development of continuous freeze drying of coffee.

High-Temperature Short Time Processing - These processes for the most part are characterized by rapid heating and cooling, holding for a short time at a relatively high temperature and filling aseptically into sterile containers.

Decaffeination of Coffee and Tea - Decaffeinated coffee and tea was first developed on a commercial basis in Europe around 1900. The process is described in U.S. patent 897,763. Green coffee beans are treated with water, heat and solvents to remove the caffeine from the beans.

Process optimization - Food Technology now allows production of foods to be more efficient, Oil saving technologies are now available on different forms. Production methods and methodology have also become increasingly sophisticated.

Nutritive value of food

Nutrition is the process of consuming the proper amount of nourishment and energy. The seven major classes of nutrients are: carbohydrates, fats, fiber, minerals, proteins, vitamins, and water. These nutrient classes are categorized as either macronutrients (needed in relatively large amounts) or micronutrients (needed in smaller quantities). The macronutrients are carbohydrates, fats, fiber, proteins, and water. The micronutrients are minerals and vitamins. Most food has its origin in plants. Some food is obtained directly from plants; but even animals that are used as food sources are raised by feeding them food derived from plants. Cereal grain is a staple food that provides more food energy worldwide than any other type of crop. Corn (maize), wheat, and rice – in all of their varieties – account for 87% of all grain production worldwide. Most of the grain that is produced worldwide is fed to livestock. Some foods not from animal or plant sources include various edible fungi, especially mushrooms. Fungi and ambient bacteria are used in the preparation of fermented and pickled foods like leavened bread, alcoholic drinks, cheese, pickles, kombucha, and yogurt. Another example is blue-green algae such as Spirulina.

Vegetables are a second type of plant matter that is commonly eaten as food. These include root vegetables (potatoes and carrots), bulbs (onion family), leaf vegetables (spinach and lettuce), stem vegetables (bamboo shoots and asparagus), and inflorescence vegetables (globe artichokes and broccoli and other vegetables such as cabbage or cauliflower). Food products produced by animals include milk produced by domestic animals, which in processed into dairy products (cheese, butter, etc.). In addition, birds and other animals lay eggs, which are often eaten, and bees produce honey, a reduced nectar from flowers, which is a popular sweetener in many cultures

Role of microbes in food biotechnology

Fermentations are traditional processes such as cheese manufacture thus ensuring consistency of process and product quality. The role of lactic acid bacteria in fermentation and the mechanisms of antibiosis with particular reference to bacteriocins and give a brief description of some important fermented foods from various countries. Fermentation ensures not only increased shelf life and microbiological safety of a food but also may also make some foods more digestible and in the case of cassava fermentation reduces toxicity of the substrate. Lactic acid bacteria because of their unique metabolic characteristics are involved in many fermentation processes of milk, meats, cereals and vegetables. Although many fermentations are traditionally dependent on inoculation from a previous batch starter cultures are available for many commercial processes such as cheese manufacture thus ensuring consistency of process and product quality. This review outlines the role of lactic acid bacteria in much such fermentation and the mechanisms of antibiosis with particular reference to bacteriocins and gives a brief description of some important fermented foods from various countries. It is anticipated that the contribution of the advances in lactic acid bacteria research towards improvement of strains for use in food fermentation will benefit both the consumer and the producer.

Bacteria

There is considerable interest in extending the range of foods incorporating probiotic organisms from dairy foods to infant formulae, baby foods, fruit juice based products, cereal based products and pharmaceuticals. Lactobacillus spp. and Bifidobacterium spp. are prominent members of the commensal intestinal flora and are the commonly studied probiotic bacteria.

Bacteria used as probiotics

Lactobacillus acidophilus

L. plantarum

L. casei

L. casei subsp. rhamnosus

L. delbreuckii subsp. bulgaricus

L. fermentum

L .reuteri

Lactococcus lactis subsp. lactis

L. lactis subsp. cremoris

Fungi

Molds are filamentous fungi that grow in the form of a tangled mass that spreads rapidly and may cover several inches of area in 2 to 3 days. The total of the mass or any large portion of it is referred to as mycelium. Mycelium is composed of branches or filaments referred to as hyphae.

Alternaria

Septate mycelia with conidiophores and large brown conidia are produced. The conidia have both cross and longitudinal septa and are variously shaped. They cause brown to black rots of stone fruits, apples,and figs. Stem-end rot and black rot of citrus fruits are also caused by species/strains of this genus.

Aspergillus

Chains of conidia are produced. Where cleistothecia with ascospores are developed, the perfect state of those found in foods is *Emericella, Eurotium*, or *Neosartorya*. Eurotium produces bright yellow cleistothecia, and all species are xerophilic. *E. herbariorum* has been found to cause spoilage of grape jams and jellies.

Yeast

Yeasts can be differentiated from bacteria by their larger cell size and their oval, elongate, elliptical, or spherical cell shapes. Typical yeast cells range from 5 to 8 urn in diameter, with some being even larger. Older yeast cultures tend to have smaller cells. Most of those of importance in foods divide by budding or fission.

Fermented foods

Fermentation in food processing is the conversion of carbohydrates to alcohols and carbon dioxide or organic acids using yeasts, bacteria, or a combination thereof, under anaerobic conditions. Fermented things can be the kinds of food that people refer to as "acquired tastes." But some of the most common things we eat and drink are fermented. The words aged and cured should be your first clue. Beneficial microorganisms beat out the kind that act on and eat up the carbohydrates in the food. The results are interesting flavors, textures, and smells.

Types and changes during fermentation

1. Coffee

Wild yeasts and bacteria from the air eat the slimy layer, called mucilage, still covering the beans after picking. The fermentation deepens the flavor and body of the beans.

2. Cheeses

The bacteria are added to give cream or milk a sour flavor. After the curds and whey are separated and the cheese is formed into a solid shape, it's inoculated with specific kinds of mold to make specific kinds of cheese (like blue cheese) and fermented (aged) again.

3. Yogurt, Sour Cream and Buttermilk

Milk or cream is exposed to souring bacteria, either by inoculation or through the air.

4. Chocolate

After cocoa beans are picked, the pulp surrounding them ferments, darkening the beans beneath and mellowing their flavor.

5. Wine

Yeast is added to the crushed grapes or naturally occurring yeasts already on the grape skins are allowed to thrive next they convert the juice's sugar to alcohol.

6. Beer

Yeast is added to grains that have been heated, soaked, and strained (leaving a sweet, grainy liquid), which converts the sugars to alcohol. Some beers, like Belgian lambics, use naturally occurring bacteria and yeasts from the air.

7. Charcuterie

Meat is heavily salted, sometimes with curing salts containing nitrates, then hung in a cool, well-ventilated place to age. The salt and nitrates discourage harmful bacteria (like those that cause botulism) and encourage beneficial ones. Dry aged beef is also mildly fermented, having hung in the open air (but without salt).

8. Vanilla

Young beans are soaked, dried, and exposed to the air for several months to cure, whereby their rich flavor develops.

9. Vinegar

A starter bacterial culture called a mother is introduced to alcohol (beer and wine are most common), which converts it to acetic acid.

10. Bread

Yeast is introduced to flour and ferments the carbohydrates, leaving behind carbon dioxide, which leavens the bread. Sourdough bread also contains a souring bacterium present in the starter.

11. Pickles, Sauerkraut, and Kimchee

Fresh vegetables are mixed with salt, packed into airtight containers, and aged. Bacteria naturally present on the vegetables' skins help create a kind of vinegar, transforming the vegetables. Not to be confused with vinegar pickles.

12. Fish Sauce

Fish is salted, aged, and pressed, and then the rotting fish juice is mixed with spices to create this staple Southeast Asian condiment.

13. Fermented Fish

Trout or salmon is packed in salt and left for anywhere from 24 hours to a couple of months, so the outside seems cooked but the inside remains moist and deliciously raw.

14. Ginger Beer

Though most commercially available ginger beer is just soda pop with air forced into it, traditionally the drink was naturally carbonated by allowing ginger, sugar, and water to ferment. Try making CHOW's Ginger Beer.

15. Miso

A mold called *Aspergillus oryzae* is mixed with rice, barley or soybeans and then aged in wooden casks for a few months to make this Japanese flavoring paste. Tamari and soy sauce or shoyu are made the same way, but in the case of shoyu wheat is also used.

16. Tempeh

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Originally created in Indonesia, this bean cake is made by cooking soybeans and inoculating them with *Rhizopus* mold. The white mold binds the beans together.

17. Natto

Slimy soybean product from Japan that is cooked beans are fermented with the bacterium *Bacillus subtilis natto* for a day, and then aged under refrigeration for a few days more.

18. Marmite

A savory brown spread from Britain often eaten on bread, made from brewer's yeast that is the byproduct of brewing beer.

19 Rumptof

A traditional German food, fruit is marinated with sugar and rum in an earthenware crock.

20. Century Egg

A duck egg is treated with quicklime, salt, and tea and then aged, oftentimes after being coated in clay-rich mud and rice husks for months. The egg's yolk turns gelatinous and greenish, and the white becomes amber-colored. The egg is often served cut up over porridge.

Nutritive value of fermented foods

Fermented foods can be more nutritious than their unfermented counterparts. This can come about in at least three different ways.

1. Microorganisms not only are catabolic, breaking down more complex compounds, but they also are anabolic and synthesize several complex vitamins and other growth factors.

2. The fermented foods can be improved nutritionally has to do with the liberation of nutrients locked into plant structures and cells by indigestible materials. This is especially true in the case of certain grains and seeds. Milling process do much to release nutrients from such items by physically rupturing cellulosic and hemicellulosic structures surrounded the endosperm, which is rich in digestible carbohydrates and proteins. Fermentation, especially by certain bacteria, yeast and molds, breaks down indigestible coatings and cell walls both chemically and physically.

3. The fermentation can enhance nutritional value, especially of plant materials, involves enzymatic splitting of cellulose, hemicellulose, and related polymers that are not digestible by humans into simpler sugars and sugar derivatives. Cellulosic materials in fermented foods can be nutritionally improved for humans by the action of microbial enzymes.

Possible Questions

Short questions

1. Write short note nutritive values of food?
2. Write short note nutritive values of fermented food?
3. Write short note on fungi in food biotechnology.
4. Write short note on Fermentation.
5. What is miso?
6. Probiotics.
7. What are bacteriocins?

Essay type questions

1. Explain in detail about nutritional value of fermented foods.
2. Write detailed notes on the beneficial role of bacteria in food biotechnology.
3. List out different types of fermented foods.
4. Explain the history and scope of food biotechnology.

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UNIT-II

SYLLABUS

Food Microbiology: Primary sources of Microorganisms in Food, Food borne Bacteria, Molds and Yeasts. Intrinsic- and Extrinsic Parameters of food affecting microbial count. Detection of Microorganisms in food - SPC, Membrane filters, Dry films. Bacterial Toxins - Botulism and Staphylococcal toxin. Fungal Toxins - Aflatoxins.

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Food Microbiology- Primary sources of microorganisms in food

The genera and species that cause deterioration of foods are found normally in food products. Each genus has its own particular requirements, and each is affected is predictable ways by the parameters of its environment. Eight environmental sources of microorganism found in food are given bellow-

1. Soil & water

2. Plants & plants products

3. Food utensils

4. Intestinal tract of human & animals

5. Food handlers

6. Animal feeds

7. Animal hides

8. Air & dust

Soil & water: These two environments are place together because many of the bacteria & fungi that inhibit both share a lot in common. Soil organism may inter the atmosphere by the action of wind & latter inter the water bodies when it rains. They also inter water when rainwater flows over soils into bodies of water. Aquatic organisms can be deposited onto soils through the actions of cloud formation & subsequent rainfall. *Alteromonous* spp. is aquatic forms that requires seawater salinity for growth & would not be expected to persist in soils.

Plant & plant products: Many or most soil & water organisms contaminate plants. Relatively, only a small numbers of organisms find the plant environment suitable to their overall well-being. Among others that are commonly associated with plants are bacterial plant pathogens in the genera *Corenebacterium, Curtobacterium*, Pseudomonas and *Xanthomonas* and fungal pathogens among several genera of molds.

Food utensils When vegetables are harvested in containers & utensils, one would expect to find some or all of the surface organisms on the products, contact surfaces. In a similar way, the cutting block in a meat market along with cutting knives and grinders are contaminated from initial samples and this process leads to build up of organisms.

Intestinal track of human & animals: This flora becomes a water source when polluted water is used to wash raw food products. The intestinal flora consist of many organisms that do not persist as long in water as do others and notable among these are pathogens such as Salmonellae.

Food handlers: The micro flora on the hands and other garments of handlers generally reflects the environment and habits of individuals, and the organisms in question may be those from soils, water, dust, and other environmental sources. Other important sources are those that are common in nasal cavities& the mouth & the skin and those from gastrointestinal track that may inter foods through poor personal hygienic practices.

Animal feeds: This is an important source of salmonellae to poultry and other farm animals. *Listeria monocytogenes* is found in dairy and meat animals. The organisms in dry animal feed are spread throughout the animal environment and may be expected to occur on animal hides.

Animal hides: The types of organisms found in raw milk can be reflection of the flora of the udder when proper procedures are not followed in milking. From both the udder and hide, organisms can contaminate the general environment.

Air & dust: Many organisms are found in air and dust in a food processing operation. Among fungi, a number of molds may be expected to occur in air and dust along with some yeast. In generals, the types of organisms in air and dust would be those that are constantly reseeded to the environment.

Food borne bacteria, molds and yeasts

Some bacteria cause more serious illness than others, but only a few are responsible for the majority of cases.

Campylobacter jejuni

Found in intestinal tracts of animals and birds, raw milk, untreated water, and sewage sludge. Transmission is by contaminated water, raw milk, and raw or under-cooked meat, poultry, or shellfish. Symptoms are fever, headache, and muscle pain followed by diarrhea (sometimes bloody), abdominal pain and nausea that appear 2 to 5 days after eating; may last 7 to 10 days.

Clostridium botulinum

Found by widely distributed in nature: in soil and water, on plants, and in intestinal tracts of fish animals. Grow in little oxygen. Transmission of the bacterium produce toxin that causes illness. Improperly canned foods, garlic in oil, and vacuum-packaged and tightly wrapped food. Symptoms are toxin which affects the nervous system. Symptoms usually appear within 18 to 36 hours, but can sometimes appear within as few as 4 hours or as many as 8 days after eating; double vision, droopy eyelids, trouble speaking and swallowing, and difficulty breathing. Fatal in 3 to 10 days if not treated.

Clostridium perfringens

Found in soil, dust, sewage, and intestinal tracts of animals and humans. Grow in little oxygen. It is cafeteria germ the outbreaks of infection from food left for long periods in steam tables or at room temperature. Bacteria destroyed by cooking, but some toxin-producing spores may survive. Symptoms are diarrhea and gas pains may appear 8 to 24 hours after eating; usually last about 1 day, but less severe symptoms may persist for 1 to 2 weeks.

Escherichia coli

Found in intestinal tracts of some mammals, raw milk, unchlorinated water; one of several strains of *E. coli* that can cause human illness. Transmission is by contaminated water, raw milk, raw or rare ground beef, unpasteurized apple juice or cider, uncooked fruits and vegetables; person-to-person. Symptoms of the infection are bloody diarrhea, abdominal cramps, nausea, and malaise; can begin 2 to 5 days after food is eaten, lasting about 8 days. Some, especially the very young, have developed Hemolytic Uremic Syndrome (HUS) that causes acute kidney failure.

Salmonella

Found in intestinal tract and feces of animals. *Salmonella enteritidis* contamination in eggs. Transmission is by raw or undercooked eggs, poultry, and meat; raw milk and dairy products; seafood. Symptoms is stomach pain, diarrhea, nausea, chills, fever, and headache usually appear 6 to 48 hours after eating; may last 1 to 2 days.

Molds are a multi-cellular form of fungi, which can grow on almost any substance used for food if the conditions are right. Mold spore cases are present in the environment. These spore cases break and release thousands of microscopic mold spores, each capable of growing mold under the right conditions. These conditions include a damp, dark, environment which provides the right environment for the growth of spores which swell and burst their walls and send out short threads. These threads “root” into the food to provide nourishment for the mold spores. The tip end of the threads spread out in the air above the surface of the food forming little globules which break up to form new spores. As the spores on the surface of the food ripen the food develops an unpleasant musty odor which destroys the fresh flavor of food. Fuzzy brightly colored mold growth can blow into the air and onto other foods. Molds cause a musty odor and destroy the fresh flavor of food.

Certain molds may produce poisonous toxins called mycotoxins. Aflatoxin is a mycotoxin that grows on nuts, corn, wheat and other grains. It may be found in products made from these foods including breads and peanut butter. Some molds are beneficial and are used in the production of antibiotics such as penicillin and in soy sauce production. Molds are specifically grown to create blue cheeses such as Roquefort and stilton and that which grows on the rind of camembert providing distinct flavors.

Yeasts are single-celled organisms which as they grow convert its food through the process of fermentation into alcohol and carbon dioxide. To multiply and grow, yeast needs moisture, food in the form of sugar or starch and a warm temperature 79°-80°F is best). Wild (naturally occurring) yeast spores are constantly floating in the air and can land on uncovered liquids and foods resulting in yeast contamination. In general, yeast contamination in food creates slime on the food surface, bubbles and an alcoholic smell or taste. In cottage cheese, it may cause a pink discoloration. They can be destroyed by heating to 136°F for 15 minutes. In the food processing industry, carefully cultured yeasts are used in the production of beer, wine and bread. Yeasts are responsible for few illnesses in humans and there is no evidence that they are transmitted by food or that the wild (naturally occurring) yeast in foods are harmful to humans.

Intrinsic parameters of food affecting microbial count

- The factors discussed in this section constitute an inclusive, rather than exclusive, list of intrinsic, extrinsic, and other factors that may be considered when determining whether a food or category of foods requires time/temperature control during storage, distribution, sale and handling at retail and in food service to assure consumer protection.
- Many factors must be evaluated for each specific food when making decisions on whether it needs time/temperature control for safety.
- These can be divided into intrinsic and extrinsic factors. Intrinsic factors are those that are characteristic of the food itself; extrinsic factors are those that refer to the environment surrounding the food.
- The need for time/temperature control is primarily determined by 1) the potential for contamination with pathogenic microorganisms of concern (including processing influences), and 2) the potential for subsequent growth and/or toxin production.
- Most authorities are likely to divide foods among three categories based on an evaluation of the factors described below: those that do not need time/temperature control for protection of consumer safety; those that need time/temperature control; and those where the exact status is questionable.
- In the case of questionable products, further scientific evidence--such as modeling of microbial growth or death, or actual microbiological challenge studies--may help to inform the decision.

Moisture content

- Microorganisms need water in an available form to grow in food products. The control of the moisture content in foods is one of the oldest exploited preservation strategies.
- Food microbiologists generally describe the water requirements of microorganisms in terms of the water activity (a_w) of the food or environment. Water activity is defined as the ratio

of water vapor pressure of the food substrate to the vapor pressure of pure water at the same temperature (Jay 2000b, p 41):$a_w = p/p_o$,

- where p = vapour pressure of the solution and p_o = vapor pressure of the solvent (usually water). The a_w of pure water is 1.00 and the a_w of a completely dehydrated food is 0.00.
- The a_w of a food on this scale from 0.00 - 1.00 is related to the equilibrium relative humidity above the food on a scale of 0 - 100%. Thus, % Equilibrium Relative Humidity (ERH) = a_w x 100. The a_w of a food describes the degree to which water is "bound" in the food, its availability to participate in chemical/biochemical reactions, and its availability to facilitate growth of microorganisms.
- Most fresh foods, such as fresh meat, vegetables, and fruits, have a_w values that are close to the optimum growth level of most microorganisms (0.97 - 0.99). Table 3-1 shows the approximate a_w levels of some common food categories.
- The a_w can be manipulated in foods by a number of means, including addition of solutes such as salt or sugar, physical removal of water through drying or baking, or binding of water to various macromolecular components in the food. Weight for weight, these food components will decrease a_w in the following order: ionic compounds > sugars, polyhydric alcohols, amino acids and other low-molecular-weight compounds > high-molecular-weight compounds such as cellulose, protein or starch.
- Microorganisms respond differently to a_w depending on a number of factors. Microbial growth, and, in some cases, the production of microbial metabolites, may be particularly sensitive to alterations in a_w.
- Microorganisms generally have optimum and minimum levels of a_w for growth depending on other growth factors in their environments. One indicator of microbial response is their taxonomic classification. For example, Gram (-) bacteria are generally more sensitive to low a_w than Gram (+) bacteria. Table 3-2 lists the approximate minimum a_w values for the growth of selected microorganisms relevant to food.
- It should be noted that many bacterial pathogens are controlled at water activities well above 0.86 and only *S. aureus* can grow and produce toxin below a_w 0.90. It must be emphasized that these are approximate values because solutes can vary in their ability to inhibit microorganisms at the same a_w value.

- To illustrate, the lower a_w limit for the growth of *Clostridium botulinum* type A has been found to be 0.94 with NaCl as the solute versus 0.92 with glycerol as the solute.
- When formulating foods using a_w as the primary control mechanism for pathogens, it is useful to employ microbiological challenge testing to verify the effectiveness of the reduced a_w when target a_w is near the growth limit for the organism of concern.
- Because a_w limits vary with different solutes or humectants, other measures may provide more precise moisture monitoring for certain products. For example, factors other than a_w are known to control the antibotulinal properties of pasteurized processed cheese spreads (Tanaka and others 1986). Also, a_w may be used in combination with other factors to control pathogens in certain food products.
- Care should be taken when analyzing multicomponent foods, because effective measurements of a_w may not reflect the actual value in a microenvironment or in the interface among the different components. In these cases, the a_w should be measured at the interface areas of the food, as well as in any potential microenvironment.

pH and acidity

- Increasing the acidity of foods, either through fermentation or the addition of weak acids, has been used as a preservation method since ancient times. In their natural state, most foods such as meat, fish, and vegetables are slightly acidic while most fruits are moderately acidic.
- A few foods such as egg white are alkaline. Table 3-3 lists the pH ranges of some common foods. The pH is a function of the hydrogen ion concentration in the food:pH = $-\log_{10}$ [H+]
- Another useful term relevant to the pH of foods is the pK_a. The term pK_a describes the state of dissociation of an acid.
- At equilibrium, pK_a is the pH at which the concentrations of dissociated and undissociated acid are equal.
- Strong acids have a very low pK_a, meaning that they are almost entirely dissociated in solution (ICMSF 1980, p 93). For example, the pH (at 25 °C [77 °F]) of a 0.1 M solution of HCl is 1.08 compared to the pH of 0.1 M solution of acetic acid, which is 2.6.

- This characteristic is extremely important when using acidity as a preservation method for foods. Organic acids are more effective as preservatives in the undissociated state.
- Lowering the pH of a food increases the effectiveness of an organic acid as a preservative. Table 3-4 lists the proportion of total acid undissociated at different pH values for selected organic acids.
- The type of organic acid employed can dramatically influence the microbiological keeping quality and safety of the food.
- It is well known that groups of microorganisms have pH optimum, minimum, and maximum for growth in foods. Table 3-5 lists the approximate pH ranges for growth in laboratory media for selected organisms relevant to food.
- As with other factors, pH usually interacts with other parameters in the food to inhibit growth.
- The pH can interact with factors such as $a_{w,}$ salt, temperature, redox potential, and preservatives to inhibit growth of pathogens and other organisms. The pH of the food also significantly impacts the lethality of heat treatment of the food. Less heat is needed to inactivate microbes as the pH is reduced.
- Another important characteristic of a food to consider when using acidity as a control mechanism is its buffering capacity.
- The buffering capacity of a food is its ability to resist changes in pH. Foods with a low buffering capacity will change pH quickly in response to acidic or alkaline compounds produced by microorganisms as they grow. Meats, in general, are more buffered than vegetables by virtue of their various proteins.
- Titratable acidity (TA) is a better indicator of the microbiological stability of certain foods, such as salad dressings, than is pH.
- Titratable acidity is a measure of the quantity of standard alkali (usually 0.1 M NaOH) required to neutralize an acid solution (ICMSF 1980, p 94).
- It measures the amount of hydrogen ions released from undissociated acid during titration. Titratable acidity is a particularly useful measure for highly buffered or highly acidic foods.

- Weak acids (such as organic acids) are usually undissociated and, therefore, do not directly contribute to pH. Titratable acidity yields a measure of the total acid concentration, while pH does not, for these types of foods.
- In general, pathogens do not grow or grow very slowly, at pH levels below 4.6; but there are exceptions.
- Many pathogens can survive in foods at pH levels below their growth minima. It has been reported that *C. botulinum* was able to produce toxin as low as pH 4.2, but these experiments were conducted with high inoculums levels (10^3-10^4 CFU/g up to 10^6 CFU/g), in soy peptone, and with the presence of *Bacillus* spp. (Smelt and others 1982).
- The panel did not consider these results to be relevant to the foods under consideration in this report. It should also be noted that changes in pH can transform a food into one which can support growth of pathogens (ICMSF 1980). For example, several botulism outbreaks have been traced to foods in which the pH increased due to mold growth.
- These are important considerations when determining the shelf life of a food formulation. Based on a comprehensive review of the literature, the panel concluded that a pH of 4.6 is appropriate to control spore-forming pathogens.
- Among vegetative pathogens, *Salmonella* spp. is reported to grow at the lowest pH values; however, in a study by Chung and Goepfert (1970), the limiting pH was greatly influenced by the acidulant used. For example, when tryptone-yeast extract-glucose broth was inoculated with 10^4 CFU/ml of salmonellae, minimum pH values for growth ranged from 4.05 with hydrochloric and citric acids to 5.5 with propionic acid or acetic acid.
- Additionally, inoculum levels were unrealistically high (10^2 - 10^6 CFU/ml) for salmonellae in food systems. These investigators also noted that these results could not be extrapolated directly to food because the experiment was run in laboratory media under ideal temperature and a_w conditions and without the presence of competitive microorganisms. Similarly, Ferreira and Lund (1987) reported that six out of 13 strains of *Salmonella* spp. representing 12 serovars could grow at pH 3.8 at 30 °C (86 °F) within 1-3 d, and at 20 °C (68 °F) in 3-5 d, when using HCl as an acidulant.
- Other reports note that certain acids at pH 4.5 inactivate salmonellae. The panel therefore concluded that using a pH minimum of 4.0 for *Salmonella* spp. would not be scientifically

substantiated for foods subject to Food Code requirements. Based on a comprehensive review of the literature data, the panel also concluded that it would be scientifically valid to use a pH minimum of 4.2 to control for *Salmonella* spp. and other vegetative pathogens.

- As with other intrinsic properties, when analyzing multi components foods, the pH should be measured not only for each component of the food but also for the interface areas among components and for any potential microenvironment.

Nutrient content

- Microorganisms require certain basic nutrients for growth and maintenance of metabolic functions.
- The amount and type of nutrients required range widely depending on the microorganism. These nutrients include water, a source of energy, nitrogen, vitamins, and minerals.
- Varying amounts of these nutrients are present in foods. Meats have abundant protein, lipids, minerals, and vitamins. Most muscle foods have low levels of carbohydrates.
- Plant foods have high concentrations of different types of carbohydrates and varying levels of proteins, minerals, and vitamins. Foods such as milk and milk products and eggs are rich in nutrients. The role of water is discussed in section 2.1.
- Food borne microorganisms can derive energy from carbohydrates, alcohols, and amino acids. Most microorganisms will metabolize simple sugars such as glucose. Others can metabolize more complex carbohydrates, such as starch or cellulose found in plant foods, or glycogen found in muscle foods. Some microorganisms can use fats as an energy source.
- Amino acids serve as a source of nitrogen and energy and are utilized by most microorganisms. Some microorganisms are able to metabolize peptides and more complex proteins. Other sources of nitrogen include, for example, urea, ammonia, creatinine, and methylamines. Examples of minerals required for microbial growth include phosphorus, iron, magnesium, sulfur, manganese, calcium, and potassium. In general, small amounts of these minerals are required; thus a wide range of foods can serve as good sources of minerals.
- In general, the Gram (+) bacteria are more fastidious in their nutritional requirements and thus are not able to synthesize certain nutrients required for growth. For example, the Gram (+)

food borne pathogen *S. aureus* requires amino acids, thiamine, and nicotinic acid for growth Fruits and vegetables that are deficient in B vitamins do not effectively support the growth of these microorganisms. The Gram (-) bacteria are generally able to derive their basic nutritional requirements from the existing carbohydrates, proteins, lipids, minerals, and vitamins that are found in a wide range of food.

- An example of a pathogen with specific nutrient requirements is *Salmonella enteritidis*. Growth of *Salmonella enteritidis* may be limited by the availability of iron. For example, the albumen portion of the egg, as opposed to the yolk, includes antimicrobial agents and limited free iron that prevent the growth of *Salmonella enteritidis* to high levels.
- Clay and Board (1991) demonstrated that the addition of iron to an inoculum of *Salmonella enteritidis* in egg albumen resulted in growth of the pathogen to higher levels compared to levels reached when a control inoculum (without iron) was used.
- The microorganisms that usually predominate in foods are those that can most easily utilize the nutrients present.
- Generally, the simple carbohydrates and amino acids are utilized first, followed by the more complex forms of these nutrients.
- The complexity of foods in general is such that several microorganisms can be growing in a food at the same time.
- The rate of growth is limited by the availability of essential nutrients. The abundance of nutrients in most foods is sufficient to support the growth of a wide range of foodborne pathogens. Thus, it is very difficult and impractical to predict the pathogen growth or toxin production based on the nutrient composition of the food.

Redox potential

- The oxidation-reduction or redox potential of a substance is defined in terms of the ratio of the total oxidizing (electron accepting) power to the total reducing (electron donating) power of the substance.
- In effect, redox potential is a measurement of the ease by which a substance gains or losses electrons. The redox potential (Eh) is measured in terms of milli volts. A fully oxidized standard oxygen electrode will have an Eh of +810 mV at pH 7.0, 30 °C (86 °F), and under the

same conditions, a completely reduced standard hydrogen electrode will have an Eh of -420 mV.

- The Eh is dependent on the pH of the substrate; normally the Eh is taken at pH 7.0.
- The major groups of microorganisms based on their relationship to Eh for growth are aerobes, anaerobes, facultative aerobes, and microaerophiles. Examples of food borne pathogens for each of these classifications include *Aeromonas hydrophila, Clostridium botulinum, Escherichia coli* O157:H7, and *Campylobacter jejuni,* respectively.
- Generally, the range at which different microorganisms can grow are as follows: aerobes +500 to +300 mV; facultative anaerobes +300 to -100 mV; and anaerobes +100 to less than -250 mV For example, *C. botulinum* is a strict anaerobe that requires an Eh of less than +60 mV for growth; however, slower growth can occur at higher Eh values.
- The relationship of Eh to growth can be significantly affected by the presence of salt and other food constituents. For example, in one study with smoked herring, toxin was produced in inoculated product stored at 15 °C (59 °F) within three days at an Eh of +200 to +250 mV (Huss and others 1979).
- In this case, the major oxidant would be trimethylamine oxide, which becomes the electron acceptor for *C. botulinum*. The anaerobe *Clostridium perfringens* can initiate growth at an Eh close to +200 mV; however, in the presence of increasing concentrations of certain substances, such as salt, the limiting Eh increases.
- The measured Eh values of various foods are given in Table 3-6. These values can be highly variable depending on changes in the pH of the food, microbial growth, packaging, the partial pressure of oxygen in the storage environment, and ingredients and composition (protein, ascorbic acid, reducing sugars, oxidation level of cations, and so on).
- Another important factor is the poising capacity of the food. Poising capacity, which is analogous to buffering capacity, relates to the extent to which a food resists external affected changes in Eh.
- The poising capacity of the food will be affected by oxidizing and reducing constituents in the food as well as by the presence of active respiratory enzyme systems. Fresh fruits and vegetables and muscle foods will continue to respire; thus low Eh values can result.

Naturally occurring and added antimicrobials

- Some foods intrinsically contain naturally-occurring antimicrobial compounds that convey some level of microbiological stability to them.
- There are a number of plant-based antimicrobial constituents, including many essential oils, tannins, glycosides, and resins, that can be found in certain foods. Specific examples include eugenol in cloves, allicin in garlic, cinnamic aldehyde and eugenol in cinnamon, allyl isothiocyanate in mustard, eugenol and thymol in sage, and carvacrol (isothymol) and thymol in oregano.
- Other plant-derived antimicrobial constituents include the phytoalexins and the lectins. Lectins are proteins that can specifically bind to a variety of polysaccharides, including the glycoproteins of cell surfaces.
- Through this binding, lectins can exert a slight antimicrobial effect. The usual concentration of these compounds in formulated foods is relatively low, so that the antimicrobial effect alone is slight.
- However, these compounds may produce greater stability in combination with other factors in the formulation.
- Some animal-based foods also contain antimicrobial constituents. Examples include lactoferrin, conglutinin and the lactoperoxidase system in cow's milk, lysozyme in eggs and milk, and other factors in fresh meat, poultry and seafood.
- Lysozyme is a small protein that can hydrolyze the cell wall of bacteria. The lactoperoxidase system in bovine milk consists of three distinct components that are required for its antimicrobial action: lactoperoxidase, thiocyanate, and hydrogen peroxide. Gram (-) psychotrophs such as the pseudomonads have been shown to be very sensitive to the lactoperoxidase system.
- Consequently, this system, in an enhanced form, has been suggested to improve the keeping quality of raw milk in developing countries where adequate refrigeration is scarce.
- Similar to the plant-derived antimicrobial compounds, the animal-derived compounds have a limited effect on ambient shelf life of foods.

KAHE

- It is also known that some types of food processing result in the formation of antimicrobial compounds in the food. The smoking of fish and meat can result in the deposition of antimicrobial substances onto the product surface.
- Maillard compounds resulting from condensation reactions between sugars and amino acids or peptides upon heating of certain foods can impart some antimicrobial activity Smoke condensate includes phenol, which is not only an antimicrobial, but also lowers the surface pH. Some processes also lower the surface pH with liquid smoke to achieve an unsliced shelf-stable product.
- Some types of fermentations can result in the natural production of antimicrobial substances, including bacteriocins, antibiotics, and other related inhibitors. Bacteriocins are proteins or peptides that are produced by certain strains of bacteria that inactivate other, usually closely-related, bacteria.
- The most commonly characterized bacteriocins are those produced by the lactic acid bacteria. The *lantibiotic nisin* produced by certain strains of *Lactococcus lactis* is one of the best characterized of the bacteriocins.
- Nisin is approved for food applications in over 50 countries around the world Nisin's first food application was to prevent late-blowing in Swiss cheese by *Clostridium butyricum*.
- Nisin is a polypeptide that is effective against most Gram (+) bacteria but is ineffective against Gram (-) organisms and fungi. Nisin can be produced in the food by starter cultures or, more commonly; it can be used as an additive in the form of a standardized preparation.
- Nisin has been used to effectively control spore-forming organisms in processed cheese formulations, and has been shown to have an interactive effect with heat. For example, an F_o process for conventional low acid canned foods may be in the 6 - 8 range, but with the addition of nisin, can be reduced to a F_o of 3 for inactivating thermophilic spores.
- There are a number of other bacteriocins and natural antimicrobials that have been described; however, these have found very limited application in commercial use as food preservatives because of their restricted range of activity, limited compatibility with the food formulation or their regulatory status.

Extrinsic parameters of food affecting microbial count

Extrinsic parameters are those properties of the environment that exist outside of the food product which affect both the foods and their microorganisms. Examples of this factor are as followed:

1. Storage temperature It is important to know that the temperature growth ranges for microorganisms of importance in foods as an aid in selecting the proper temperature for product storage. Microorganisms divided according to their temperature growth range to:

- **Psychrophilic microorganisms** such as *Staphylococcus aureus* have an optimum growth range of 12 °C to 15 °C with a maximum range of 15 °C to 20 °C.

- **Mesophilic microorganisms** include virtually all human pathogens and have an optimum growth range of between 30 °C and 45 °C and a minimum growth temperature ranging from 5 to 10 °C.

- **Thermophilic Microorganisms:** the optimum temperature for growth of thermophiles is between 55 to 65 °C with the maximum as high as 90 °C and a minimum of around 40 °C.

- **Psychrotrophic microorganisms** such as *L. monocytogenes* and *C. botulinum* are capable of growing at low temperatures (minimum of - 0.4 °C and 3.3 °C, respectively, to 5 °C). those microorganisms are much more relevant to food and include spoilage bacteria, spoilage yeast and molds, as well as certain foodborne pathogens.

2. Relative humidity

The relative humidity of the storage environment is important both from the standpoint of water activity (aw) within foods and the growth of microorganisms at the surfaces.

3. Presence/concentration of gases

Carbon dioxide (CO_2) is the single most important atmospheric gas that is used to control microorganisms in foods. The inhibitory effects of CO_2 increase with decreasing temperature due to the increased solubility of CO_2 at lower temperatures. Therefore, when carbon dioxide dissolves in the food, it lowers the pH of the food, and this leads to kill pathogenic bacteria.

4. Presence/activities of other microorganisms

Some foodborne microorganisms produce substances that are either inhibitory or lethal to others. These include antibiotics, bacteriocins, hydrogen peroxide, and organic acids (such as lactic acid).

DETECTION OF MICROORGANISMS IN FOOD

- As the food industry increases the demand for more and more testing, whether it is for customers, regulators or for self-monitoring, the concept of detection becomes more and more important. Testing often includes food product testing and environmental monitoring for pathogens, indicators and/or spoilage organisms.
- During a recent visit to a small processor, the owner of the company asked several questions about a laboratory report they had just received from their third-party testing laboratory.

Detection Methodology

- Since microorganisms are so very small, the detection of their presence in a food sample is challenging at best, even when present at levels in the thousands to millions of cells per gram or millilitre of a food product or rinse or on an equipment surface.
- The detection and quantification of microorganisms in food and food processing begins with the ability of the method to move (or remove) the microbes from the food (or surface) to the detection system.
- The methods by which microorganisms are removed or detached from a food or surface are quite varied. Taking a sample from a food product or surface may be accomplished by swabbing or sponging a food or food equipment surface, excising a thin layer of food product surface or rinsing the food product or piece of equipment in or with a buffered diluent. Frequently used methods for removing (detaching) microbes from food product or swab samples include blending, stomaching (or macerating) and rinsing.
- The advantages of rapid methods such as PCR are numerous, including increased sensitivity and speed of detection, and identification of microorganisms from numerous and varied sample matrices. Compared with techniques such as traditional culture

methods, the detection time required for the assay can be reduced from days or weeks to hours.

- In addition, these methods are particularly applicable to target organisms expected to be present in low numbers. For any method, the intrinsic properties of a food product, such as pH, water activity, ingredients such as salt or spices and the chemicals and sanitizers used in food environments that may interfere with the test method, must be considered.

More recently, the questions of sub-lethally injured cells and their roles in food borne illness and the appropriate methodology for resuscitation of these cells have also come to light.

Limits of Detection

- Whatever the method and whatever the matrix, the bottom line is the limit of detection for the method and the associated results of the analysis.
- The limit of detection of a particular method, the ability to recover and determine the presence of microorganisms, is often described as a particular level of organisms recoverable in a sample of a particular size. The limit of detection needed for a specific process or food type varies with the reason for taking the sample in the first place.
- If the goal is to reach zero tolerance, as is expected for many ready-to-eat food processes, selecting a method with the lowest limit of detection may be necessary.

Detection of microorganisms in food

- According to Strategic Consulting Inc.'s latest market research report, Food Micro, Fifth Edition: Microbiology Testing in the U.S. Food Industry, the total volume of microbiology testing in the U.S. increased by 14.4% in the past 2 years.
- The test volume for routine/indicator organisms went up by just over 10% between 2008 and 2010. During that same 2-year period, pathogen testing increased by more than 30%, driven by a number of important factors including regulations, recalls and increased customer requirements.

- For pathogen analysis, the use of traditional methods continues to decline, and in 2010, accounted for just 11% of test volume. Antibody-based methods were the leading analytical method followed by molecular-based methods.
- This trend away from traditional methods for pathogen analysis is forecasted to continue over the coming 5-year period, along with an increase in the use of molecular methods.

Standard Plate Count -SPC

The Standard Plate Count is the most common method used to quantify bacteria in foods. To perform a standard plate count, the food to be tested is suspended in liquid and a sample is then spread over the surface of a solid medium in a petri plate. Bacterial cells present will form colonies that can be counted to determine the number of cells in the original sample. When the objective is to estimate the total number of bacteria, a complex medium called Plate Count Agar is commonly used since it will support growth of many different types of bacteria. We call the results the number of Colony Forming Units (CFU), not total bacteria. This is because no single culture medium will support all different types of bacteria, we can only count those that do grow to form a visible colony.

Serial Dilution of samples

When performing a bacteria count, between 30 and 300 bacterial colonies need to be on the plate. A minimum of 30 assures that the data is statistically reliable; however, if there are more than 300 colonies are present, competition for nutrients can suppress growth of colonies. For example, if a sample were to contain 10^6 cells\ml, a 1 ml sample would contain 10^6 bacteria – far more than the 300 cell limit of a standard plate count – and the sample must be serially diluted: The standard way to dilute a sample in microbiology is through serial dilution.

Membrane filters

This method is also used for estimating bacterial numbers in water sample. Method is as follows:

- Sample - known volume of food homogenate

- Filter through 0.45 µm cellulose or polycarbonate filter

- Place membrane on nutrient agar medium, incubate and enumerate colonies

Other variant of membrane filtration is Micro colony Direct Epifluorescent Filter Technique.

Dry films

Food Grade P.T.F.E. (Polytetrafluoroethylene) is a dry film lubricant that has an extremely low friction value. Food Grade PTFE is white in colour. Food Grade PTFE is carried in a fast evaporating solvent with non stick properties and is clean and stain free. The solvent evaporates within a few seconds leaving a long lasting fine film of PTFE deposited on to the surface being sprayed. Food Grade PTFE spray prevents a build up of resin on metal tools and metal surfaces. Food Grade PTFE Spray is particularly effective in locations where a grease, oil, or silicone lubricant is not acceptable.

Food Grade PTFE spray is an ideal dry lubricant for metal, wood, plastics, rubber, glass, leather, fabric and foam materials. Food Grade PTFE flakes are non-flammable; however the solvent and propellant in this aerosol are flammable. Food Grade PTFE is stable at temperatures from -40°C to +260°C (applies to base product before aerosol packing). PTFE spray is silicone free with long lasting lubricant and protection effect. Food Grade PTFE spray is insoluble in water and is non toxic. Food Grade PTFE spray is used in engineering, automotive, farm, factory, and DIY industries. Food Grade PTFE spray can be used on cams, slides, chutes, printing machinery, saw blades, router cutters, fasteners, bearings, and electro-mechanical parts in electronic assemblies.

Bacterial toxin-Botulism and Staphylococcal toxin

Toxigenesis, or the ability to produce toxins, is an underlying mechanism by which many bacterial pathogens produce disease. At a chemical level, there are two main types of bacterial toxins, lipopolysaccharides, which are associated with the cell wall of Gram-negative bacteria, and proteins, which are released from bacterial cells and may act at tissue sites removed from the site of bacterial growth. The cell-associated toxins are referred to as endotoxins and the extracellular diffusible toxins are referred to as exotoxins.

BACTERIAL PROTEIN TOXINS

Exotoxins are usually secreted by living bacteria during exponential growth. The production of the toxin is generally specific to a particular bacterial species that produces the disease associated with the toxin (e.g. only *Clostridium tetani* produces tetanus toxin; only *Corynebacterium diphtheriae* produces the diphtheria toxin). Usually, virulent strains of the bacterium produce the toxin while non-virulent strains do not, and the toxin is the major determinant of virulence (e.g. tetanus and diphtheria). At one time, it was thought that exotoxin production was limited mainly to Gram-positive bacteria, but clearly both Gram-positive and Gram-negative bacteria produce soluble protein toxins.

Bacterial protein toxins are the most powerful human poisons known and retain high activity at very high dilutions. Usually the site of damage caused by an exotoxin indicates the location for activity of that toxin. Terms such as **enterotoxin**, **neurotoxin**, **leukocidin** or **hemolysin** are descriptive terms that indicate the target site of some well-defined protein toxins.

- A few bacterial toxins that obviously bring about the death of an animal are known simply as **lethal toxins**, and even though the tissues affected and the target site or substrate may be known, the precise mechanism by which death occurs is not clear (e.g. anthrax LF).
- Some bacterial toxins are utilized as **invasins** because they act locally to promote bacterial invasion. Examples are extracellular enzymes that degrade tissue matrices or fibrin, allowing the bacteria to spread.
- This includes collagenase, hyaluronidase and streptokinase. Other toxins, also considered invasins, degrade membrane components, such as phospholipases and lecithinases. The pore-forming toxins that insert a pore into eucaryotic membranes are considered as invasins, as well, but they will be reviewed here.
- Some protein toxins have very **specific cytotoxic activity** (i.e., they attack specific types of cells). For example, tetanus and botulinum toxins attack only neurons. But some toxins (as produced by *Staphylococci, Streptococci, Clostridia*, etc.) have fairly **broad cytotoxic activity** and cause nonspecific death of various types of cells or damage to tissues, eventually resulting in necrosis.

- Toxins that are phospholipases act in this way. This is also true of pore-forming hemolysins and leukocidins.
- Bacterial protein toxins are strongly **antigenic**. *In vivo*, specific antibody neutralizes the toxicity of these bacterial exotoxins (**antitoxin**). However, *in vitro,* specific antitoxin may not fully inhibit their activity.
- This suggests that the antigenic determinant of the toxin may be distinct from the active portion of the protein molecule. The degree of neutralization of the active site may depend on the distance from the antigenic site on the molecule.
- However, since the toxin is fully neutralized *in vivo*, this suggests that other host factors must play a role in toxin neutralization in nature.
- Protein exotoxins are inherently **unstable**. In time they lose their toxic properties but retain their antigenic ones. This was first discovered by Ehrlich who coined the term "toxoid" for this product. **Toxoids** are detoxified toxins which retain their antigenicity and their immunizing capacity.
- The formation of toxoids can be accelerated by treating toxins with a variety of reagents including formalin, iodine, pepsin, ascorbic acid, ketones, etc. The mixture is maintained at 37 degrees at pH range 6 to 9 for several weeks.

The resulting toxoids can be used for **artificial immunization** against diseases caused by pathogens where the primary determinant of bacterial virulence is toxin production. Toxoids are effective immunizing agents against diphtheria and tetanus that are part of the DPT (DTP) vaccine.

BOTULINUM TOXIN

Botulinum neurotoxins (BoNTs) are the causative agents of the deadly food poisoning disease, botulism, and could pose a major biological warfare threat due to their extreme toxicity and ease of production. They also serve as powerful tools to treat an ever expanding list of medical conditions.

Pathogenesis: Not all strains of *C. botulinum* produce the botulinum toxin. Seven toxigenic types of the organism exist, each producing an immunologically distinct form of botulinum toxin. The toxins are designated A, B, C1, D, E, F, and G. Lysogenic phages encode toxin C and D serotypes. Food-borne botulism is not an infection but an intoxication since it results from the ingestion of foods that contain the preformed clostridial toxin. If contaminated food has been insufficiently sterilized or canned improperly, the spores may germinate and produce botulinum toxin. The toxin is released only after the death and lysis of cells. The toxin resists digestion and is absorbed by the upper part of the GI tract and then into the blood. It then reaches the peripheral neuromuscular synapses where the toxin binds to the presynaptic stimulatory terminals and blocks the release of the neurotransmitter acetylcholine. This results in flaccid paralysis. Even 1-2 µg of toxin can be lethal to humans.

STAPHYLOCOCCAL TOXIN

Immune evasion proteins from *Staphylococcus aureus* have a significant conservation of protein structures and a range of activities that are all directed at the two key elements of host immunity, complement and neutrophils. These secreted virulence factors assist the bacterium in surviving immune response mechanisms.

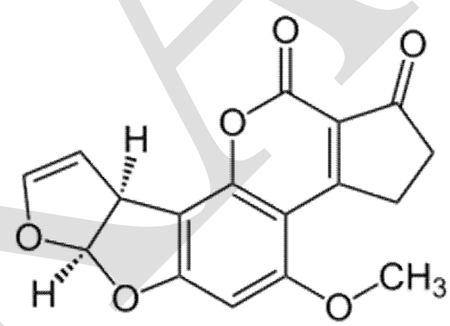
Pathogenesis: If the food is stored for some time at room temperature the organism may multiply in the food and produce toxin. The bacteria produce enterotoxin while multiplying in food. *S. aureus* is known to produce six serologically different types of enterotoxins (A, B, C, C2, D and E) that differ in toxicity. Most food poisoning is caused by enterotoxin A. Isolates commonly belong to phage type III. These enterotoxins tend to be heat stable, with type B being most heat resistant. Low temperature heat inactivated enterotoxin can undergo reactivation in some food. Ingestion of as little as 23 µg of enterotoxin can induce vomiting and diarrhoea. Staphylococcal enterotoxins act as super antigens, binding to MHC II molecules and stimulating T cells to divide and produce lymphokines such as IL-2 and TNF-alpha, which induces diarrhea. The toxin acts on the receptors in the gut and sensory stimulus is carried to the vomiting center in the brain by vagus and sympathetic nerves.

FUNGAL TOXINS –-AFLATOXIN

Aflatoxins are naturally occurring mycotoxins that are produced by *Aspergillus flavus* and *Aspergillus parasiticus*, species of fungi. The name was created around 1960 after the discovery that the source of turkey X disease was *Aspergillus flavus* toxins. Aflatoxins are toxic and among the most carcinogenic substances known. After entering the body, aflatoxins may be metabolized by the liver to a reactive epoxide intermediate or hydroxylated to become the less harmful aflatoxin M_1.

At least 14 different types of aflatoxin are produced in nature. Aflatoxin B_1 is considered the most toxic and is produced by both *Aspergillus flavus* and *Aspergillus parasiticus*. Aflatoxin G_1 and G_2 are produced exclusively by *A. parasiticus*. While the presence of *Aspergillus* in food products does not always indicate harmful levels of aflatoxin are also present, it does imply a significant risk in consumption. Aflatoxins M_1, M_2 were originally discovered in the milk of cows that fed on moldy grain. These compounds are products of a conversion process in the animal's liver. However, aflatoxin M_1 is present in the fermentation broth of *Aspergillus parasiticus*.

Aflatoxin



- Aflatoxin B_1 & B_2, produced by *Aspergillus flavus* and *A. parasiticus*
- Aflatoxin G_1 & G_2, produced by *Aspergillus parasiticus*
- Aflatoxin M_1, metabolite of aflatoxin B_1 in humans and animals (exposure in ng levels can come from a mother's milk)

- Aflatoxin M_2, metabolite of aflatoxin B_2 in milk of cattle fed on contaminated foods
- Aflatoxin Q_1 (AFQ_1), major metabolite of AFB_1 in *in vitro* liver preparations of other higher vertebrates

There are two principal techniques that have been used most often to detect levels of aflatoxin in humans.

The first method is measuring the AFB_1-guanine adduct in the urine of subjects. The presence of this breakdown product indicates exposure to aflatoxin B1 in the past 24 hours. However, this technique measures only recent exposure, and, due to the half-life of this metabolite, the level of AFB_1-guanine measured can vary from day to day, based on diet, and thus is not ideal for assessing long-term exposure.

Another technique that has been used is a measurement of the AFB_1-albumin adducts level in the blood serum. This approach provides a more integrated measure of exposure over several weeks/months.

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Possible Questions

Short questions

1. What is Aflatoxins
2. What is Staphylococcal toxin
3. Fungal toxin
4. What is SPC?
5. Write short note on Dry films?
6. Write short notes on Botulism.
7. What are invasins?
8. What is called exotoxin?
9. What is called endotoxin?
10. What are toxoids.
11. Define pH
12. Define TA

Essay type questions

1. Describe about the bacterial and fungal toxins.
2. How will you detect microorganisms in food?
3. Explain the method of detection of microbes in foods
4. Give an account on food-borne microbes.
5. Explain in detail about the extrinsic parameters of food affecting microbial count.
6. Explain in detail about the intrinsic parameters of food affecting microbial count.

UNIT-III

SYLLABUS

Fermented Foods: Origin, scope and development and preservation- Cheese, Yoghurt, Butter, miso, tempeh, kefir, koumiss, acidophilus milk, sourkraut, pickles and vinegar. Fresh juice production –Mango, orange, and pineapple. Technological aspects of industrial production of beer, wine and baker's yeast.

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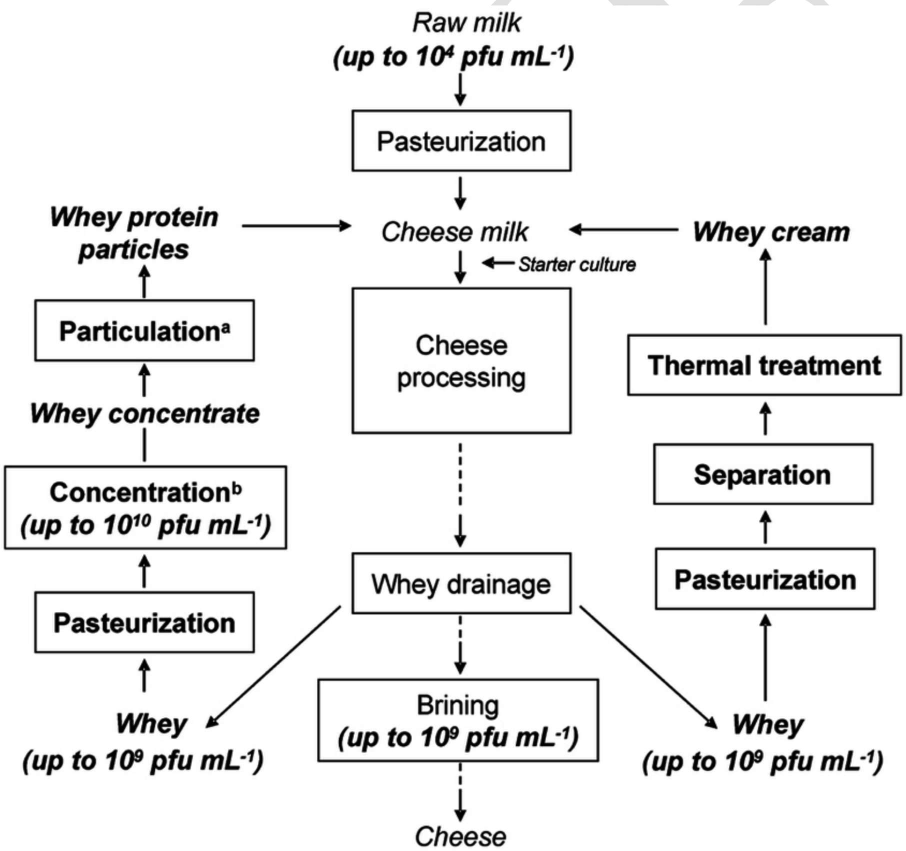
Cheese production

This is produced by coagulating milk, separating it from whey and letting it ripen generally with bacteria and sometimes also with molds. To make firmer, longer lasting cheese and speed the separation process, an enzyme called '*rennet*' is added. *Rennet is found in the stomach of milk-drinking mammals*. It enables the young to digest the mother's milk. It is extracted from the lining of the stomach of a milk-fed calf and



Yogurt: Whole milk, partially skimmed milk, skim milk or cream may be used in the production of yogurt. In the use of whole raw milk, the following conditions must be met: Low bacteria count, Free from antibiotics and No contamination by bacteriophages.

The ingredients used are:

- ✓ Other dairy products such as concentrated skim milk, non-fat dry milk, whey and lactose
- ✓ Sweeteners: glucose or sucrose
- ✓ Stabilizers: gelatin, carboxymethyl cellulose, locust bean guar
- ✓ Flavour: contributed mainly by the following fermentation products: Lactic acid, Acetaldehyde, Acetic acid and Diacetyl
- ✓ Fruit preparations: including natural and artificial flavouring colour.

The starter culture for most yogurt production is a symbiotic blend of *Streptococcus salivarus* sub sp *thermophilus* (ST) and Lactobacillus delbrueckii subsp. Bulgaricus (LB). When used together, the rate of acid production is higher.

Symbiosis of the starter culture: ST grows faster and produces both acid and CO_2. The formate (an acid) and CO_2 produced stimulate LB growth. On the other hand, the proteolytic activity of LB produces stimulatory peptides and amino acids for use by ST. The yogurt mixture coagulates during fermentation due to drop in pH.

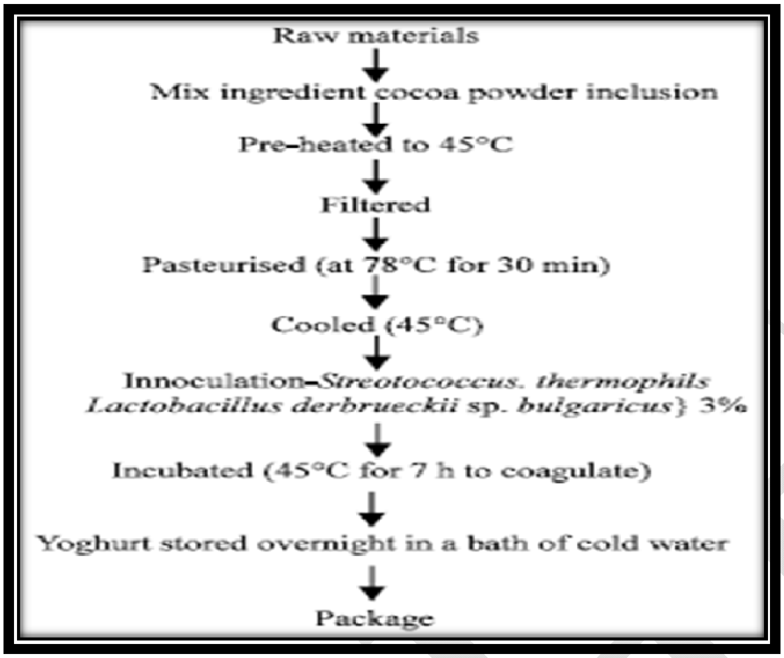
Types of yogurt:

- Stirred style yogurt (mainly industrial)
- Set style yogurt: In this type, the yogurt is packaged immediately after inoculation with the starter culture and is incubated in the packages.

Fruit-on-the-bottom style: fruit is layered at the bottom followed by inoculated yogurt.

Incubation occurs in the sealed cups.

- Stirred style yogurt with fruit preparation.



__Butter__

Milk & cream

Collected from cows. Butter can also be produced from the milk of buffalo, camel, goat, ewe, and mares. Cream is separated from the milk. The cream can be either supplied by a fluid milk dairy or separated from whole milk by the butter manufacturer. The cream should be sweet (pH greater than 6.6), not rancid, not oxidized, and free from off flavors. The cream is pasteurized at a temperature of 95°C or more to destroy enzymes and micro-organisms.

Ripening

Sometimes, cultures are added to ferment milk sugars to lactic acid and desirable flavor and aroma characteristics for cultured butter. This is more common in European butters.

Aging

Cream is held at cool temperatures to crystallize the butterfat globules, ensuring proper churning and texture of the butter. In the aging tank, the cream is subjected to a program of controlled cooling designed to give the fat the required crystalline structure. As a rule, aging takes 12 - 15 hours. From the aging tank, the cream is pumped to the churn or continuous buttermaker via a plate heat exchanger which brings it to the requisite temperature.

Churning

Cream is agitated, and eventually butter granules form, grow larger, and coalesce. In the end, there are two phases left: a semisolid mass of butter, and the liquid left over, which is the buttermilk.

Draining & washing

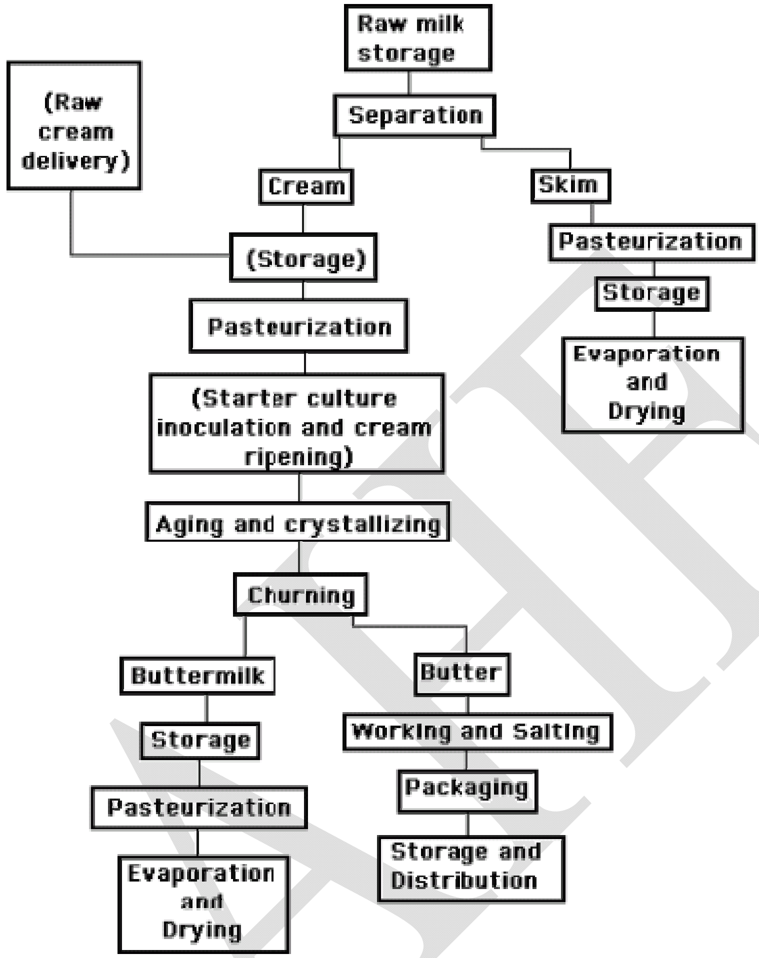
Thus the cream is split into two fractions: butter grains and buttermilk. In traditional churning, the machine stops when the grains have reached a certain size, whereupon the buttermilk is drained off. With the continuous butter maker the draining of the buttermilk is also continuous. After draining, the butter is worked to a continuous fat phase containing a finely dispersed water phase. It used to be common practice to wash the butter after churning to remove any residual buttermilk and milk solids but this is rarely done today. This washing process would ensure that all the butter milk is washed out of the butter. Otherwise the butter would not keep and go rancid.

Salting & working

Salt is used to improve the flavor and the shelf-life, as it acts as a preservative. Further, the butter is worked to improve its consistency.

Packing & storage

The butter is finally patted into shape and then wrapped in waxed paper and then stored in a cool place. As it cools, the butterfat crystallizes and the butter becomes firm. Whipped butter, made by whipping air or nitrogen gas into soft butter , is intended to spread more easily at refrigeration temperatures.



Kefir

- Transfer the active kefir grains into up to 4 cups of fresh milk.
- Cover with a coffee filter or butter muslin secured by a rubber band or jar ring.
- Place in a warm spot, 68°-85°F, to culture.
- Culture until milk is slightly thickened and aroma is pleasant

Koumiss

- Slightly alcoholic milk beverage Alcohol and carbon dioxide produced by yeasts contribute to its refreshing, frothy taste
- Traditionally made from mares milk
- Fermented by back-slopping or by allowing the milk to ferment naturally

- Popular beverage of nomads in Asia and some regions of Russia
- Similar to kefir , but no solid inoculation matrix

Acidophilus milk: skim or whole milk is fermented with *Lactobacillus acidophilus* (LA) which is said to have therapeutic benefits in the gastrointestinal tract. The milk is heated to high temperature (95^0C for 1hr) to reduce the microbial load and favour the slow growing LA culture. The milk is inoculated at a level of 2-5% and incubated at 37^0C until coagulated.

Vinegar

Vinegar production Vinegar is the product made from the conversion of ethyl alcohol to acetic acid by a genus of bacteria, *Acetobacter*. Therefore, vinegar can be produced from any alcoholic material from alcohol-water mixtures to various fruit wines (Peppler and Beaman 1967). Vinegar bacteria, also called acetic acid bacteria (AAB), are members of the genus Acetobacter and characterized by their ability to convert ethyl alcohol (C2 H5 OH) into acetic acid(CH3 COOH) by oxidation as shown below: Vinegar is a solution of acetic acid produced by a two-step bioprocess. In the first step, fermentable sugars are transformed into ethanol by the action of yeast. In the second step, AAB oxidize the ethanol into acetic acid in an aerobic process. AAB are well known for their ability to spoil wines because they can produce large amounts of acetic acid from ethanol and other compounds present in wines .

Types of Vinegar

Balsamic vinegar is brown in colour with a sweet-sour flavour. It is made from the white Trebbiano grape and aged in barrels of various woods. Some gourmet Balsamic vinegars are over 100 years old.

Cane vinegar is made from fermented sugarcane and has a very mild, rich-sweet flavour. It is most commonly used in Philippine cooking. ˆ

Cider vinegar is made from apples and is the most popular vinegar used for cooking in the United States. It should contain at least 1.6 grams of apple solids per 100ml of which more than 50% are reducing sugars, and at least 4 grams of acetic acid per 100 ml at 20°C.

Coconut vinegar is low in acidity, with a musty flavour and a unique aftertaste. It is used in many Thai dishes. ˆ Distilled vinegar is harsh vinegar made from grains and is usually colourless. It is best used only for pickling. ˆ

Malt vinegar is very popular in England. It is made from fermented barley and grain mash, and flavoured with woods such as beech or birch. It has a hearty flavour and is often served with fish and chips. ˆ

Rice wine vinegar has been made by the Chinese for over 5,000 years. There are three kinds of rice wine vinegar: red (used as a dip for foods and as a condiment in soups), white (used mostly in sweet and sour dishes), and black (common in stir-fries and dressings).

Sherry vinegar is aged under the full heat of the sun in wooden barrels and has a nutty-sweet taste. Spirit vinegar is made by acetic fermentation of dilute ethyl alcohol. It should contain at least 4 grams of acetic acid per 100ml at 20°C. It may be coloured with caramel. This vinegar is also called "grain vinegar" or "distilled vinegar".

White vinegar is made from the distilled vinegar. The term "distilled" is misleading, because the vinegar is not distilled, but it is made from alcohol which is distilled. ˆ

Wine vinegar or Grape vinegar made from grapes by acetic fermentation is called "wine vinegar" or "grape vinegar". It can be made from white, red, or rose, wine. These vinegars make the best salad dressings. It should contain at least one gram of grape solids, 0.13 gram of grape ash and 4 grams of acetic acid per 100ml at 20°C.

Beer

An alcoholic beverage produced by the fermentation of sugar-rich extracts derived from cereal grains or other starchy materials.

Ingredients: Malted barley, Cereal Adjunct, Hops, Water

Malted Barley: Barley provides fermentable sugars, flavor, and color.

Malting process: Steeping, Germination, Kilning

Purpose: Activate enzyme systems, Preserve for brewhouse

Steeping: Soak, aerate, drain for 2 days

Germination: Ventilated to remove CO_2, Repeated turning, 4 to 5 days

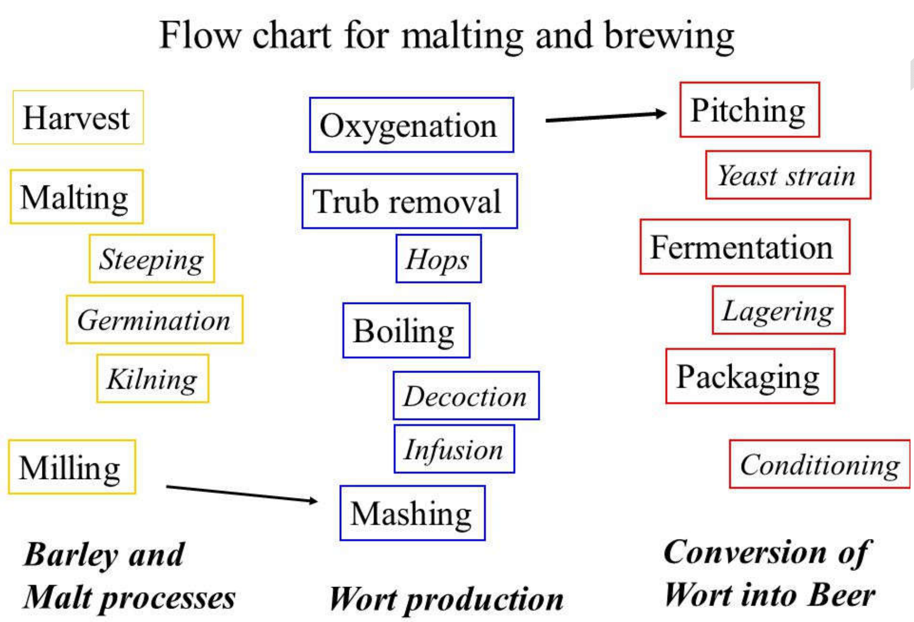
Cereal Adjuncts: Types of adjuncts commonly used: Corn grits, Rice, Corn syrups (high maltose and dextrose)

Purpose: Additional source of fermentable sugars, Lighter body

Hops: Spice of beer Provides aroma and bitterness

Flower (cone) of a vine-growing plant

Humulus lupulus Used as: Whole cones,Pellets,Extracts



Wine Making

The process of **fermentation** in winemaking turns grape juice into an alcoholic beverage. By putting grape juice into a container at the right temperature, adding yeast which turns the sugar in the juice into alcohol and carbon dioxide the grape juice will **ferment**.

Harvesting

Grapes are picked up by hand or mechanically

Stemming/Crushing

Stemming is the separation of the stems and grapes. Crushing: A horizontal press squeezes the broken grapes, separating the fresh juice (must) from the skins (marc). After crushing starts the fermentation process

Fermentation

sugar and acids that naturally react with wild yeasts. Vineyard adding their own yeast fermentation can take from 10 to 30 days to convert natural sugar to alcohol

Draining

Liquid wine is drained from the vat without being pressed and goes into barrels (free-run wine). The remaining pulp retains about 20% of the wine.

Pressing

The remaining pulp, after draining, is pressed to squeeze out the press wine. The press wine tends to be dark, harsh and unpalatable, and is mixed with free-run wine to produce something decent

Mixing

The free-run wine and press wine, always from the same source, are mixed together in appropriate ratios to obtain the desired balance.

Clarification

Clarification is the step of stabilization of fermentation. During clarification all remaining solids are removed from the fermented liquid. Clarification done in numerous ways:fining, a process that calls for the addition of substances that cause the solids in the liquid to adhere to one another and sink to the bottom of the vatrunning the liquid through coarse and fine filters siphoning the liquid off the top of the fermenting vats after the solids have settled to the bottom

Aging

The final stage in vinification is aging the wine. At this point, the clarified wine is transferred into either wooden barrels or metal vats in which the wine is allowed to further mature and develop flavors. If a winemaker chooses to age the wine in wooden casks, he will be allowing the wine to pick up flavors from the wood, adding greater depth to its flavors. While this can add body to some wines, keep in mind that the “woody” flavor isn’t suited to all types of wine, hence the use of metal vats.

Bottling: The final step of wine production.
A dose of sulfite is added to help preserve the wine and prevent unwanted fermentation in the bottle.The wine bottles then are traditionally sealed with a cork, although alternative wine clossure such as synthetic corks and screwcaps, which are less subject to cork taint, are becoming increasingly popular.

Crushing and primary (alcoholic) fermentation
Crushing is the process when gently squeezing the berries and breaking the skins to start to liberate the contents of the berries.the harvested grapes are sometimes crushed by trampling them barefoot or by the use of inexpensive small scale crushers.larger wineries, a mechanical crusher/destemmer is used.

Secondary (malolactic) fermentation and bulk aging
During the secondary fermentation and aging process, which takes three to six months, the fermentation continues very slowly.The wine is kept under an airlock to protect the wine from oxidation. Proteins from the grape are broken down and the remaining yeast cells and other fine particles from the grapes are allowed to settle. The secondary fermentation usually takes place in either large stainless steel vessels with a volume of several cubic meters, or oak barrels, depending on the goals of the winemakers.

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Possible Questions

Short questions

1. What is Miso?
2. What is temph?
3. Write note on Kumiss and kefir production.
4. What is must?
5. Write short note malting process.
6. What is called Whey?
7. What is the role of Hop flower?
8. What is blue cheese?
9. Explain the process of canning
10. Define Pasteurization.

Essay type questions

1. Describe the production process of different cheeses.
2. Explain the manufacturing method of pickles and sauerkraut.
3. Give an account on food-borne microbes.
4. Elaborate the fresh juice production process of Mango, orange, and pineapple.
5. Explain in detail about the industrial production of wine and beer.
6. Discuss the technological aspects on industrial production process of Baker's yeast.

UNIT-1V

SYLLABUS

Food Spoilage and Preservation: Causes of Food Spoilage, Spoilage of Fruits, Vegetables, Meat, Soft Drinks, Eggs, Dairy products. Food Preservation through chemicals - Acids, Salts, Sugars, Antibiotics, Ethylene oxide, Antioxidants. Other Methods of Food Preservation - Radiations, Low and High temperature, Drying. Food packaging materials and their properties.

Food Spoilage and Preservation

Causes of Food Spoilage

Spoilage is the process in which food deteriorates to the point in which it is not edible to humans or its quality of edibility becomes reduced. Various external forces are responsible for the spoilage of food. Food that is capable of spoiling is referred to as perishable food.

Food spoilage refers to undesirable changes occurring in food due to the influence of air, heat, light, moisture, which foster the growth of microorganisms. Foods take different period of time to lose their natural form though spoilage. In context to food preservation foods are classified as perishable, (meat, fish, milk fruits and some vegetable), semi perishable (eggs, onions, potatoes, carrot, beans) and non-perishable (cereals, pulse nuts).

Foods are spoilt by the action of: (1) Micro-organisms (2) Enzymes and (3) Insects.

1. Micro-organisms:

The micro-organisms responsible for food spoilage are moulds, yeast and bacteria.

Moulds:

Moulds are in the form of threads developed on perishable foods and are easily visible to the eye. They contain spores which can spread through the air and start new mould plants. When these moulds find a favorable environment, they germinate and produce a fluffy growth, often white or grey but sometimes bluish-green, red, orange or some other colour, depending upon the variety of the mould. Most moulds are not harmful. A relatively small proportion of the moulds, found on foods are capable of producing toxic materials known as mycotoxins of which aflatoxins is an example.

Yeasts:

Yeasts are tiny organisms which are not visible to the naked eye, but which can be seen through the microscope. They multiply very fast and cause fermentation by acting on certain components of the perishable foods like fruit juices, syrups etc. During yeast fermentation, the sugars present in the food are broken up to form alcohol and carbon dioxide. Foods liable to be spoiled by yeasts are fruit juices, syrups, molasses, honey, jams and jellies.

Bacteria:

Bacteria are unicellular organism and are much smaller in size than either yeasts or moulds. They occur in different sizes and shapes and are classified as coccus (spheroidal), bacilli (cylindrical) or spirillae (spirillar) on the basis of their shape as seen under the microscope. They also vary in their requirement for food, moisture, acidity, temperature and oxygen. Bacteria can grow and develop rapidly between 20°C and 53°C. Bacteria are classified according to the temperature ranges that they need for growth:

1. A higher temperature than 45°C are known as thermopile, (e.g. in canning industry and milk processing plants).

2. Temperatures between 20-25°C are called Mesophiles.

3. Temperature less than 20°C are called psychrophites (e.g. in Refrigerator and in cold storages).

2. Spoilage by Enzymes:

Enzymes are organic catalyst present in living cells. The life of every living cell depends upon the chemical reactions activated by these enzymes. Hence, they cause food spoilage due to the chemical reactions as in cutting apples; it becomes brown while tomato cause develops a black scum. Enzymes are sensitive to heat and are easily destroyed by heat. They can act from 0°C to 60°C; their optimum temperature of reaction is usually 37°C. All enzymes are inactivated by temperatures above 80°C. Therefore, enzyme activity can be prevented by heating foods to temperature which inactivate the enzymes. It can also be prevented by cooling (as in freezing and refrigeration) by elimination of air, by protection from light and by addition of anti-oxidants.

3. Spoilage by insects:

Worms, bugs, weevils, fruit flies, moths cause extensive damage to food and reduce its nutritional value and make it unfit for human consumption**.**

Spoilage of Meat

Aerobic storage of chilled red meats, either unwrapped or covered with an oxygen permeable film, produces a high redox potential at the meat surface suitable for the growth of psychrotrophic aerobes. Non-fermentative Gram-negative rods grow most rapidly under these conditions and come to dominate the spoilage microflora that develops. Taxonomic description of these organisms has been somewhat unsettled over the years with some being described as Moraxella and Moraxella-like. Such terms have now been largely abandoned in favour of a concensus that has emerged from numerical taxonomy studies. In this, the principal genera are described as Pseudomonas, Acinetobacter and Psychrobacter with Pseudomonas species such as *P. fragi, P. lundensis and P. fluorescens* generally predominating. Other organisms are usually only a minor component of the spoilage microflora, but include psychrotrophic Enterobacteriaceae such as *Serratia liquefaciens* and *Enterobacter agglomerans,* lactic acid bacteria and the Gram-positive *Brochothrix thermosphacta.* The first indication of spoilage in fresh meat is the production of off odours which become apparent when microbial numbers reach around 10^7 cfu cm^2. At this point it is believed that the micro-organisms switch from the diminishing levels of glucose in the meat to amino acids as a substrate for growth. In meat with lower levels of residual glucose this stage is reached earlier and this accounts for the earlier onset of spoilage in high pH meat. Bacterial metabolism produces a complex mixture of volatile esters, alcohols, ketones and sulfur-containing compounds which collectively comprise the off odours detected. Such mixtures can be analysed by a combination of gas chromatography and mass spectrometry and the origin of different compounds can be established by pure culture studies. These have confirmed the predominant role of pseudomonads in spoilage of aerobically stored chilled meat. Usually the different spoilage taints appear in a sequence reflecting the order in which components of the meat are metabolized. The first indication of spoilage is generally the buttery or cheesy odour associated with production of diacetyl (2,3- butanedione), acetoin (3-hydroxy-2-butanone), 3-methyl-butanol and 2-methylpropanol. These compounds are produced from glucose by members of the Enterobacteriaceae, lactic acid bacteria and *Brochothrix* *thermosphacta*. Pseudomonads then begin to increase in importance and the meat develops a sweet or fruity odour. This is due to production of a range of esters by Pseudomonas and Moraxella species degrading glucose and amino acids and by esterification of acids and alcohols produced during the first phase of spoilage. Ester production is particularly associated with *Pseudomonas fragi* which can produce ethyl esters of acetic, butanoic and hexanoic acids from glucose, but other pseudomonads and Moraxella species are also capable of producing esters when grown on minced beef. As the glucose becomes exhausted, the meat develops a putrid odour when Pseudomonas species and some *Acinetobacter* and *Moraxella* species turn their entire attention to the amino acid pool, producing volatile sulfur compounds such as methane thiol, dimethyl sulfide and dimethyl disulfide. In the later stages of spoilage an increase in the meat pH is seen as ammonia and a number of amines are elaborated. Some of these have names highly evocative of decay and corruption such as putrescine and cadaverine but in fact do not contribute to off odour. When microbial numbers reach levels of around 10^8 cfu cm^{-2}, a further indication of spoilage becomes apparent in the form of a visible surface slime on the meat. Vacuum and modified-atmosphere packing of meat changes the meat microflora and consequently the time-course and character of spoilage. In vacuum packs the accumulation of CO_2 and the absence of oxygen restrict the growth of pseudomonads giving rise to a microflora dominated by Gram-positives, particularly lactic acid bacteria of the genera *Lactobacillus, Carnobacterium* and *Leuconostoc.* Spoilage of vacuum packed meat is characterized by the development of sour acid odours which are far less objectionable than the odour associated with aerobically stored meat. The micro-organisms reach their maximum population of around 10^7 cfu cm^{-2} after about a week's storage but the souring develops only slowly thereafter. Organic acids may contribute to this odour, although the levels produced are generally well below the levels of endogenous lactate already present. Some work has suggested that methane thiol and dimethyl sulfide may contribute to the sour odour. The extension of shelf-life produced by vacuum packing is not seen with high pH (4-6) meat. In this situation Shewanella putrefaciens, which cannot grow in meat at normal pH, and psychrotrophic Enterobacteriaceae can grow and these produce high levels of hydrogen.

Spoilage of fruits

Despite the high water activity of most fruits, the low pH leads to their spoilage being dominated by fungi, both yeasts and moulds but especially the latter. The degree of specificity shown by many species of moulds, active in the spoilage of harvested fruits in the market place or the domestic fruit bowl, reflects their possible role as pathogens or endophytes of the plant before harvest. Thus *Penicillium italicum* and *P. digitatum* show considerable specificity for citrus fruits, being the blue mould and green mould respectively of oranges, lemons and other citrus fruits. *Penicillium expansum* causes a soft rot of apples and, although the rot itself is typically soft and pale brown, the emergence of a ring of tightly packed conidiophores bearing enormous numbers of blue conidiospores, has led to this species being referred to as the blue mould of apples. This particular species has a special significance because of its ability to produce the mycotoxin patulin which has been detected as a contaminant in unfermented apple juices but not in cider.

Spoilage of Vegetables

The higher pH values of the tissues of many vegetables makes them more susceptible to bacterial invasion than fruits although there are also a number of important spoilage fungi of stored vegetables. The bacteria involved are usually pectinolytic species of the Gram-negative genera *Pectobacterium, Pseudomonas and Xanthomonas*, although pectinolytic

strains of Clostridium can also be important in the spoilage of potatoes under some circumstances, and the non-sporing Gram-positive organism *Corynebacterium sepedonicum* causes a ring rot of potatoes. Not all pathogens are necessarily transmitted to vegetables by direct or indirect faecal contamination. Organisms such as *Clostridium botulinum* have a natural reservoir in the soil and any products contaminated with soil can be assumed to be contaminated with spores of this organism, possibly in very low numbers. This would not normally present a problem unless processing or storage conditions were sufficiently selective to allow subsequent spore germination, growth and production of toxin. In the

past, this has been seen mainly as a problem associated with under processed canned vegetables, but now it must be taken into consideration in the context of sealed, vacuum or modified-atmosphere packs of prepared salads. Those salads containing partly cooked ingredients, where spores may have been activated and potential competitors reduced in numbers could pose particular problems.

Spoilage of Dairy products

When raw milk is left standing for a while, it turns "sour". This is the result of fermentation, where lactic acid bacteria ferment the lactose in the milk into lactic acid. Prolonged fermentation may render the milk unpleasant to consume. This fermentation process is exploited by the introduction of bacterial cultures (e.g. *Lactobacilli sp., Streptococcus sp., Leuconostoc sp.*, etc.) to produce a variety of fermented milk products. The reduced pH from lactic acid accumulation denatures proteins and causes the milk to undergo a variety of different transformations in appearance and texture, ranging from an aggregate to smooth consistency. Some of these products include sour cream, yogurt, cheese, buttermilk, viili, kefir, and kumis. Pasteurization of cow's milk initially destroys any potential pathogens and increases the shelf life, but eventually results in spoilage that makes it unsuitable for consumption. This causes it to assume an un pleasant odor, and the milk is deemed non-consumable due to unpleasant taste and an increased risk of food poisoning. In raw milk, the presence of lactic acid-producing bacteria, under suitable conditions, ferments the lactose present to lactic acid. The increasing acidity in turn prevents the growth of other organisms, or slows their growth significantly. During pasteurization, however, these lactic acid bacteria are mostly destroyed.

In order to prevent spoilage, milk can be kept refrigerated and stored between 1 and 4 degrees Celsius in bulk tanks. Most milk is pasteurized by heating briefly and then refrigerated to allow transport from factory farms to local markets. The spoilage of milk can be forestalled by using ultra-high temperature (UHT) treatment. Milk so treated can be stored unrefrigerated for several months until opened but has a characteristic "cooked" taste. Condensed milk, made by removing most of the water, can be stored in cans for many years, unrefrigerated, as can evaporated milk. The most durable form of milk is powdered milk, which is produced from milk by removing almost all water. The moisture content is usually less than 5% in both drum- and spray-dried powdered milk.

Spoilage of eggs

Certain spoilage organisms (e.g., *Alcaligenes, Proteus, Pseudomonas,* and some molds) may produce green, pink, black, colourless, and other rots in eggs after long periods of storage. However, since eggs move through market channels rapidly, the modern consumer seldom encounters spoiled eggs.

Soft drinks rarely present health risks

• Ingredients could be contaminated

• Fresh fruit juices can become contaminated with pathogens

• Heat process destroys them

• Only usually a problem in fresh pressed products (no thermal process)

• Contamination of fallen fruit by under grazing animals

• Any contamination in a heat-processed product is usually due to post-process contamination

There are a wide range of yeasts associated with spoilage of soft drinks

Three yeast genera that cause often spoilage in soft drinks are:

• *Saccharomyces*

• *Zygosaccharomyces*

• *Dekkera*

Many moulds associated with spoilage of soft drinks

• Spoilage in soft drinks commonly caused by:

• *Aspergillus*

• *Penicillium*

• *Byssochlamys*

- *Fusarium*
- *Talaromyces*
- *Paecilomyces*
- *Eupenicillium*
- *Neosartorya*

FOOD PRESERVATION THROUGH CHEMICALS

CHEMICAL PRESERVATIVES

The addition of chemicals to food is not a recent innovation but has been practised throughout recorded history. Doubtless too, there has also always been a certain level of misuse but this must have gone largely undetected until modern analytical techniques became available. When chemical analysis and microscopy were first applied to foods in the early 19th century, they revealed the appalling extent of food adulteration then current. Pioneering work had been done by the 18th century chemist Jackson, but publication of the book 'A Treatise on Adulterations of Food, and Culinary Poisons' by Frederick Accum in 1820 marks a watershed. Accum exposed a horrifying range of abuses such as the sale of sulfuric acid as vinegar, the use of copper salts to colour pickles, the use of alum to whiten bread, addition of acorns to coffee, blackthorn leaves to tea, cyanide to give wines a nutty flavour and red lead to colour Gloucester cheese.

Organic Acids and Esters

Benzoic acid occurs naturally in cherry bark, cranberries, greengage plums, tea and anise but is prepared synthetically for food use. Its antimicrobial activity is principally in the undissociated form and since it is a relatively strong acid (pKa 4.19) it is effective only in acid foods. As a consequence, its practical use is to inhibit the growth of spoilage yeasts and moulds. Activity against bacteria has been reported but they show greater variability in their sensitivity. Inhibition by benzoic acid appears multifactorial. The ability of the dissociated molecule to interfere with membrane energetics and function appears to be of prime importance since growth inhibition has been shown to parallel closely the inhibition of amino acid uptake in whole cells and membrane vesicles. Some inhibition may also result from benzoic acid once it is inside the cell as a number of key enzyme activities have also been shown to be adversely affected.

Parabens (para-hydroxybenzoic acid esters) differ from the other organic acids described here in the respect that they are phenols rather than carboxylic acids. Sorbic acid is an unsaturated fatty acid, 2,4-hexadienoic acid, found naturally in the berries of the mountain ash. It has a pKa of 4.8 and shows the same pH dependency of activity as other organic acids. It is active against yeasts, moulds and catalase-positive bacteria but, interestingly, is less active against catalase-negative bacteria. This has led to its use as a selective agent in media for clostridia and lactic acid bacteria and as a fungal inhibitor in lactic fermentations. Propionic acid (pKa 4.9) occurs in a number of plants and is also produced by the activity of propionic bacteria in certain cheeses. It is used as a mould inhibitor in cheese and baked products where it also inhibits rope-forming bacilli.

Salts

Nitrite

The antibacterial action of nitrite was first described in the 1920s though it had long been employed unwittingly in the production of cured meats where it is also responsible for their characteristic colour and flavour. In early curing processes nitrite was produced by the bacterial reduction of nitrate present as an impurity in the crude salt used, but now nitrate, or more commonly nitrite itself, is added as the sodium or potassium salt. Nitrite is inhibitory to a range of bacteria. Early workers showed that a level of 200mg kg^{-1} at pH 6.0 was sufficient to inhibit strains of *Escherichia, Flavobacterium, Micrococcus, Pseudomonas* and others, although *Salmonella* and *Lactobacillus* species were more resistant. Of most practical importance though is the ability of nitrite to inhibit spore forming bacteria such as Clostridium botulinum which will survive the heat process applied to many cured meats. To achieve this commercially, initial levels of nitrite greater than 100 mg kg^{-1} are used. The mechanism of its action is poorly understood partly due to the complexity of the interaction of several factors such as pH, salt content, presence of nitrate or nitrite and the heat process applied to the cured meat.

Preservative	[a]ADI (mg kg^{-1} body wt).	Typical usage and levels	(mg kg^{-1})
E200 Sorbic acid E201 Sodium salt E202 Potassium salt E203 Calcium salt	25	Salad dressing bakery products fruit desserts	<2000
E210 Benzoic acid E211 Sodium salt E212 Potassium salt E213 Calcium salt	5	Cider, soft drinks, fruit products, bottled sauces	<3000
E260 Acetic acid	No limit	Pickles, sauces chutneys	up to % levels (1% = 10 000 mg kg^{-1})
E270 Lactic acid	No limit	Fermented meats dairy and vegetable products. Sauces and dressings. Drinks.	up to % levels (1% = 10 000 mg kg^{-1})
E280 Propionic acid E281 Sodium salt E282 Calcium salt E283 Potassium salt	10	Bakery goods Cheese spread	1000–5000
Parabens	10		
E214 *p*-Hydroxybenzoic acid ethyl ester E215 Sodium salt		Bakery goods, pickles, fruit products, sauces	<2000
E216 *p*-Hydroxybenzoic acid *n*-propyl ester E217 Sodium salt		Bakery goods, pickles, fruit products, sauces	<2000
E218 *p*-Hydroxybenzoic acid methyl ester E219 Sodium salt		Bakery goods, pickles, fruit products, sauces	<2000

Salt and Sugar

The method of sugar and salt preservation of food is basically done in the same way, chemically speaking, in that water withdrawal is the main result, although the way this comes about is different. The type of food preserved is usually of a different variety, also. Sugar is the best preservative for fruits, along with that of drying and freezing.

Salt works best with meat and fish and a few vegetable varieties. The famous Virginia ham is one example of how meat can be cured' and there's kraut, a vegetable, cabbage, that been preserved in salt for centuries.

Preservatives protect food from decay and fermentation and from four main type of food spoilers, enzymes, molds, yeast, and bacteria (a) enzymes are produced by living cells; (b) molds are formed when moisture is allowed to collect on top of jellies, jams; (c) yeast are single-celled fungus that reproduces itself by budding; (d) bacteria are disease producing microscopic animals.

Salt has been used in preserving meat for centuries. It works by incorporating its crystals among the tissue cells of meat and dries up the water, making it impossible for bacteria to grow while also protecting from yeast and mold which need water to grow.

Sugar prohibits growth of bacteria by the process of diffusion. This method of preservation works by drawing the water out of the fruit or other food by high levels of sugar content. The water removed is in proportion to the level of sugar added.

As already mentioned, salt and sugar works to preserve food in much the same way in that water is removed, but there are differences. Sugar does away with the water and salt only binds the water in its method. A salt cured ham, as an example, can be reconstituted.

Some types of molds that grow on foods are dangerous. There are documentations of epidemics of frenzy caused by notorious examples of hallucinogenic delusions caused by people eating rye bread contaminated with the fungus ergot.

Preservation works because all living organisms, helpful to humanity or not helpful to humanity, must have certain conditions to live. They either thrive with excess sweetness, or they are overcome by it. The neutral point of acidity and sweetness is the number seven. All below this measures the level of acidity, (6.99 being minutely acid) and all above the number seven (ph.7) measuring the sweetness level.

The dreaded organism, clostridium botulism, is the culprit all food preservers work to rid. On the news frequently we hear of outbreaks of food poisoning where several persons have either died or been ill from eating contaminated food.

And again, some commercial food from time to time is removed from shelves when it has been discovered that some mistake in handling has resulted in contamination, or the possibility of contamination. Thus salt and sugar plays a much more important role in our diet than simply being a pleasure sensation for our taste buds. Often times a little sugar and little salt go a long way in keeping ourselves healthy, especially when a few wise words are spoken, or are thought, or read. When in doubt, throw it out.

Ethylene oxide

Ethylene oxide widely used fumigant for decontaminating insects and microorganisms in dry food ingredients, particularly spices and vegetables seasoning was bannnned by the European Union starting From 1 January 19991. Other advanced countries such as USA and Canada are under a strong pressure to ban the use of ethylene oxide for health and occupational safety reasons.

Antibiotics

Natamycin formerly known as pimaricin, is a polyene macrolide antibiotic produced by the bacterium *Streptomyces natalensis*. It is a very effective antifungal agent as it binds irreversibly to the fungal sterol, ergosterol, disrupting the fungal cell membrane leading to a loss of solutes from the cytoplasm and cell lysis. Natamycin is poorly soluble in water and is used as an aqueous suspension for the surface treatment of cheeses and sausages to control yeast and mould growth. It has some advantages over sorbate in this respect since it remains localised on the surface of the product, is not dependent on a low pH for its activity and has no effect on bacteria important in the fermentation and maturation of such products.

<u>CHEMICAL PRESERVATIVES</u>

Food additives / preservatives:

"A substance or a mixture of substance which are specifically added to prevent deterioration or decomposition of a food"

Deterioration may be caused by:

(a) Microorganisms

(b) Food enzymes

(c) Chemical reactions

Chemical preservatives are used mainly to inhibit the growth and activity of microorganisms by:

(a) Interfering with their cell membranes

(b) Their enzymes activity

(c) Their genetic mechanisms

They can also be used as:

(a) Antioxidants to prevent oxidation of unsaturated fats.

(b) Neutralizers of ‘acidity.

(c) Stabilizers to prevent physical changes.

(d) Firming agents.

(e) Coating to keep out microorganisms.

(f) Prevent loss of water.

An ideal chemical preservative should have:

(a) A wide range of antimicrobial activity

(b) Non toxic to human beings and animals

(c) Economical

(d) No effect on the flavour, taste or aroma of the original food

(e) Should not be inactivated by the food

(f) Should not encourage the development of resistant strains

(g) Should rather kill than inhibit microorganisms

(a) Propionates

Used in bakery, cheese food & spreads

- Sodium or calcium propionates used in the prevention of mold growth and rope development

(b) Benzoates

- Used in jam, jellies, margarine, carbonated drinks, fruits etc.

(c) Sorbates

- Sorbic acids and sorbate salts are used as a direct antimicrobial additive in foods as a spray, dip or coating on packaging materials.

- Used in cheese, dried fruit, bakery etc.

(d) Acetates

- Dehydroacetic acid has been used to impregnate wrappers for disease to inhibit mold growth.

- Acetic acid (vinegar) is used in may**onnaise, ketchup, sausages etc.**

(e) Nitrites and nitrates

- Used in meats because nitrites can give a stable red color.

- The use of nitrates is being restricted because it can react to other substance e.g. amines and form nitrosomines which is carcinogenic.

- Nitrites are shown to have an inhibitory effect toward C. *botulinum.*

(f) Sulfur dioxide and sulfites

- Used in the wine industry to sanitize equipment and to reduce normal flora of the grape must.

- In aqueous solution, they form sulfurous acid, the active antimicrobial compound.

(g) Ethylene and propylene oxide

- Powerful sterilants which kills almost all microorganisms
- Useful for fumigation, packaging materials, dried fruits, eggs, cereals and spices.

(h) Alcohol

- Ethanol can be germicidal effectively at 70 - 95% concentration.

- Flavoring extracts e.g. vanilla & lemon are preserved by alcohol.

- Methanol is poisonous and should not be added to foods.

(i) Formaldehyde

- Not permitted to be added to food except, as a minor constituted of wood smoke.

- Very effective against molds, bacterial and viruses.

(j) Others

- Halogen (chlorine) are added to water for sanitation

• Iodine - impregnated wrappers have been employed to lengthen the keeping time of fruits.

OTHER PRESERVATIVE METHODS

(a) Filtration

• Although fruit juices can be preserved by chemical preservatives, now we can get product with no preservatives added.

• Fruit juices are subjected to filters with steam sterilize methods for 10-20 minutes. The sterile products are filled aseptically in sterile bottles or cartons.

(b) Radiation

• Gamma ray is the cheapest form of radiation for food preservation.

• X-rays essentially has the same character like gamma rays but produced differently.

• Factors affecting radiation:

(i) Types and species of microbes

-Spores are generally radio resistant

(ii) Number of microbes

-The more cell present, the less effective a given dose of radiation

(iii) Composition of medium

-Cells in protein medium are more resistant

-Protein exerts protective effect against radiation

(iv) Presence or absence of oxygen

-Resistance is reportedly increase when oxygen is absent

(v) Physical state of food

-Dried cells are more resistant than moist cells

(vi) Age of cells

-Cells in lag phase are more resistant than in other phase

(c) Antibiotics

• Antibiotics such as aureomycin, terramysin and chloromycetin were found to be effective in lengthen the storage time of raw food especially meats, fish and poultry at chilling temperature.

• Niasin has been used to suppress anaerobes in cheese and cheese products.

• Natamycin has been tested in orange juice, fresh fruits, sausage and cheese.

• Some problems in the use of antibiotics:

(a) Effect of antibiotic on microorganisms varies with the species.

(b) Organisms ' may be adapted to increasing concentrations of an antibiotic so that resistant strains finally develop

(c) Other organism which is not a significant food spoiler but has acquired resistant will eventually important in food spoilage

(d) Effect of antibiotic to consumer.

Antioxidants

The action of oxygen in the air is the chief cause of the destruction of the fats in food. Oxidation produces a complex mixture of volatile aldehydes, ketones and acids that cause the rancid odor/taste.

Antioxidants can be:

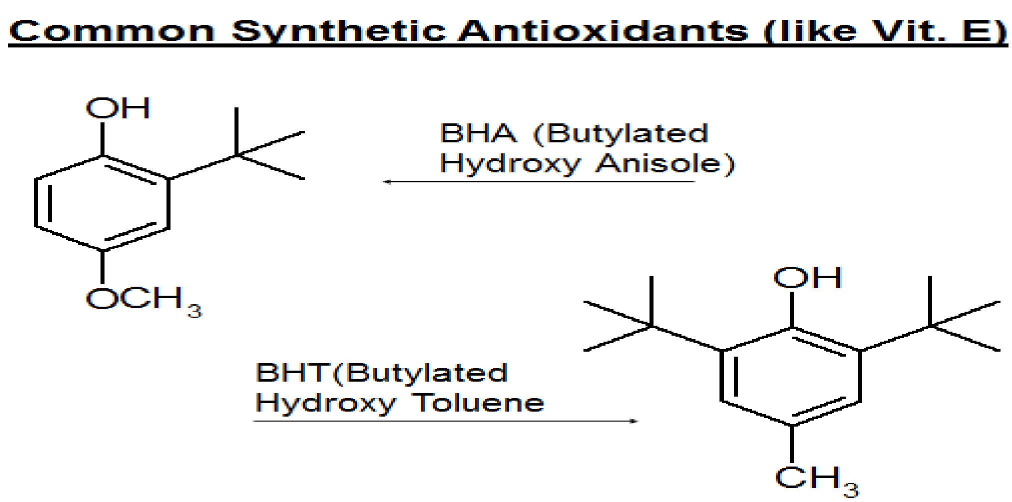
Organic – Ascorbates

Butylated hydroxyanisole (BHA)

Butylated hydroxytoluence (BHT)

Lecithin (a 'natural' phospholipid)

Inorganic - Sulfur Dioxide and Sulfites



Other Methods of Food Preservation

Radiation

As far as food microbiology is concerned, only three areas of the e.m. spectrum concern us; microwaves, the UV region and gamma rays. We will now consider each of these in turn.

Microwave Radiation

Microwaves have been slow to find industrial applications in food processing, although they are used in a number of areas. Microwaves have been used to defrost frozen blocks of meat prior to their processing into products such as burgers and pies thus reducing wear and tear on machinery. There has also been a limited application of microwaves in the blanching of fruits and vegetables and in the pasteurization of soft bakery goods and moist (30% H_2O) pasta to destroy yeasts and moulds. In Japan, microwaves have been used to pasteurize high-acid foods, such as fruits in syrup, intended for distribution at ambient temperature. These are packed before processing and have an indefinite microbiological shelf-life because of the heat process and their low pH. However, the modest oxygen barrier properties of the pack has meant that their biochemical shelf-life is limited to a few months.

UV Radiation

Determination of UV D values is not usually a straightforward affair since the incident radiation can be absorbed by other medium components and has very low penetration. Passage through 5 cm of clear water will reduce the intensity of UV radiation by two-thirds. This effect increases with the concentration of solutes and suspended material so that in milk 90% of the incident energy will be absorbed by a layer only 0.1mm thick. This low penetrability limits application of UV radiation in the food industry to disinfection of air and surfaces. Low-pressure mercury vapour discharge lamps are used: 80% of their UV emission is at a wavelength of 254nm which has 85% of the biological activity of 260 nm. Wavelengths below 200nm are screened out by surrounding the lamp with an absorbent glass since these wavelengths are absorbed by oxygen in the air producing ozone which is harmful. The output of these lamps falls off over time and they need to be monitored regularly.

Air disinfection is only useful when the organisms suspended in air can make a significant contribution to the product's micro flora and are likely to harm the product; for example, in the control of mould spores in bakeries. UV lamps have also been mounted in the head space of tanks storing concentrates, the stability of which depends on their low a_w.

Fluctuations in temperature can cause condensation to form inside the tank. If this contacts the product, then areas of locally high aw can form where previously dormant organisms can grow, spoiling the product. Process water can be disinfected by UV; this avoids the risk of tainting sometimes associated with chlorination, although the treated water will not have the residual antimicrobial properties of chlorinated water. UV radiation is commonly used in the depuration of shellfish to disinfect the water recirculated through the depuration tanks. Chlorination would not be suitable in this situation since residual chlorine would cause the shellfish to stop feeding thus stopping the depuration process. Surfaces can be disinfected by UV, although protection of microorganisms by organic material such as fat can reduce its efficacy. Food containers are sometimes treated in this way and some meat chill store rooms have UV lamps to retard surface growth. UV can however induce spoilage of products containing unsaturated fatty acids where it accelerates the development of rancidity. Process workers must also be protected from UV since the wavelengths used can cause burning of the skin and eye disorders.

Ionizing Radiation

Ionizing radiation can affect micro-organisms directly by interacting with key molecules within the microbial cell, or indirectly through the inhibitory effects of free radicals produced by the radiolysis of water. These indirect effects play the more important role since in the absence of water, doses 2–3 times higher are required to obtain the same lethality. Removal of oxygen also increases microbial resistance 2–4 fold and it is thought that this may be due to the ability of oxygen to participate in free radical reactions and prevent the repair of radiation induced lesions. As with UV irradiation, the main site of damage in cells is the chromosome. Hydroxyl radicals cause single- and double-strand breaks in the DNA molecule as a result of hydrogen abstraction from deoxyribose followed by b-elimination of phosphate which cleaves the molecule. They can also hydroxylate purine and pyrimidine bases.

HIGH-PRESSURE PROCESSING–PASCALIZATION

Microbiologists have continued to study the effect of pressure on micro-organisms, although this work has centred on organisms such as those growing in the sea at great depths and pressures. Interest in the application of high pressures in food processing, sometimes called pascalization, lapsed until the 1980s when progress in industrial ceramic processing led to the development of pressure equipment capable of processing food on a commercial scale and a resurgence of interest, particularly in Japan.

High hydrostatic pressure acts primarily on non-covalent linkages, such as ionic bonds, hydrogen bonds and hydrophobic interactions, and it promotes reactions in which there is an overall decrease in volume. It can have profound effects on proteins, where such interactions are critical to structure and function, although the effect is variable and depends on individual protein structure. Some proteins such as those of egg, meat and soya form gels and this has been employed to good effect in Japan where high pressure has been used to induce the gelation of fish proteins in the product surimi. Other proteins are relatively unaffected and this can cause problems when they have enzymic activity which limits product shelf-life. Pectin esterase in orange juice, for instance, must be inactivated to stabilize the desired product cloudiness. Nonprotein macromolecules can also be affected by high pressures so that pascalized starch products often taste sweeter due to conformational changes in the starch which allow salivary amylase greater access. Adverse effects on protein structure and activity obviously contribute to the antimicrobial effect of high pressures, although the cell membrane also appears to be an important target. Membrane lipid bilayers have been shown to compress under pressure and this alters their permeability. As a general rule vegetative bacteria and fungi can be reduced by at least one log cycle by 400MPa applied for 5 min.

Bacterial endospores are more resistant to hydrostatic pressure, tolerating pressures as high as 1200 MPa. Their susceptibility can be increased considerably by modest increases in temperature, when quite low pressures (100 MPa) can produce spore germination, a process in which the spores lose their resistance to heat and to elevated pressure.

High pressure processing is typically a batch process employing a pressure vessel, the pressure transmission fluid (usually water) and pumps to generate the pressure. Although the capital cost of equipment is quite high, hydrostatic processing has a number of appealing features for the food technologist. It acts instantly and uniformly throughout a food so that the processing time is not related to container size and there are none of the penetration problems associated with heat processing. With the exceptions noted above, adverse effects on the product are slight; nutritional quality, flavour, appearance and texture resemble the fresh material very closely. To the consumer it is a 'natural' process with none of the negative associations of processes such as irradiation or chemical preservatives.

LOW-TEMPERATURE STORAGE – CHILLING AND FREEZING

The rates of most chemical reactions are temperature dependent; as the temperature is lowered so the rate decreases. Since food spoilage is usually a result of chemical reactions mediated by microbial and endogenous enzymes, the useful life of many foods can be increased by storage at low temperatures**.**

Chill Storage

Chilled foods are those foods stored at temperatures near, but above their freezing point, typically 0–5 ºC. This commodity area has shown a massive increase in recent years as traditional chilled products such as fresh meat and fish and dairy products have been joined by a huge variety of new products including complete meals, prepared and delicatessen salads, dairy desserts and many others. Three main factors have contributed to this development:

(1) the food manufacturers' objective of increasing added value to their products;

(2) consumer demand for fresh foods and ease of preparation while at the same time requiring the convenience of only occasional shopping excursions; and

(3) the availability of an efficient cold chain – the organization and infrastructure which allows low temperatures to be maintained throughout the food chain from manufacture/harvest to consumption. Chill storage can change both the nature of spoilage and the rate at which it occurs. There may be qualitative changes in spoilage characteristics, as low temperatures exert a

selective effect preventing the growth of mesophiles and leading to a microflora dominated by psychrotrophs.

This can be seen in the case of raw milk which in the days of milk churns and roadside collection had a spoilage microflora comprised largely of mesophilic lactococci which would sour the milk

Freezing

Freezing is the most successful technique for long-term preservation of food since nutrient content is largely retained and the product resembles the fresh material more closely than in appetized foods. Foods begin to freeze somewhere in the range 0.5 to 3 ºC, the freezing point being lower than that of pure water due to the solutes present. As water is converted to ice during freezing, the concentration of solutes in the unfrozen water increases, decreasing its freezing point still further so that even at very low temperatures. The temperatures used in frozen storage are generally less than 18 ºC. At these temperatures no microbial growth is possible, although residual microbial or endogenous enzyme activity such as lipases can persist and eventually spoil a product. This is reduced in the case of fruits and vegetables by blanching before freezing to inactivate endogenous polyphenol oxidases which would otherwise cause the product to discolour during storage. Freezer burn is another non-microbiological quality defect that may arise in frozen foods, where surface discolouration occurs due to sublimation of water from the product and its transfer to colder surfaces in the freezer. This can be prevented by wrapping products in a water-impermeable material or by glazing with a layer of ice. Freezing and defrosting may make some foods more susceptible to microbiological attack due to destruction of antimicrobial barriers in the product and condensation, but defrosted foods do not spoil more rapidly than those that have not been frozen. Injunctions against refreezing defrosted products are motivated by the loss of textural and other qualities rather than any microbiological risk that is posed.

Drying

Solar drying, while perhaps easy and cheap, is subject to the vagaries of climate. Drying indoors over a fire was one way to avoid this problem and one which had the incidental effect of imparting a smoked flavour to the food as well as the preservative effect of chemical components of the smoke. Solar drying is still widely practised in hot climates for products such as fruits, fish, coffee and grain. The traditional technique of spreading the product out in the sun with occasional turning often gives only rudimentary or, sometimes, no protection from contamination by birds, rodents, insects and dust. Rapid drying is essential to halt incipient spoilage; this is usually achievable in hot dry climates, though in tropical countries with high humidity drying is usually slower so that products such as fish are often pre-salted to inhibit microbial growth during drying. There are a number of procedures for mechanical drying which are quicker, more reliable, albeit more expensive than solar drying. The drying regime must be as rapid as possible commensurate with a high quality product so factors such as reconstitution quality must also be taken into account. With the exception of freeze-drying where the product is frozen and moisture sublimed from the product under vacuum, these techniques employ high temperatures. During drying a proportion of the microbial population will be killed and sub-lethally injured to an extent which depends on the drying technique and the temperature regime used. It is however no substitute for bactericidal treatments such as pasteurization. Although the air temperature employed in a drier may be very high, the temperature experienced by the organisms in the wet product is reduced due to evaporative cooling. As drying proceeds and the product temperature increases, so too does the heat resistance of the organisms due to the low water content. This can be seen for example in the differences between spray dried milk and drum dried milk. In spray drying, the milk is pre-concentrated to about 40–45% solids before being sprayed into a stream of air heated to temperatures up to 260 ºC at the top of a tower. The droplets dry very rapidly and fall to the base of the tower where they are collected. In drum drying, the milk is spread on the surface of slowly rotating metal drums which are heated inside by steam to a temperature of about 150 ºC. The film dries as the drum rotates and is scraped off as a continuous sheet by a fixed blade close to the surface of the drum. Although it uses a lower temperature, drum drying gives greater lethality since the milk is not subject to the same degree of pre-concentration used with spray-dried milk and the product spends longer at high temperatures in a wet state.

Spray drying is however now widely used for milk drying because it produces a whiter product which is easier to reconstitute and has less of a cooked flavour. Milk is pasteurized before drying although there are opportunities for contamination during intervening stages. Most of the organisms which survive drying are thermoduric but Gram-negatives may survive and have on occasion been the cause of food poisoning outbreaks.

Package design and construction play a significant role in determining the shelf life of a food product. The right selection of packaging materials and technologies maintains product quality and freshness during distribution and storage. Materials that have traditionally been used in food packaging include glass, metals (aluminum, foils and laminates, tinplate, and tin-free steel), paper and paperboards, and plastics.

Food Packaging materials and their Properties

The principal roles of food packaging are to protect food products from outside influences and damage and to provide consumers with ingredient and nutritional information.Package design and construction play a significant role in determining the shelf life of a food product. The right selection of packaging materials and technologies maintains product quality and freshness during distribution and storage. Materials that have traditionally been used in food packaging include glass, metals (aluminum, foils and laminates, tinplate, and tin-free steel), paper and paperboards, and plastics**.**

Glass

Glass containers used in food packaging are often surface-coated to provide lubrication in the production line and eliminate scratching or surface abrasion and line jams. Glass coatings also increase and preserve the strength of the bottle to reduce breakage. Improved break resistance allows manufacturers to use thinner glass, which reduces weight and is better for disposal and transportation

Metal

Metal is the most versatile of all packaging forms. It offers a combination of excellent physical protection and barrier properties, formability and decorative potential, recyclability, and consumer acceptance. The 2 metals most predominantly used in packaging are aluminum and steel.

Aluminum

Commonly used to make cans, foil, and laminated paper or plastic packaging, aluminum is a lightweight, silvery white metal derived from bauxite ore, where it exists in combination with oxygen as alumina

Laminates and metallized films.

Lamination of packaging involves the binding of aluminum foil to paper or plastic film to improve barrier properties

Tinplate

Produced from low-carbon steel (that is, blackplate), tinplate is the result of coating both sides of blackplate with thin layers of tin. The coating is achieved by dipping sheets of steel in molten tin (hot-dipped tinplate) or by the electro-deposition of tin on the steel sheet (electrolytic tinplate). Although tin provides steel with some corrosion resistance, tinplate containers are often lacquered to provide an inert barrier between the metal and the food product

Plastics

Plastics are made by condensation polymerization (polycondensation) or addition polymerization (polyaddition) of monomer units.Multiple types of plastics are being used as materials for packaging food, including polyolefin, polyester, polyvinyl chloride, polyvinylidene chloride, polystyrene, polyamide, and ethylene vinyl alcohol. Although more than 30 types of plastics have been used as packaging materials (Lau and Wong 2000), polyolefins and polyesters are the most common

Polyolefins

Polyolefin is a collective term for polyethylene and polypropylene, the 2 most widely used plastics in food packaging, and other less popular olefin polymers. Polyethylene and polypropylene both possess a successful combination of properties, including flexibility, strength, lightness, stability, moisture and chemical resistance, and easy processability, and are well suited for recycling and reuse. The simplest and most inexpensive plastic made by addition polymerization of ethylene is polyethylene

Polyesters

Polyethylene terephthalate (PET or PETE), polycarbonate, and polyethylene naphthalate (PEN) are polyesters, which are condensation polymers formed from ester monomers that result from the reaction between carboxylic acid and alcohol. The most commonly used polyester in food packaging is PETE.

Polyvinyl chloride

Polyvinyl chloride (PVC), an addition polymer of vinyl chloride, is heavy, stiff, ductile, and a medium strong, amorphous, transparent material. It has excellent resistance to chemicals (acids and bases), grease, and oil; good flow characteristics; and stable electrical properties

Polyvinylidene chloride

Polyvinylidene chloride (PVdC) is an addition polymer of vinylidene chloride. It is heat sealable and serves as an excellent barrier to water vapor, gases, and fatty and oily products. Major applications include packaging of poultry, cured meats, cheese, snack foods, tea, coffee, and confectionary. It is also used in hot filling, retorting, low-temperature storage, and modified atmosphere packaging

Polystyrene

Polystyrene, an addition polymer of styrene, is clear, hard, and brittle with a relatively low melting point.

Ethylene vinyl alcohol

Ethylene vinyl alcohol (EVOH) is a copolymer of ethylene and vinyl alcohol. It is an excellent barrier to oil, fat, and oxygen.

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Paper and paperboard

The use of paper and paperboards for food packaging dates back to the 17th century with accelerated usage in the later part of the 19th century. Paper and paperboard are sheet materials made from an interlaced network of cellulose fibers derived from wood by using sulfate and sulfite. The fibers are then pulped and/or bleached and treated with chemicals such as slimicides and strengthening agents to produce the paper product. FDA regulates the additives used in paper and paperboard food packaging (21 CFR Part 176). Paper and paperboards are commonly used in corrugated boxes, milk cartons, folding cartons, bags and sacks, and wrapping paper. Tissue paper, paper plates, and cups are other examples of paper and paperboard product

Kraft paper—Produced by a sulfate treatment process,. The natural kraft is the strongest of all paper and is commonly used for bags and wrapping. It is also used to package flour, sugar, and dried fruits and vegetables.

Sulfite paper—Lighter and weaker than kraft paper, sulfite paper is glazed to improve its appearance and to increase its wet strength and oil resistance.. It is used to make small bags or wrappers for packaging biscuits and confectionary.

Parchment paper—Parchment paper is made from acid-treated pulp (passed through a sulfuric acid bath) and is used to package fats such as butter and lard

Paperboard

Paperboard is thicker than paper with a higher weight per unit area and often made in multiple layers. It is commonly used to make containers for shipping—such as boxes, cartons, and trays—and seldom used for direct food contact

Possible Questions

Essay type questions

1) What is food spoilage? Give a detailed account on spoilage of fruits and vegetables.
2) Describe in detail about food preservation through chemicals.
3) What is spoilage? Give an account on spoilage of dairy products.
4) Write detailed notes on preservation methods: i) Antibiotics ii) Antioxidants.
5) Describe in detail about spoilage of meat and vegetables.
6) What is food spoilage? Explain about radiation mediated food preservation.
7) Describe about the various methods of food preservation.
8) Explain in detail about spoilage of fruits and vegetable.

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UNIT-V

SYLLABUS

Food Adulteration and Food Safety: Adulteration, Responsibility for food safety, Food Additives - Definition, Types and Functional characteristics. Natural Colors -Types, Applications, Advantages of natural colors. Sweeteners - Types and Applications. Adulteration Detection systems and sensors. Food safety - HACCP System to food protection, FSSAI guidelines.

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FOOD ADULTERATION

Food Adulteration refers to the process by which the quality or the nature of a given food is reduced through addition of adulterants or removal of vital substance. Food adulterants refer to the foreign and usually inferior chemical substance present in food that cause harm or is unwanted in the food.

FOOD ADULTERATION

Food safety is a scientific discipline describing handling, preparation, and storage of food in ways that prevent foodborne illness. This includes a number of routines that should be followed to avoid potentially severe health hazards. The tracks within this line of thought are safety between industry and the market and then between the market and the consumer. In considering industry to market practices, food safety considerations include the origins of food including the practices relating to food labelling, food hygiene, food additives and pesticide residues, as well as policies on biotechnology and food and guidelines for the management of governmental import and export inspection and certification systems for foods. In considering market to consumer practices, the usual thought is that food ought to be safe in the market and the concern is safe delivery and preparation of the food for the consumer.

Food can transmit disease from person to person as well as serve as a growth medium for bacteria that can cause food poisoning. In developed countries there are intricate standards for food preparation, whereas in lesser developed countries the main issue is simply the availability of adequate safe water, which is usually a critical item. In theory, food poisoning is 100% preventable. The five key principles of food hygiene, according to WHO, are:

1. Prevent contaminating food with pathogens spreading from people, pets, and pests.
2. Separate raw and cooked foods to prevent contaminating the cooked foods.
3. Cook foods for the appropriate length of time and at the appropriate temperature to kill pathogens.

4. Store food at the proper temperature.

5. Do use safe water and cooked materials.

RESPONSIBILITY FOR FOOD SAFETY

1) Personal Hygiene

- **Hand washing**: frequent and adequate hand washing with soap, running warm water, and single use paper towels.
- **Illness:** not handling food when you are ill with 1) diarrhea, 2) vomiting, 3) sore throat with a fever, 4) are jaundiced (yellowing of eyes, skin, scalp), and 5) have infected cuts, wounds, or sores.
- **Clean clothes:** clean apron worn to cover street clothes, or freshly laundered uniforms, and a clean hat or hairnet, with hair effectively restrained.

2) Controlling Time and Temperature for Safety

Proper temperature control for Cold ≤ 41°F (5°C) or Hot ≥ 135°F (57°C) for TCS foods: Sliced or cut Melon, Baked Potatoes, Cut Leafy Greens (includes cabbage), Sliced or cut Tomatoes, Cooked Rice, Beans, and Vegetables, Untreated Garlic & Oil mixtures, Raw Sprouts and Sprout Seeds, Milk/Milk Products/Cheese and Beef.

- **Proper time control:** 4 hour limit, in total flow of food-from purchasing and receiving to service.

3) Cross-Contamination

- Proper storing of refrigerated food, according to the cooking temperature. Poultry-165°F (74°C) on bottom shelf – top shelf-ready to eat food, such as:
- Changing cutting boards and knives, when preparing raw meat then vegetables.
- Separate tools used when handling/cooking raw meat product, and final cooked product, such as hamburger patties.

4) Cleaning and Sanitizing

- Cleaning = removing dirt or debris – use soap and water
- Sanitizing = reducing microorganisms that can make people ill – use Quat or Regular Chlorine Bleach

FOOD ADDITIVES

DEFINITION

Food additives are substances added to food to preserve flavor or enhance its taste and appearance. Some additives have been used for centuries; for example, preserving food by pickling (with vinegar), salting, as with bacon, preserving sweets or using sulfur dioxide as with wines. With the advent of processed foods in the second half of the 20th century, many more additives have been introduced, of both natural and artificial origin.

TYPES AND FUNCTIONAL CHARACTERISTICS

Food additives can be divided into several groups, although there is some overlap between them.

Acids

Food acids are added to make flavors "sharper", and also act as preservatives and antioxidants. Common food acids include vinegar, citric acid, tartaric acid, malic acid, fumaric acid, and lactic acid.

Acidity regulators

Acidity regulators are used to change or otherwise control the acidity and alkalinity of foods.

Anticaking agents

Anticaking agents keep powders such as milk powder from caking or sticking.

Antifoaming agents

Antifoaming agents reduce or prevent foaming in foods.

Antioxidants

Antioxidants such as vitamin C act as preservatives by inhibiting the effects of oxygen on food, and can be beneficial to health.

Bulking agents

Bulking agents such as starch are additives that increase the bulk of a food without affecting its taste.

Food colouring

Colourings are added to food to replace colors lost during preparation, or to make food look more attractive.

Color retention agents

In contrast to colorings, color retention agents are used to preserve a food's existing color.

Emulsifiers

Emulsifiers allow water and oils to remain mixed together in an emulsion, as in mayonnaise, ice cream, and homogenized milk.

Flavours

Flavours are additives that give food a particular taste or smell, and may be derived from natural ingredients or created artificially.

Flavor enhancers

Flavor enhancers enhance a food's existing flavors. They may be extracted from natural sources (through distillation, solvent extraction, maceration, among other methods) or created artificially.

Flour treatment agents

Flour treatment agents are added to flour to improve its color or its use in baking.

Glazing agents

Glazing agents provide a shiny appearance or protective coating to foods.

Humectants

Humectants prevent foods from drying out.

Tracer gas

Tracer gas allows for package integrity testing to prevent foods from being exposed to atmosphere, thus guaranteeing shelf life.

Preservatives

Preservatives prevent or inhibit spoilage of food due to fungi, bacteria and other microorganisms.

Stabilizers

Stabilizers, thickeners and gelling agents, like agar or pectin (used in jam for example) give foods a firmer texture. While they are not true emulsifiers, they help to stabilize emulsions.

Sweeteners

Sweeteners are added to foods for flavouring. Sweeteners other than sugar are added to keep the food energy (calories) low, or because they have beneficial effects for diabetes mellitus and tooth decay and diarrhoea.

Thickeners

Thickening agents are substances which, when added to the mixture, increase its viscosity without substantially modifying its other properties.

FUNCTIONS OF FOOD ADDITIVES

Hundreds of chemical additives are incorporated into foods directly or migrate into foods from the environment or packaging materials. A food additive can be sometimes defined as a substance whose intended use will lead to its incorporation into the food or will affect the characteristics of the foods. These additives generally provide some types of benefits to the food producer, processor or consumer. For the consumer, additives can improve organoleptic qualities of foods, improve the nutritive value, or ease the preparation of ingredients and meals. Typical additive benefits to the food producer or processor include improving product quality, safety and variety.

Additive may found in varying quantities in foods, perform different functions in foods and ingredients, and function synergistically with other additives. Their functions can usually be classified as one of the following:

- To maintaining or improve nutritional quality
- To maintain or improve product safety or quality
- To aid in processing or preparations
- To enhance sensory characteristics

Additives that affect nutritional quality are primarily vitamins and minerals. In some foods, these may be added to enrich the food or replace nutrients that may have been lost during processing. In other foods, vitamins and minerals may be added for fortification in order to supplement nutrients that may often be lacking in human diets. Preservatives or antimicrobial substances are used to prevent bacterial and fungal growth in foods. These additives can delay spoilage or extend the shelf life of the finished product. Antioxidants are additives that also can extend the shelf life of foods by delaying rancidity or lipid oxidation. Additives that maintain product quality may also ensure food product safety for the consumer. For, example, acids that may be added to prevent the growth of microorganisms.

The cause of food spoilage may also prevent the growth of microorganisms that can cause food borne illness.

Additives that are used as processing or preparation aids, usually affect the texture of ingredients and finished foods. Some of these are classified as emulsifiers, stabilizers, thickeners, leavening agents, humectants and anti-caking agents. Chemical in this group of food additives are also used to adjust the homogeneity, stability and volume of foods. The fourth major, function of food additives is to enhance the flavor or color of foods to make them more appealing to the consumer. Flavoring chemicals may be used to magnify the original taste or aroma of food ingredients or to restore flavors lost during processing. Natural and artificial coloring substances are added to increase the visual appeal of foods, to distinguish flavors or foods, to increase the intensity of naturally occurring color or to restore color lost during processing.

Food Coloring

Food coloring is added to foods to replace lost colors during preparation, or to make foods look more attractive. In the USA there are seven artificial colorings that are permitted in foods. They include FD&C Blue No. 1- Brilliant Blue FCF, FD & C Blue No. 2- Indigotine, FD & C Green No. 3- Fast Green, FD & C Red No. 40- Allura Red AC, FD & C Red No. 3- Erythrosine, FD & C Yellow No. 5- Tartrazine, and FD&C Yellow No.6- Sunset Yellow.

Brilliant Blue FCF- It's often used in ice cream, tinned processed peas, dairy products, sweets, and drinks. It has the appearance of a reddish-blue powder.

Indigotine- It has a distinctive blue color. It's used as a food colorant, but it's mainly used to dye blue jeans.

Green No.3- It's a green triarylmethan food dye. It can be used for tinned green peas and other vegetables, jellies, sauces, fish, desserts, and dry bakery mixes.

Allura Red AC- It's a red azo dye. It has the appearance of a dark red powder. It was originally introduced in the U.S. as a replacement for the use of amaranth as a food coloring.

Erythrosine- It's a cherry-pink synthetic fluorone food coloring. It's commonly used in sweets such as candies and popsicles. It's more widely used in cake-decorating gels.

Tartrazine- It's a synthetic lemon yellow azo dye. Foods that commonly have tartrazine confectionery, cotton candy, soft drinks, energy drinks, instant puddings, flavored corn chips, cereals, cake mixes, pastries, custard powder, soups, sauces, some rices, powdered drink mixes, sports drinks, ice cream, candy, chewing gum, marzipan, jam, jelly, gelatins, marmalade, horseradish, yogurt, noodles, pickles and other pickled products, certain brands of fruit squash, fruit cordial, potato chips, biscuits, and many more convenience foods.

Sunset Yellow- It's a synthetic coal tar and azo yellow dye. It may be found in orange squash, orange jelly, marzipan, apricot jam, citrus marmalade, lemon curd, sweets, hot chocolate mix, packet soups, trifle mix, breadcrumbs, cheese sauce mix, soft drinks, some yogurts, fortune cookies, some red sauces, certain pound cakes, and other red food products.

Color Retention Agents

Color retention agents are used to preserve a foods existing color. Many of these agents work by absorbing or binding to oxygen before it can damage the foods. An example is ascorbic acid, or vitamin C. It's often added to brightly colored fruits, such as peaches, during canning. It's also added to wines, fruit, and vegetable-based drinks, juices, baby foods, and fat-containing cereal based foods, such as biscuits and rusks.

NATURAL COLORS, TYPES AND APPLICATIONS

Natural Food Color is any dye, pigment or any other substance obtained from vegetable, animal, mineral, or source capable of colouring food drug, cosmetic or any part of human body, colors come from variety of sources such as seeds, fruits, vegetables, algae & insect.

According to the application a suitable Natural Color can be achieved by keeping in mind the factors such as pH. heat, light storage and the other ingredients of the formula or recipe. The stirage conditions for natural colors depends on the particular need of the product.

A tight sealed container is best to store he product in a cool storage to preserve color strength and quality, along with its degree of cooling point.

Bioflavonoids in Natural Food Colors

Some natural food colors are rich in bioflavonoids. Bioflavonoids are pigments that are naturally occurring in a vegetable or fruit. It has many reported benefits. One of which is its role in maintaining healthy capillaries. Bioflavonoids are said to prevent easy bruising, haemorrhages and other circulatory problems. Currently, it is being studied in its role in heart disease prevention.

Researchers have also discovered that Vitamin C may have been overly credited for its role in the immune system. Based on several studies, bioflavonoids have the same immunity-boosting effects as vitamin C.

Another potential benefit of bioflavonoids is in cancer prevention. Studies show that it helps in removing mutagens and carcinogens. It also helps in neutralizing cancer cells.

Natural Food Dyes Contain Polyphenols

Polyphenols are chemical substances found in plants. They have antioxidant qualities. Most vegetable and fruit dyes are great antioxidants. As antioxidants, they fight free radicals. Not only do they fight cancer and heart diseases but they also prevent aging.

Homemade Food Coloring

Extracting dye from food can be easily done by using a small amount of water and a fruit or vegetable with distinct color. A light yellow color can be extracted from saffron threads by wetting and squeezing it. The same can be done in blueberries, turmeric, beets, among others.

Commercially Available Natural Food Colors

There are several companies that offer a wide range of natural food colorings. Some of the known ones are India Tree, Nature's Flavor and Seelect. Manufacturers caution users that since natural food colorings are derived from actual food, they will have their own flavor and may affect the taste of the finished product. Natural food colors are also not guaranteed to retain its original color when subjected to high temperatures. As for the price, natural food colors are pricier compared to artificial food colors.

When doing food shopping, it is best to read the nutritional labels. Organic and all-natural foods, particularly those labeled by the USDA as certified organic, use natural food colors and ingredients. They are safer and healthier.

ADVANTAGES OF NATURAL COLOURS

Grapes

Grapes or grape skin is a good source for the production of purple dye pigment. The skin and flesh of the fruit is rich in anthocyanin compounds that are responsible for producing lively Purple hue. It is commonly used in candy, yogurt, ice cream, jams and jellies. The vitamins contained in grapes help in preventing and reducing the risk of diseases, rheumatism, arthritis, kidney and liver disorders, diabetes, anemia and certain types of cancer.

This substance is not suitable for pregnant and breastfeeding women. In some people it can cause sore throat, nausea and headache and allergy.

Turmeric

A popular ingredient for the manufacture of yellow food colouring, turmeric is used in particular for spicing up dishes such as curries, salads, soups, cheese and mustard. Turmeric is Curcumin, which is said to prevent or reduce the risk for flu, cirrhosis, ulcers, Alzheimer's disease, and some cancers. One should not use turmeric sloppy, though. Consuming too much turmeric may lead to gastrointestinal diseases. It can also have adverse effects on the pregnant and lactating women. It is not necessary to use large quantities of turmeric for food coloring as well. Only a small amount just concentrated amount of yellow color.

Caramel

This is probably one of the most used additives, especially in sweets. Natural starches and sugars are caramelized by using high temperatures, producing a liquid amber color, which can be used from soft drinks to processed meats. There are several classes of caramel, classified any chemical agent for the caramelizing process. Drive from caramel coloring, which contain ammonia and sulphite, which can be harmful for the body. Caramel is excellent, but has very little nutritional content should be used with caution. Consuming too much caramel dye can lead to allergies, immune deficiencies, diabetes, cancer, and asthma in some people.

Beet juice

Beet is one of the most recommended health ingredients for the production of red and pink food colouring. The roots are juice and powder, then added a lot of food and drinks, from ice cream to the spices. It packs a lot of nutrients that contain magnesium, manganese, iron and foliates, vitamin C and other antioxidants. Beet juice from the fruit is good for patients with immune deficiencies, renal colic, problems with the liver and colon cancer. It is also good to drink for those who want to control obesity.

Excessive consumption of beet root can cause allergies and cause damage to the kidney stones. Pregnant and nursing women should consume root beet juice in moderation.

SWEETENERS - TYPES AND APPLICATIONS

Sweeteners

Sweeteners are added to foods for flavoring. A few nutritive sweeteners incude sugar alcohols, honey, and syrups.

Sugar alcohol- In commercial foodstuffs it's commonly used in place of table sugar. Some common sugar alcohols include glycol, glycerol, Erythritol, threitol, arabitol, arabitol, xylitol, and ribitol.

Honey- It is a sweet food made by certain insects using nectar from flowers. The variety produced by honey bees is the one most commonly consumed by humans. Honey is usually added, as a sweetner, to tea and in some commercial beverages. It's also used in cooking, baking, and as a spread on breads.

Syrups- They ARE thick, biscous liquids, containing large amounts of dissolved sugars. A lot of beverages use syrups to offset the tartness of some juices used in the drink recipes.

Types of sweetener

It is possible to categorize all sweeteners into 6 groups:

1. Sugars

2. Sugar Alcohols

3. Natural Caloric Sweeteners

4. Natural Zero Calorie Sweeteners

5. Modified Sugars

6. Artificial Sweeteners

Nearly all types of sweetener fall into these 6 categories. A few such as insulin could be considered as sugar fibers, but they could also fall under the Sugar heading.

1. Sugars

These are carbohydrates and contain 4 calories per gram. They are found naturally in many foods including fruit, vegetables, cereals and milk. They can be harmful to teeth and tend to have a high glycemic index.

The most common are:

Sucrose, Glucose, Dextrose, Fructose, Lactose,Maltose, Galactose and Trehalose.

2. Sugar Alcohols

Like sugars these are carbohydrates and occur naturally, though in small amounts, in plants and cereals. They typically contain fewer calories per gram than sugar and do not cause tooth decay. Because they are carbohydrates, they should have 4 calories per gram. However the body is unable to fully metabolize them, and consequently they tend to have fewer available calories per gram. The downside of this is that they can cause cramps or bloating if taken in excess. They are harmless to teeth and tend to have a very low glycemic index.

The most common are:

Sorbitol, Xylitol, Mannitol, Maltitol, Erythritol, Isomalt, Lactitol, Glycerol

3. Natural Caloric Sweeteners

These are the oldest known sweeteners and include honey and maple syrup. They contain sugar but also other nutritive qualities. They tend to have a somewhat lower glycemic index.

They include:

Honey, Maple Syrup, Coconut Palm Sugar and Sorghum Syrup.

4. Natural Zero Calorie Sweeteners

These are not carbohydrates and contain little or no calories. It is only in recent years that interest has grown in these as a better alternative to artificial sweeteners. They have zero glycemic index and are harmless to teeth. Like artificial sweeteners they can have an aftertaste.

They include:

Luo Han Guo, Stevia, Thaumatin, Pentadin, Monellin, Brazzein.

5. Modified Sugars

These are typically sugars produced by converting starch using enzymes. The list also includes sugars that have been modified such as caramel or golden syrup. They tend to have a high glycemic index and can be harmful to teeth. They are often used in cooking or in processed foods.

A few are:

High Fructose Corn Syrup, Refiners Syrup, Caramel, Inverted Sugar, Golden Syrup.

6. Artificial Sweeteners.

There are many types on the market and some appear to be safer than others. They have been in use in America and Europe for over 120 years. They have zero glycemic index and are harmless to teeth.

The most common are:

Aspartame, Sucralose, Saccharin, Neotame, Acesulfame K, Cyclamate.

Typical applications are:

- Reducing color, taste, odor and turbidity in liquid sugar and bottling syrups

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- Cane sugar refining to reduce color, odor and turbidity prior to crystallization
- Beet sugar decolorization
- Reducing color, taste, odor and turbidity in HFCS (high fructose corn syrup)
- Reducing color, taste and odor in sorbitol, mannitol, and other natural and artificial sweeteners
- Reducing color in syrup
- Reclaiming scrap sugars

HACCP SYSTEM TO FOOD PROTECTION

HACCP (Hazard analysis and critical control points)

Hazard analysis and critical control points or HACCP is a systematic preventive approach to food safety from biological, chemical, and physical hazards in production processes that can cause the finished product to be unsafe, and designs measurements to reduce these risks to a safe level. In this manner, HACCP is referred as the prevention of hazards rather than finished product inspection. The HACCP system can be used at all stages of a food chain, from food production and preparation processes including packaging, distribution, etc.

The Food and Drug Administration (FDA) and the United States Department of Agriculture (USDA) say that their mandatory HACCP programs for juice and meat are an effective approach to food safety and protecting public health. Meat HACCP systems are regulated by the USDA, while seafood and juice are regulated by the FDA. The use of HACCP is currently voluntary in other food industries. HACCP is believed to stem from a production process monitoring used during World War II because traditional "end of the pipe" testing on artillery shell's firing mechanisms could not be performed, and a large percent of the artillery shells made at the time were either duds or misfiring. HACCP itself was conceived in the 1960s when the US National Aeronautics and Space Administration (NASA) asked Pillsbury to design and manufacture the first foods for space flights. Since then, HACCP has been recognized internationally as a logical tool for adapting traditional inspection methods to a modern, science-based, food safety system. Based on risk-assessment, HACCP plans allow both industry and government to allocate their resources efficiently in establishing and auditing safe food production practices. In 1994, the organization of *International HACCP Alliance* was established initially for the US meat and poultry industries to assist them with implementing HACCP and now its membership has been spread over other professional/industrial areas.

Hence, HACCP has been increasingly applied to industries other than food, such as cosmetics and pharmaceuticals. This method, which in effect seeks to plan out unsafe practices based on science, differs from traditional "produce and sort" quality control methods that do nothing to prevent hazards from occurring and must identify them at the end of the process. HACCP is focused only on the health safety issues of a product and not the quality of the product, yet HACCP principles are the basis of most food quality and safety assurance systems, and the United States, HACCP compliance is regulated by 21 CFR part 120 and 123. Similarly, FAO/WHO published a guideline for all governments to handle the issue in small and less developed food businesses.

Principles

1. **Conduct a hazard analysis**

Plans determine the food safety hazards and identify the preventive measures the plan can apply to control these hazards. A food safety hazard is any biological, chemical, or physical property that may cause a food to be unsafe for human consumption.

2. **Identify critical control points**

A critical control point (CCP) is a point, step, or procedure in a food manufacturing process at which control can be applied and, as a result, a food safety hazard can be prevented, eliminated, or reduced to an acceptable level.

3. **Establish critical limits for each critical control point**

A critical limit is the maximum or minimum value to which a physical, biological, or chemical hazard must be controlled at a critical control point to prevent, eliminate, or reduce to an acceptable level.

4. **Establish critical control point monitoring requirements**

Monitoring activities are necessary to ensure that the process is under control at each critical control point. In the United States, the FSIS requires that each monitoring procedure and its frequency be listed in the HACCP plan.

5. **Establish corrective actions**

These are actions to be taken when monitoring indicates a deviation from an established critical limit. The final rule requires a plant's HACCP plan to identify the corrective actions to be taken if a critical limit is not met. Corrective actions are intended to ensure that no product is injurious to health or otherwise adulterated as a result of the deviation enters commerce.

6. **Establish procedures for ensuring the HACCP system is working as intended**

Validation ensures that the plants do what they were designed to do; that is, they are successful in ensuring the production of a safe product. Plants will be required to validate their own HACCP plans. FSIS will not approve HACCP plans in advance, but will review them for conformance with the final rule. Verification ensures the HACCP plan is adequate, that is, working as intended. Verification procedures may include such activities as review of HACCP plans, CCP records, critical limits and microbial sampling and analysis. FSIS is requiring that the HACCP plan include verification tasks to be performed by plant personnel. Verification tasks would also be performed by FSIS inspectors. Both FSIS and industry will undertake microbial testing as one of several verification activities. Verification also includes 'validation' – the process of finding evidence for the accuracy of the HACCP system (e.g. scientific evidence for critical limitations).

7. **Establish record keeping procedures**

The HACCP regulation requires that all plants maintain certain documents, including its hazard analysis and written HACCP plan, and records documenting the monitoring of critical control points, critical limits, verification activities, and the handling of processing deviations. Implementation involves monitoring, verifying, and validating of the daily work that is compliant with regulatory requirements in all stages all the time. The differences among those three types of work are given by Saskatchewan Agriculture and Food.

Standard

The seven HACCP principles are included in the international standard ISO 22000 FSMS 2005. This standard is a complete food safety and quality management system incorporating the elements of prerequisite programmes (GMP & SSOP), HACCP and the quality management system, which together form an organization's Total Quality Management system. Other Standards, such as Safe Quality Food Institute's SQF 2000 Code, also relies upon the HACCP methodology as the basis for developing and maintaining Food Safety (Level 2) and Food Quality (Level 3) Plans and programs in concert with the fundamental prerequisites of Good Manufacturing Practices.

Training

Training for developing and implementing HACCP Food Safety management system are offered by several quality assurance companies. However, ASQ does provide a Trained HACCP Auditor (CHA) exam to individuals seeking professional training. In the UK the Chartered Institute of Environmental Health (CIEH) offers a HACCP for Food Manufacturing qualification, accredited by the QCA (Qualifications and Curriculum Authority).

Applications

- Fish and fishery products
- Fresh-cut produces
- Drinks and nectary products
- Food outlets
- Meat and poultry products
- School food and services

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Question	Opt 1	Opt 2	Opt 3	Opt 4	Answer
Unit I					
Canning of vinegar was introduced in the year	1785	1787	1781	1782	1782
The pasteurization of milk was introduced in the year	1887	1884	1883	1880	1880
Who demonstrated the occurrence of bacteria in milk?	Pasteur	Miquel	Forster	Kircher	Kircher
Who demonstarted the ability of bacteria to grow at 0 ^{0}C?	Forster	Pasteur	S. Elliot	Winslow	Forster
Miquel was the first to study ----- type of bacteria	Heat resistant	Thermophilic	Gram positive	Mesophilic	Thermophilic
Which organism was demonstrated by L.R. Koupal and R.H. Diebel?	*Streptococci*	*Salmonella enterotoxin*	*Bacilli*	*Mycobacterium*	*Salmonella enterotoxin*
Which organism is present in human urine?	*Lacto bacillus*	*Klebsilla*	*E.coli*	*Bacillus*	*Klebsilla*
Which of the following is heat resistant bacteria?	*Clostridium*	*Aeromonas*	*Bacillus*	*E.coli*	*Bacillus*
Listeria causes ………..	Respiratory disorder	Brain fever	Dysentry	Diarrhoea	Brain fever
Serratia is ……...pigmented	Blue	Yellow	Red	Green	Red
Which of the following comes under acid fast staining bacteria?	*Shigella*	*Brevibacterium*	*Mycobacterium*	*Bacillus*	*Mycobacterium*
Which organism is used in tea production?	*Aspergillus acidus*	*Aspergillus niger*	*Aspergillus fumigatus*	*Aspergillus oryzae*	*Aspergillus acidus*
A.nige r is used in the production of ……….	Tea	Awamori	Meat	Bread	Awamori
……..is used in the preparation of choclates	*A.oryzae*	*A. niger*	*A.fumigatus*	*P. camemberti*	*A.fumigatus*
…… organism is used in the production of meat	*P.chrysogenum*	*P. solitum*	*Pichia fermentans*	*P. camemberti*	*P. solitum*
…… is ued in the production of cheese	*P. solitum*	*Pichia fermentans*	*P. camemberti*	*Lactobacillus platarum*	*P. camemberti*
Pichia fermentans is used in the production of …..	Dairy	Awamori	Cider	Tea	Dairy
Saccharomyces species is used in the preparation of…….	Tea	Awamori	Cheese	Cider	Cider
Dough is usually leavened by…..	Molds	Yeasts	Bacteria	Virus	Yeasts
…… toxin is produced by *Omphalotus olearius*	Coprine	Illudin	Orrelanin	Amatoxin	Illudin
Kidney damage is caused by…….toxin	Amatoxin	Orrelanin	Coprine	Amatoxin & Orrelanin	Amatoxin & Orrelanin
Amatoxin is the toxin present in …….species	*Amanita sp.*	*Cortinarius sp.*	*Omphalitus sp.*	*Coprinus sp.*	*Amanita sp.*
Aflatoxin is the toxin produced by……. organism	*A.ochraceus*	*A.paraciticus*	*A.flavus*	*A.paraciticus* & *A.flavus*	*A.paraciticus* & *A.flavus*
….. toxin affects nephrons	Aflatoxin	Nephrotoxin	Locyctin	Coprine	Nephrotoxin
Fussarium moniliforme produces …. toxin	T_2 toxin	Patulin	Ochrotoxin	Amatoxin	T_2 toxin
T_2 toxin causes…….. diseases	Breast cancer	Oesophagal cancer	Skin infection	Stomach infection	Oesophagal cancer
Patulin is the toxin produced by…….organism	*P.italicum*	*P. digitatum*	*A. ochraceus*	*P.italicum* & *P. digitatum*	*P.italicum* & *P. digitatum*
Which of the following lactic acid producing bacteria grows at low temperature?	*Lactobacillus bulgaricus*	*Lactobacillus platarum*	*Lactobacillus brevis*	*Lactobacillus platarum* & *Lactobacillus brevis*	*Lactobacillus platarum* & *Lactobacillus brevis*
Lactobacillus bulgaricus grow at……..temperature	High	Low	Moderate	Neutral	High
…. is the principal malt beverages	Ale	Cheese	Meat	Fish	Ale
Ropiness of beer causes…. diseases	Salmonellasis	Sarcina sickness	Gastrointestinal irritation	Diarrhoea	Sarcina sickness
Sake is a ….beer	Yellow rice	Ginger	Bock	Rice	Yellow rice
Cider vinegar is derived from…..	Apple juice	Grapes	Alcohol	Grains	Apple juice
Sauerkraut is prepared using shredded …..	Cabbage	Tomato	Potato	Tomato	Cabbage
Sauerkraut may be canned by filling tha cans at….. temperature	79.1 ^{0}C	73.9 ^{0}C	71.7 ^{0}C	75.8 ^{0}C	73.9 ^{0}C
First step in the degradation of pectin of cucumber is the removal of ….group.	Ethoxyl	Methoxyl	Benzyl	Phenyl	Methoxyl
Ripe olives can be affected by …. species	*Bacillus*	*Coccus*	*Aspergillus*	*Penicillium*	*Bacillus*
……discoloration is produced when H_2S is reacted with metals or metallic salts	Blue	Red	Black	Yellow	Blue
…… are hard cheeses in the following?	Cheddar	Swiss	Brie	Cheddar & Swiss	Cheddar & Swiss
Oospora species is called the……	Dairy mold	Dairy yeast	Dairy Bacteria	Dairy Yeast & Bacteria	Dairy mold
Clodosporium sp . is characterized by….	Dark green to black	Black to dark green	Light green to dark green	Dark green to Light green	Dark green to black
…. species surface is sufficiantly moist	*Penicillum*	*Monilia*	*Oospora*	*Bacillus sp.*	*Monilia*
The method used for curing coffee is	Dry method	Wet method	Moist heat method	Dry & Wet method	Dry & Wet method
….. species predominant during the fermentation of citrus fruits	*Saccharomyces sp.*	*Bacillus sp.*	*Penicillum sp.*	*Saccharomyces sp.* & *Bacillus sp.*	*Saccharomyces sp.* & *Bacillus sp.*
Soy sauce is mostly exported from ……	Ukraine	United States	Europe	Germany	United States
…..grow in the koji to improve flavor	*Bacillus subtilis*	*Pedicoccus halophilus*	*Aspergillus soyae*	*Saccharomyces rouxii*	*Saccharomyces rouxii*
PER refers to…	Protein Estimation Ratio	Protein Efficiency Ratio	Primary Enzyme Ratio	Primary Efficiency Ration	Protein Efficiency Ratio
……. is a Japanese sauce	Soy sauce	Tamari sauce	Tomato sauce	Chilly sauce	Tamari sauce
Tempeh mash is packed into a…. container	Plastic	Wood	Glass	Steel	Plastic
Ang-khak is a chinese red……..	Rice	Wheat	Barley	Bean	Rice
Soybean cheese is otherwise called as	Tou-fu-ju	Tofu	Natto	Tou-fu-ju &Tofu	Tou-fu-ju &Tofu
…….grows first in the batter of Idli	*Leuconostoc sp*	*Streptococcus sp.*	*Pediococcus sp.*	*Clostridium sp.*	*Leuconostoc sp*
….. is a chinese preserved egg	Piden	Minchin	Tofu	Natto	Piden
Piden is made from…..eggs	Hen	Duck	Emu	Duck & Emu	Duck
Caron for growth of microorganisms mostly comes from…..	CO_2	Organic compounds	NO_2	CO_2 & Organic acids	CO_2 & Organic acids
Meats are high in …. vitamin	A	B	C	D	B
….. acids are heat- liable	Alanine	Mycotoxins	Folic acid	Pentoic ac id	Folic acid
Which of the following are proteolytic	Yeasts	Molds	Bacteria	Virus	Bacteria
…. may be useful for lactic acid- fermentation	*Streptococcus sp.*	*Lactobacillus sp.*	*Penicillum sp.*	*Clostridium sp.*	*Streptococcus sp.*

……process is discovered by Louis Pasteur	Pasturization of milk	Processing of milk	Enhance the nutritional level of milk	Reduce the nutrional level of milk	Pasturization of milk
Unit II					
Which one of the following is of intestinal origin?	*Pseudomonas*	*Alcaliges*	*Escherichia*	*Proteus*	*Escherichia*
Handling pig or beef carcassed may lead to…..	Tuberculosis	Salmonellasis	Brain fever	Skin Cancer	Salmonellasis
Which of the following bacterial group grows in water	*Alcaliges*	*Enterobacter aerogenes*	*Staphylococcus aureus*	*Proteus*	*Enterobacter aerogenes*
……. is not used in the filtration of microorgnisms in air	Cotton	Plastic	Fiber glass	Activated carbon	Plastic
……..causes surface taint of butter	*Alcaligenes viscolactics*	*E.coli*	*Pseudomonas putrefaciens*	*Enterobacter aerogenes*	*Pseudomonas putrefaciens*
Organisms which grow on dry foods are called……..	Osmotolerant	Halotolerant	Xerotolerant	Salt tolerant	Xerotolerant
The maximum temperature of thermophiles is……	15 - 25 ^{0}C	110-120 ^{0}C	60-90 ^{0}C	0-5 ^{0}C	60-90 ^{0}C
Obligate psychrophiles do not grow at temperature above	5 ^{0}C	10 ^{0}C	15 ^{0}C	20 ^{0}C	20 ^{0}C
Which of the following is not a mesophile?	*Salmonella sp.*	*Staphylococcus aureus*	*Bacillus sp.*	*Clostridium perfringes*	*Bacillus sp.*
…… are more resistant to high gaseous atmosphere	Moulds	Gram positive	Gram negative	Fungi	Gram positive
Which one of the following affect the growth of microorganisms?	Temperature	Humidity	O_2 level	Moisture	Temperature
Most of the molds are……	Thermophilic	Mesophilic	Psychrophilic	Basilophilic	Mesophilic
Which of the following is an aerobic?	Mould	Yeast	Bacteria	Virus	Bacteria
Botulism is a disease caused by….	Enterotoxin	Neurotoxin	Nephrotoxin	Exotoxin	Neurotoxin
Staphylotoxin is a ……..	Exotoxin	Neurotoxin	Enterotoxin	Nephrotoxin	Enterotoxin
Which of the following is not responsible for chronic diarrhoea?	*S.aures*	*B. cereus*	*C. perfringens*	*V. parahaemolyticus*	*V. parahaemolyticus*
Which one of the following is the fungal toxin?	Staphylotoxin	Aflatoxin	Streplo toxin	Nyotoxin	Aflatoxin
Aflatoxin is a…..	Mycotoxin	Algal toxin	Bacterial toxin	Chemical toxin	Mycotoxin
The pH range at which salmonelle grow is…..	6.1 to 7.9	1 to 4	4.1 to 9.0	6.0 to 7.0	4.1 to 9.0
Gastroenteritis is caused by……	Exoenterotoxin	Neurotoxin	Enterotoxin	Nephrotoxin	Enterotoxin
Which of the following is Gram negative?	*Streptococcus sp.*	*Lactobacillus*	*Salmonella*	*Shigella*	*Salmonella*
Optimal growth temperature of *E.coli* is	30 ^{0}C	25 ^{0}C	5 ^{0}C	37 ^{0}C	37 ^{0}C
Which of the following is a faecal origin?	*Klebsiella*	*Serratia*	*Shigella*	*Proteus*	*Shigella*
…….. is typiclly enteropathogenic in humans	*Proteus*	*Salmonella*	*Shigella*	*Salmonella* & *Shigella*	*Salmonella* & *Shigella*
…….is usually detected in coliform tests	*Shigella*	*Salmonella*	*Escherichia*	*Proteus*	*Escherichia*
Which of the following organism is plant associated?	*Escherichia*	*Erwinia*	*Salmonella*	*Proteus*	*Erwinia*
In DEFT, which colour is produced bydead cells on adding acridine orange?	Orange	Green	Yellow	Blue	Green
Acridine orange on binding to double - starnded DNA, produces….. colour	Orange	Green	Yellow	Blue	Green
On binding with acridine orange, single strand RNA produces….colour	Green	Orange	Yellow	Blue	Orange
Baird parker agar is used for the isolation of	*E.coli*	*Bacillus sp.*	*S.aureus*	*Clostridium perfringes*	*S.aureus*
Pore size of the membrane filter is	4 μm	0.45 μm	0.004 μm	0.05 μm	0.45 μm
Membrane filter is used for the analysis of	Solid food	Colloidal food sample	Liquid food materials	Collateral food sample	Liquid food materials
Which of the following is immunological method for detecting microbes?	PCR	ELISA	SPC	DEFT	ELISA
Which one of the following group are known as haptens?	Algal toxins	Mycotoxins	Bacerial toxins	Chemical toxins	Mycotoxins
…… is not a mycotoxin	Aflatoxin	Ochratoxin	Staphylotoxin	Fumoisins	Staphylotoxin
Thermus aquaticus is an example for…. bacteria	Thermophilic	Mesophilic	Psychrophilic	Thermophilic & Mesophilic	Thermophilic
Fermented foods have ---- pH	High	Low	Neutral	Medium	Low
Protein decomposition under anaerobic condition results in…..	Ammonification	Denitrification	Putrefacation	Nitrification	Putrefacation
….. Of fungl groups produce mycotoxin	*Penicillum*	*Aspergillus*	*Agaricus*	Penicillum & Aspergillus	Penicillum & Aspergillus
PCR is used for the detection of ….	DNA or RNA	Protein	Antigen or antibody	Direct count of microbes	DNA or RNA
Microbial growth in food …..the redox potential	Increases	Reduces	Maintain	Does not effect	Reduces
Which of the following has the low redox potential?	Spinach	Potato tuber	Barley	Lemon	Lemon
The redox potential of raw meat is….	6.5	7	5.7	6	5.7
Which of the followingis an intrinsic factor?	Temperature	Humidity	Nutrients	Gaseous atmosphere	Nutrients
Life occurs when water is in … state	Solid	Vapour	Liquid	Semi- solid	Liquid
Which of the following causes meningitis?	*Bacillus*	*Streptococcus*	*Listeria*	*Staphylococcus*	*Listeria*
Vegetable juice have ….buffering power	High	Moderate	Low	No power	Low
Which of the following is a good buffer?	Milk	Fruit juice	Vegetable juice	Oil	Milk
Volume of sample in direct microscopy is …..	5X10^6 ml	5 X10 $^{-6}$ ml	5 X 10 ^{2} ml	5 X 10 $^{-2}$ ml	5 X10 $^{-6}$ ml
Enumerating low number of viable organisms is referred as……	Plate counts	Most probable number counts	PCR	Mould count	Most probable number counts
Dry films are made up of…..	Acetate membrane	Polyester membrane	Cellular membrane	Nylon membrane	Cellular membrane
Which of the following organisms donot produce toxins?	*Staphylococcus sp.*	*Lactobacillus sp.*	*Clostridium sp.*	*Aspergillus sp.*	*Lactobacillus sp.*
Molds and yeasts donot grow well above…. temperature	12-15 ^{0}C	35-37 ^{0}C	40-45 ^{0} C	20- 25 ^{0}C	35-37 ^{0}C
Which aflatoxin is more toxic?	M_1	M_2	B_1	B_2	B_1

Which of the following is toxic to human beings?	Aflatoxin	Patulin	Sterigmatocystin	Alimentary toxic aleukia	Alimentary toxic aleukia
Patulin is a toxin present in….	Mango	Apple	Orange	Cashew	Apple
Which among the following is useful for lactate - Fermentation?	*Clostridium perfringes*	*Clostridium botulism*	*Streptococcus lactis*	*Lactobacillus acidophilus*	*Streptococcus lactis*
The water activity of pure water is…..	1.5	1	0	2	1
….acid is more inhibitory than other acids	Inorganic acids	Organic acids	Butryic acid	Inorganic acids & Organic acids	Organic acids
Microorganisms grows well in ….. of salts and sugar	Low concentration	High concentration	Absence	Presence	Low concentration
Unit III					
What is the percentage of water content in milk?	86.50%	75.60%	87.70%	88.70%	87.70%
Microorganisms involved in making curd…..	*Streptococcus lactis*	*Lactobacillus acidophilus*	*S. cremoris*	*Lactobacillus bulgaricus*	*Streptococcus lactis*
Microorganism invoved in making cheese	*S.thermophilus*	*Penicillum roquefartie*	*Micrococci*	Both a & b	*S.thermophilus & Penicillum roquefartie*
What is the percentage of lactose in milk?	5%	6.40%	4.90%	8.00%	4.90%
What is the percentage of minerals in milk?	1%	0.60%	0.70%	0.80%	0.70%
…… is prepared from mayer's milk	Kefir	Leber	Cheese	Kumiss	Kumiss
……is prepareed from mixed milk	Kefir	Leber	Cheese	Kumiss	Kefir
High speed configuration removes about ……. of bacteria from milk	97%	98%	99%	100%	99%
The centrifugal procedure used for removing bacteria from milk known as…..	Bactocentrifugation	Bactofugation	Bactoremoving	Bactofusion	Bactofugation
Pasteurization is ……	High heat treatment	Mild heat treatment	Midium heat treatment	Heat treatment	Mild heat treatment
Pasteurization process involves at a temperature of ……	72 ^{0}C for 20 sec	72 ^{0} C for 15 sec	75 ^{0}C for 20 sec	75 ^{0}C for 15 sec	72 ^{0} C for 15 sec
…….system is the most widely used commercial pasteurization process	STHT	HTST	TSHT	TTSH	HTST
…… is a proteolytic bacteria	*B. licheniformis*	*B.subtilis*	*B. cereus*	*B. coagulars*	*B. cereus*
…….. is a thermophilic bacteria	*B. licheniformis*	*B.subtilis*	*B. cereus*	*B. coagulars*	*B. coagulars*
……. is a gas-forming bacteria	*B. coagulars*	*B. polymyxa*	*B. Subtilis*	*B. cereus*	*B. polymyxa*
Which one is the not a milk fermented product?	Cheese	Yogurt	Kefir	Wine	Wine
Evaporated milk is made by removing ….. of the water from milk	50%	60%	70%	80%	60%
The product from skim milk contains about….. of total sugars	57%	58%	59%	60%	58%
……bacteria are most numerous in the day product	Proteolytic	Thermophilic	Thermoduric	Gas - forming	Thermoduric
….acts as a preservative of sweetened condensed milk	Salt	Sugar	Flavour	Salt & Sugar	Sugar
Common salt is added in the manufacture of cheese, its mainly for	Acid forming	Controlling microbial growth	Gas - forming	Growth of microorganisms	Controlling microbial growth
What is the moisture content in butter?	16.34%	17.34%	18.34%	19.34%	16.34%
How much salt content is present in butter?	2.35%	4.35%	1.35%	5.35%	2.35%
Mold spoilage of cheese is usually delayed by adding	Sorbic acids	Glutamic acid	Citric acid	Aspartic acid	Sorbic acids
…….light is used in torege backs containing liquid sugar to prevent mold growth on the surface	Infra red	Visible light	Ultraviolet	Tugsten light	Ultraviolet
Which milk causes damage to teeth?	Flavoured milk	Heat treated milk	Sterilized milk	UHT	Flavoured milk
Which milk mostly used for production of soft drinks?	Heat treated milk	Flavoured milk	Sterilized milk	UHT	Flavoured milk
Ultra heat treated milk has been treated at ….. Temperature	120 ^{0}C	125 ^{0}C	130 ^{0}C	135 ^{0}C	135 ^{0}C
99 % of heat treated milk was expoted to……	USA	UK	Russia	Canada	UK
Which milk is stored for one year	UHT	Sterilized milk	Evaporated milk	Untreated ilk	Evaporated milk
Which milk has half life period?	UHT	Sterilized milk	Evaporated milk	Untreated ilk	Untreated ilk
…. ..milk is the combination of buffalo milk and skim milk	Untreated milk	Filtered milk	Stardardized milk	Whole milk	Stardardized milk
……milk contains 3.25% of fat	Untreated milk	Filtered milk	Stardardized milk	Whole milk	Stardardized milk
Standardized milk maintain……fat content	3%	3.50%	4%	4.50%	3.50%
Standardized milk is the combination of …….	Buffalo milk & skim milk	Cow milk & skim milk	Buffalo milk & cow milk	Cow milk & Goat milk	Buffalo milk & skim milk
Reduced fat milk contain about …. fat content	2%	3%	4%	5%	2%
Which milk is consumed by old people?	Whole milk	Reduced fat milk	Low fat milk	Filtered milk	Whole milk
1% of fat in low fat milk gives …… calories	20 calories	23 calories	30 calories	35 calories	23 calories
Which milk is otherwise called as non- fat milk?	Whole milk	Low fat milk	Filtered milk	Skim milk	Whole milk
Which is other wise called as breakfast milk?	Jercy milk	Whole milk	Filtered milk	Skim milk	Jercy milk
……. is prepared form ass's milk	Kumiss	Kefir	Leber	Cheese	Kumiss
The temperature of raw milk is……..	10 to 37 ^{0}C	20 to 37 ^{0}C	10 to 27 ^{0}C	20 to 27 ^{0}C	10 to 37 ^{0}C
………bacteria is most likely to cause the souring	*S. lactis*	*S. thermophilus*	*L. acidophilus*	*L. bulgaricus*	*S. lactis*
At high temperature (37 to 50 ^{0}C) S. thermophilus and S. faecalis produce…….acid	1%	2%	3%	4%	1%
The pasteurization of milk kills the more active……..bacteria	Acid forming	Base forming	Both a & b	Alkaline	Acid forming
Butyric acid may be produced in milk by action of …….	*B. coagulars*	*B. polymyxa*	*B.subtilis*	*Clostridiun sp.*	*Clostridiun sp.*
The chief gas - former bacteria is……….	Coliform bacteria	*B. coagulars*	*B. subtilis*	*B. cereus*	Coliform bacteria

……forming bacteria are not active in milk but form gas in cheese	Citric acid	Propionic acid	Glutamic acid	Aspartic acid	Propionic acid
Burnt or caramel flavour produced by……	*S. lactis*	*B. coagulars*	*B. subtilis*	*B. cereey*	*S. lactis*
which bacteria can cause blue and yellow milk?	*P. syncyanea*	*Serratia marcescens*	*B. erythrogenes*	*P. putrefaciens*	*P. syncyanea*
……. milk is usually caused by species of *Serratia*	Red	Blue	Yellow	Brown	Red
Cheeseness is caused by……bacteria	*Lactobacilli*	*Enterobacter*	*P. mephitica*	*A. hydrophila*	*Lactobacilli*
Barny flavour is caused by……bacteria	*Lactobacilli*	*Enterobacter*	*P. mephitica*	*A. hydrophila*	*Enterobacter*
……flavour is caused by Coliform bacteria	Barny flavour	Malty flavour	Flat flavour	Unclean	Unclean
……flavour is caused by molds and actinomycetes	Barny flavour	Musty flavour	Malty flavour	Unclean	Musty flavour
Malty flavour is produced by…….	*Lactobacilli*	*Enterobacter*	*S. Lactis*	*A. hydrophila*	*S. Lactis*
……..is caused by *A. hydrophila*	Fishiness	Esterlike flavour	Musty flavour	Malty flavour	Fishiness
Skunk like flavour is caused by……	*Lactobacilli*	*P. mephitica*	*S. Lactis*	*A. hydrophila*	*P. mephitica*
Roquefart like flavour is caused by…..	Molds	Yeast	Bacteria	Virus	Molds
……….flavour is caused by *P. fragi*	Ester like flavour	Fishiness	Barny flavour	Malty flavour	Ester like flavour
Unit 1V					
The surface of well washed tomato may contain …..microbes per square centimeter	400 to 500	400 to 600	400 to 700	400 to 800	400 to 700
Outer tissue of unwashed cabbage might contain ….microbes per gram	1 to 2 million	2 to 3 million	3 to 4 million	4 to 5 million	1 to 2 million
Ordinary potatoes turn sweet at …… temperature	1.1 to 3.3 ^{0}C	2.2 to 4.4 ^{0}C	1.1 to 4.4 ^{0}C	2.2 to 3.3 ^{0}C	2.2 to 4.4 ^{0}C
Potatoes stored at higher temperature are used for….	Chips	Sweets	Cheese	Yogurt	Chips
Enterotoxin forming *Staphylococci* in frozen corn was found by…..	T. Kensett	Jones & lochead	S. Elliott	Miquel	Jones & lochead
……has been found in frozen vegetables	*C. botulinum*	*Flavo bacterium*	*Enterobacter sp.*	*Micrococcus*	*C. botulinum*
Bacteria count in frozen vegetable range from	10^4	10^5	10^6	10^7	10^5
…….vapours will control Fusarium on potatoes	Phenyl	Biphenyl	Triphenyl	Tetra phenyl	Biphenyl
…… is the only added chemical preservative in common use	Salt	Sugar	Oil	Vinegar	Salt
……..has been reported to be the predominant organisms in frozen fruits	Bacteria	Molds	Yeast	Both b & c	Molds & yeast
Bacterial soft rot is caused by……	*Erwinia carotovara*	*B. cinerea*	*R. stolonifer*	*C. cocodes*	*Erwinia carotovara*
Grey mold rot is caused by……	*Erwinia carotovara*	*B. cinerea*	*R. stolonifer*	*C. cocodes*	*B. cinerea*
Blue mold rot is caused by …..	*C. lendemuthianum*	*A. tenius*	*P. digitatum*	*B. cinerea*	*P. digitatum*
Scleratinia scleratiorus causes	Watery soft rot	Alternaria rot	Gray mold rot	Anthracnose	Watery soft rot
Colletotrichum lindenuthranium causes	Watery soft rot	Alternaria rot	Gray mold rot	Anthracnose	Anthracnose
Black mold rot is caused by…..	*Alternaria*	*A. niger*	*T. roseum*	*S. scleratiorum*	*A. niger*
………is causd by *Fusarium* sp.	Black rot	Pink mold rot	Fusarium rot	Brown rot	Fusarium rot
Most meat products are…. foods	High acid food	Low acid food	High basic food	low basic food	Low acid food
…….in meat help to kill spores of anaerobic bacteria	Nitrites	Aldehyde	Carbon	Oxygen	Nitrites
The processing temperature for shelf - stable canned cured meats is…..	96 ^{0}C	97 ^{0}C	98 ^{0}C	99 ^{0}C	98 ^{0}C
……..can grow in meat at low temperature	Bacteria	Virus	Yeast	Molds	Yeast
……residues in food may be associated with asthmtric attacks	Sulfite	Sulfate	Nitrate	Nitrite	Sulfite
Number of viable microorganisms in frozen fruits are considerably….than in frozen vegetables	Higher	Equal	Lower	Equal and Lower	Lower
At what temperature Lactobacilli would be likely to grow and produce lactic acid?	22.2 to 25 ^{0}C	32.2 to 35 ^{0}C	42.2 to 45 ^{0}C	52.2 to 55 ^{0}C	32.2 to 35 ^{0}C
Cured meat preferably are packen in an tight film with Evacuation	Hydrogen	Nitrogen	Carbon	Oxygen	Oxygen
Food poisoning is caused by….	*L. bulgaricus*	*Yeast*	*Salmonella*	*E.coli*	*L. bulgaricus*
Older methods of drying meats are usually combined with…..	Salting & Haeating	Salting & Cooling	Salting & Smoking	Salting & Steaming	Salting & Smoking
……plays a role in the colour of meat	Nitrite	Nitrate	Sulphate	Sulphite	Nitrate
…..will reduce the rate of invasion of the tissues by microorganism	Slow cooling	Rapid cooling	Slow heating	Rapid heating	Rapid cooling
…… is caused by *Pseudomonas*	Surface slime	Colour changes	Changes in fats	Phosphorescens	Surface slime
Changes in colour of meat is caused by…..	*Pseudomonas*	*Lactobacillus*	*Photobacterium*	*Flavobacterium*	*Lactobacillus*
The oxidation of unsaturated fats in meats take place chemically in….	Water	Chemical	Air	Soil	Air
Luminous bacterium causes	Phosphorescence	Off- odours	Off- tastes	Surface slime	Phosphorescence
Skickiness is caused by	Bacteria	Yeast	Molds	Virus	Molds
Cladosporium herbarum causes…..	White spot	Black spot	Green spot	Red spot	Black spot
……..causes white spot	*Sporotrichum cornis*	*A. niger*	*T. roseus*	*S. scleratiorum*	*Sporotrichum cornis*
…….is cause by Penicillium	White spot	Black spot	Green spot	Red spot	Green spot
……gives musty flavour to meat in the vicinity of their growth	Bacteria	Yeast	Molds	Virus	Molds
Pseudomonas usually predominant in beef which is stored at….. temperature	10 ^{0}C	20 ^{0}C	30 ^{0}C	40 ^{0}C	10 ^{0}C
The sourness at low temperature is caused chiefly by…..	*S. carnis*	*A. niger*	*Pseudomonas*	*Sporotrichum*	*Pseudomonas*
Curing salt make meats are not favorable for the growth of…..	Gram positive Bacteria	Gram negative Bacteria	Yeast	Molds	Gram negative Bacteria

Beef hams are made spongy by species of……	*Halobacterium*	*Penicillium*	*Bacillus*	*Rhodotorula*	*Bacillus*
Gill tissue may harbor …. Killion per gram	1000 to 1	10,000 to 1	100000 to 1	1000000 to 1	1000 to 1
Live crabs are cooked in retorts up to ….. temperature	100 0C	110 0C	121 0C	131 0C	121 0C
Number of bacteria in fish - curing brines vary with the concentration of…..	Sugar	Salt	Vinegar	Oil	Salt
Crabs and Oyster may contain species of…..	*Pseudomonas*	*Acinetobacter*	*Moraxella*	*Vibrio*	Vibrio
Uncommon type of spoilage by an asporogenous yeast causes …. Oysters	Blue	Green	Pink	Yellow	Pink
The total number of microorganisms per shell of a hen's egg has been reported to range from…	10 2 to 10 5	10 2 to 10 6	10 2 to 10 7	10 2 to 10 8	10 2 to 10 6
Egg spolage is caused by……	*Salmonella*	*Staphylococcus*	*Bacillus*	*Penicillium*	*Salmonella*
Colourless rots caused by….	*Pseudomonas*	*A. niger*	*Cladosporium*	*S. scleratiorum*	Pseudomonas
Green rot in egg is caused by	*Pseudomonas*	*Bacillus*	*Penicillium*	*Cladosporium*	Pseudomonas
……in egg caused by Pseudomonas	Pink rot	Green rot	Yellow rot	Brown rot	Pink rot
The incidence of salmonella -positive birds has been reported to range from…..	0 to 20%	0 to 30%	0 to 40%	0 to 50%	0 to 50%
…..is found to survive frreze drying and rehydration at 60 ^{0}C	*Staphylococcus*	*Bacillus*	*Penicillium*	*Cladosporium*	Staphylococcus
The undesirable changes in a food that makes it unsafe for human consumption is refered as	Food decay	Food spoliage	Food loss	Food processing	Food spoliage
Food preservation involves	Incresing shelf life of food	Decresing shelf life of food	Reducing nutritions level	Incresing microbial level	Incresing shelf life of food
Pasteurization is a	Heating method	Chemical method	Biological method	Heating and chemical method	Heating method
Which of the following statements are true about chemical preservatives?	Enhancing the microbial growth	Enhancing nutrient level	Lossing nutrient level	Inhibiting the microbial growth	Inhibiting the microbial growth
The major carrier of salmonellosis are	Meat and eggs	Meat and soft drinks	Eggs and milk products	Eggs and fruits	Meat and eggs
Which is physical treatment of food preservation?	Adding salt	Adding sugars	Radiation	Chlorination	Radiation

Unit V

HACCP refers to….	Hazard Analysis Count Control Point	Hazard Amplification count	Hazard analysis critical control point	Hazard analysis control critical point	Hazard analysis critical control point
HACCP is primarily a preventive apprach to …….. Assurance.	Quality	Quantity	Volume	Taste	Quantity
HACCp was adopted in the year of….	1970	1729	1973	1972	1973
Processing steps in CCP includes….	Steaming	Heating	Freezing	Salting	Freezing
Sensory information of CCP includes….	Texture	Colour	Nutritional Level	Microbial Level	Texture
Important part in verification of CCP includes …..testing	Physical	Chemical	Microbiological	Physical & Chemical	Microbiological
Control of pathogens in the product is obtained by….of milk	Boiling	Pasteurization	Freezing	Cooling	Pasteurization
The US department of agriculture has produced a generic HACCP analysis of production of raw…	Milk	Beef	Meat	Fruits	Beef
…..are naturally available food additives	Strychninc	Botulinum toxin	Animal materials	Strychninc & Botulinum toxin	Strychninc & Botulinum toxin
…..are woodsmoke components	Phenol	Methanol	Formoldehyde	Phenol & Methanol	Phenol & Methanol
….activity is possessed by natural food components	Antibacterial	Antifungal	Antimicrobial	Antibiotic	Antimicrobial
Bacteriocins are produced by….bacteria	*Streptococcus*	Lactic acid	*Staphylococcus*	*Aeromonas*	Lactic acid
Antimicrobial effect is the result of….	Cooling	Drying	Freezing	Heating	Drying
……posses antimicrobial activity in milk	Lactoperoxidase	Essential oils	Lactose	Lactoperoxidase & Essential oils	Lactoperoxidase & Essential oils
Nisin is produced by….organisms	*Lactobacillus lactis*	*Lactococcus lactis*	*Streptococcus sp.*	*Staphylococcus sp.*	*Lactococcus lactis*
Which acid is used as a food additive?	Sulphuric acid	Nitric acid	Citric acid	Hydrochloric acid	Citric acid
Vitamin C act as a ……	Antifungal agent	Antioxidant agent	Antiviral agent	Antimalarial agent	Antioxidant agent
Vitamin C otherwise called as ……	Ascorbic acid	Vinegar	Malic acid	Lactic acid	Ascorbic acid
Vinegar is used for…	Preservative	Colouring agent	Flavour	Presrvative & Flavour	Preservative
Flavourare additives that give food a particular….	Taste	Colour	Colour & Taste	Nutritional level	Taste
Preservatives are prevent or inhibit ….	Taste	Colour	Microbial growth	Microbial growth & colour	Microbial growth
Which one is the best example of food additives?	Sulphuric acid	Nitric acid	Citric acid	Hydrochloric acid	Citric acid
What is the function of food additives?	To improve the product safety	To improve the product colour	To decrease the nutritional level	To decrease 1the product safety	To improve the product safety
Which one is the food colouring agent?	Amphicillin	Erythrosine	Tetracyclin	Vitamin C	Erythrosine
Tartrazine is a ……colour	Green	Red	Yellow	Purple	Yellow
Erythrosine produce…..colour	Green	Red	Yellow	Pink	Pink
Tartrazine is a ……dye	Amide	Azo	Direct	Acid	Azo
Which one is a natural food colours?	Turmeric	Brilliant Blue	Tartrazine	Erythrosine	Turmeric
…….is a synthetic dye	Anthrocyanin	Turmeric	Erythrosine	Caramel	Erythrosine
…..is the best example of sweetners	Honey	Grapes	Beet - root juice	Carrot juice	Honey
Food contamination means…..	Food spoilage	Food preservation	Food processing	Adding the food additives	Food spoilage
What is sterilization?	Growing of microorganisms	Inhibit the growth of microorganisms	Killing the microorganisms	Stimulating the microorganisms	Killing the microorganisms
Saccharin is a …..	Synthetic sugar	Natural sugar	Semisynthetic sugar	Modified sugar	Natural sugar
What is the best example of sugar alcohol?	Glucose	Sucrose	Sorbitol	Fructose	Sorbitol
Monelling is ….. sweetners	Natural	Artificial	Modified sugar	Natural zero caloric sugar	Natural zero caloric sugar
Which one is the Natural caloric sweetners?	Caramel	Inverted sugar	Golden syrup	Honey	Honey
Pruple colour natural dyes is obtained from….	Beet root	Caramel	Grapes	Turmeric	Grapes
Vitamin C is predominantly present in ….	Meat	Amla	Fish	Cookies	Amla
Natural yellow colour dye is derived from…..	Sunflower	Lemon	Turmeric	Cucumber	Turmeric

Anthocyanin compounds are rich in….fruit	Grapes	Lemon	Cucumber	Amla	Grapes
Which has a distinctive blue colour?	Brilliant blue	Indigotine	Erythrosine	Tartrazine	Indigotine
Bioflavonoids are pigments that are naturally occuring in a……	Eggs	Fish	Vegetables & fruits	Meat	Vegetables & fruits
Sunset yellow is…..colour dye	Yellow	Orange	Pinkish yellow	Red	Yellow
Antioxidants fight with ……	Microbes	Free radicals	Antigens	Antibodies	Free radicals
Which one is the homemade food colouring agent?	Blue berries	Strawberry	Apple	Orange	Blue berries
Sorgum syrup is a …..sweetners	Artificial	Modifed	Semi- synthetic	Natural caloric	Natural caloric
HFCS refers to…..	High Fructose Cabbage Syrup	High Fructose Corn Syrup	High Fructose Cucumber Syrup	High Fructose Carrot Syrup	High Fructose Corn Syrup
Sugar alcohols are ……	Glycerol & glucose	Manitol & sorbitol	Manitol & maltose	Sucrose & Sorbitol	Manitol & sorbitol
Exclusive concepsion of beet- root will cause…..	Allergy	Pimples	Vomiting	Diarrhea	Allergy
Which is the besy example of stabilizer?	Cellulose	Semicellulose	Agar agar	Amylose	Agar agar
Which one is reducing or preventing foaming in food?	Antioxidant	Anticaking agent	Antifoaming agent	Bulking agent	Antifoaming agent
High fructose corn syrup is…….	Modified sugar	Natural sugar	Artificial suagr	Low calorie sugar	Modified sugar
Vinegar is a……	Anticaking agent	Antifoaming agent	Antioxidant	Additives	Additives
Lactic acid is present in…..	Dairy products	Fish products	Meat products	Soft drinks	Dairy products
Starch is a …. agent	Antioxidant	Anticaking	Antifoaming	Bulking	Bulking
Colour retention agent are used to preserve a foods ……	Excisting colour	Excisting nutrients	Excisting colour & nutrients	Excisting flavour	Excisting colour
Most of the vegetable and fruit dyes are….agent	Antioxidant	Anticaking	Antifoaming	Bulking	Antioxidant
Natural food dyes are….	Blue berries, apple and beet root	Blue berries, carrot and beet root	Green leaves, turmerics and beet root	Blue berries, turmerics and carrot	Blue berries, apple and beet root
Mapple syrup is a…..sweetner	Artificial	Modifed	Natural zero caloric	Natural caloric	Natural caloric
Which one is a azo dye	Green No. 3	Erythrosine	Allura red Ac	Indigotine	Allura red Ac