Microbiology and Deterioration of Milk and Milk Products

- Milk constitutes an excellent medium for the growth of micro-organisms.
- Freshly drawn milk from healthy animals contains a small number of harmless micro-organisms, however, during milking process and storage the contamination takes place, the extent of which depends upon the hygienic measures taken before, during and after milking process and storage conditions observed thereafter.
Nearly all the changes that take place in the flavor and appearance of the milk after it is drawn from the cow, are the result of the activities of m.o., therefore, it is very essential to control these m.o.

Significance of m.o. in milk:

- Microbial content serves as an indicator of production conditions and sanitary quality of milk.
- Prevention of spoilage.
- Prevention of milk borne illnesses.
- Production of dairy products with desired characteristics imparted via m.o. introduction.
Micro-organisms in Milk

- The types of m.o found in milk vary considerably
- Bacteria, yeasts, moulds and bacteriophages are commonly encountered.
- Viruses and protozoa are seldom observed in milk, except as occasional contaminants.

Bacteria

Most common and most numerous of m.o found in milk and milk products.
They belong to four main groups:

1. Gram +ive cocci
2. Gram +ive non-spore forming rods
3. Gram +ive spore-forming rods

LAB

Normally present in milk and they are also used as starter culture for the production of cultured dairy products. They ferment lactose and yield lactic acid.
LAB reclassified (older names in parenthesis).

i. Lactococci
   - *L. delbrueckii sub sps. lactis* (Str. Lactis)
   - *L. Lactis sub sps. Cremoris* (Str. Cremoris)

ii. Lactobacili
   - *L. Casei*
   - *L. delbrueckii sub sps. lactis* (L. Lactis).
   - *L. delbrueckii sub Sps. bulgaricus* (L. bulgaricus)

iii. Leuconostoc
Coliforms

- Facultative anaerobes
  - Optimum growth @ 37°C
  - Indicator organism and are closely associated with the presence of pathogens but not necessary pathogens themselves.

- They ferment lactose with production of acid and gas
  - Cause rapid spoilage of milk

- They are killed by pasteurization
- Their presence is an indication of PP contamination of milk.
Yeast

- Most frequently encountered in raw cream during hot weather produce acid and co$_2$. They are potential contaminants throughout the year.

Moulds

- Their growth is visible as a fuzzy or fluffy growth on the surface of milk and milk products.
- They may be black, green, grey, blue or white.
- They discolor the product and often produce repulsive undesirable off odors.
- Essential in production of certain varieties of cheese.
Bacteriophages

- Particularly obnoxious in starter cultures used for the production of cultured dairy products.
- Phages kill bacterial culture and entire fermentation process fails (slow or dead vat).

Factors affecting growth of m.o in milk

1. Food supply (H₂O, energy, C, N Vit. & Mineral source)
2. Moisture (a_w)
3. Oxygen supply (Obligate aerobes, facultative, microaerophillic, Aerotolerant anaerobes, obligate anaerobes)
4. Acidity and pH (Acidophilic)
5. Preservatives

6. Light (phototrophic)

7. Concentration (osmophillic yeasts)

8. Temperature (psychrotrophs- 20-30-07, Mesophiles-30-40, Thermophiles-55-65°c)

9. Antimicrobial constituents

**Products of microbial growth in milk**

~ Enzymes ~ Decomposition products of protein, fat & CHO etc. ~ Pigments, Toxins etc

(mycotoxins & bacterial toxin)
Result of microbial growth in milk (Spoilage)

- Principal cause are Psychrotrophs
- Most of these are destroyed by pasteurization
- Some may survive e.g. *Pseudomonas fluorescens*, *Pseudomonas fragi*
- Other species and strains that survive pasteurization and grow at Refrigeration temp. produce heat stable proteolytic & lipolytic enzymes and cause spoilage:
  - *Bacillus*, *Clostridium*, *Cornebacterium*
  - *Arthrobacter*, *Lactobacillus*, *Microbacterium*
  - *Micococcus*, *Streptococcus*

Deteriorative changes:
Souring - Lactose fermentation → LA, VFA
Souring & gassiness - coliforms → acid & gas
Aroma production - starter culture → diacetyl
Proteolysis - unpleasant odors - undesirable. controlled → desirable – cheese prod.
Ropiness - Milk drawn into long threads (Alkaligenes viscolactis)
Sweet curdling - due to prod of rennin like enzyme which curdles without souring
Stormy fermentation: Rapid fermentation by Clostridium perfringens

Color changes
Pseud. syncyanea (blue); Pseud. synxantha (yellow);
Serratia marcescens (red)
Stages of milk decay

Rancid
("on the turn")-Milk consumable

Curdling
Separation of curd and whey – milk still consumable

Coagulation
period of aromatic decay with mould growth – milk beyond use

Dry
dehydration ensues- hard and chalky – milk beyond use
Pathogenic micro-organisms in milk

Food borne illnesses occur as a result of:
- Ingestion of raw milk
- Improper pasteurization
- Poor handling / storage leading to PP contamination

Measures to decrease the threat:
- Hygienic production practices
- Proper handling and storage
- Pasteurization
Bacterial Pathogens of current concern

- Bacillus cereus
- Listeria monocytogens
- Yersinea entrocolitica
- Salmonella spp.
- E.coli O 157:H<sub>7</sub>
- Campylobacter jejuni
- Coxeilla burnetii
- Moulds (Aspergillus, Fusarium, Penicillium) grow in milk and milk products & produce potentially hazardous mycotoxins
Means of destruction of micro-organisms

1. Heat - pasteurization, sterilization etc.
2. Ionizing Radiations - UV., gamma rays
3. High frequency sound waves - super & ultrasonic
4. Electricity - by the heat generated.
5. Pressure - 600 x > atmospheric pressure
6. Chemicals Acids, alkalis, halogens $H_2O_2$ etc.
Microbiological Standards for milk & Milk Products

( BIS & other related monographs)

Native Inhibitory substances in milk:

a) Immune system.
b) Phagocytosis.
c) Bacteriostatic & bacteriocidal protein
HACCP

- Raw and end-products may be tested for the presence, level, or absence of microorganisms.

- Traditionally these practices were used to reduce manufacturing defects in dairy products and ensure compliance with specifications and regulations, however, they have many drawbacks:

1. Destructive and time consuming
2. Slow response
3. Small sample size

4. Delays in the release of food
   - In 1960's the Pillsbury company, the U.S. Army, and NASA introduced a system for assuring pathogen free foods for the space programme.
   - This system, called Hazard Analysis and Critical Control Points (HACCP), is a focus on critical food safety areas as part of TQM.
   - Involves a critical examination of entire food manufacturing process to determine every step where there is a possibility of physical, chemical, or microbiological contamination which would render food unsafe or unacceptable for human consumption.
These identified points are critical control points (CCP).

Seven principles to HACCP:

1. analyze hazards
2. determine CCPs
3. establish critical limits
4. establish monitoring procedures
5. establish deviation procedures
6. establish verification procedures
7. establish record keeping procedures

Before these principles can be put into place, a prerequisite programme and preliminary setup is necessary.
Prerequisite Programme

- Premise control
- Receiving and storage control
- Equipment performance and maintenance control
- Personnel training
- Sanitation
- Recall procedure

Preliminary setup

- Assemble team
- Describe the product
- Identify intended use
- Construct flow diagram and plant schematic
- Verify the diagram on site
Starter cultures are those microorganisms that are used in the production of cultured dairy products such as yogurt and cheese.

The natural micro flora of milk is either inefficient, uncontrollable and unpredictable, or is destroyed altogether by the heat treatments given to the milk.
A starter culture can provide desired characteristics in a more controlled and predictable fermentation.

The primary function of lactic starters is the production of lactic acid from lactose. Other functions of starter culture may include the following:

- Flavour, aroma, and alcohol production
- Proteolytic and lipolytic activities
- Inhibition of undesirable organisms
There are two groups of lactic starter cultures:

1. Simple or defined: single strain, or more than one in which the number is known.
2. Mixed or compound: more than one strain each providing its own specific characteristics

Starter cultures may be categorized as mesophillic or thermophillic:

Mesophilic
- *Lactococcus lactis subsp. Cremoris*
- *L. delbrueckii subsp. Lactis*
- *L. lactis subsp. Lactis biovar diacetylactis*
- *Leuconostoc mesenteroides subsp. Creamoris*
- Thermophilic
  - *Streptococcus salivarius subsp. Thermophilus (S. thermophilus)*
  - *Lactobacillus delbrueckii subsp. bulgaricus*
  - *L. delbrueckii subsp. Lactis*
  - *L. helveticus*
  - *L. plantarum*
  - *L. casei*
Mixtures of mesophillic and thermophillic microorganisms can also be used as in the production of some cheeses.
Starter culture preparation

- Commercial manufacturers provide starter cultures in lyophilized (freez-dried), frozen or spary-dried forms.
- The dairy product manufacturers need to inoculate the culture into milk or other suitable substrate.
- There are a number of steps necessary for the propagation of starter culture ready for production:
  1. Commercial culture
  2. Mother culture - first inoculation; all cultures will originate from this preparation
3. Intermediate culture - in preparation of large volumes of prepared starter

4. Bulk starter culture - this stage is used in dairy product production