

Spoilage of milk and milk products:

Raw milk :

The average composition of cow's milk is 3.2% protein, 4.8% carbohydrates, 3.9% lipids, and 0.9% minerals. Besides casein and lactalbumin, it has free amino acids that provide a good Nitrogen-source. Microbial spoilage of raw milk can potentially occur from the metabolism of lactose, proteinaceous compound, fatty acids, and the hydrolysis of triglycerides.

Microbiota of milk from healthy cows are *Micrococcus*, *Staphylococcus*, *Lactic acid cocci* (*Lactococcus* and *Streptococcus*) ,Counts usually $<10^3$ cells/ ml in the bulk tank. While Microbe of milk from cows with mastitis are *Staph.aureus*, *Strep. agalactiae*, Coliforms, *Pseudomonas*, and other *Streptococci* ,Counts $>10^3$ cells/ ml in the bulk tank .

Sources of Spoilage raw milk

Raw milk contains many types of microorganisms coming from different sources:

- Animal itself:

Gram negatives and Gram positives organisms on cow surfaces (hides, udders) from manure, soil, feed, water, and few Gram positive microorganisms in the teat sinus. Milk is the vehicle for some diseases. Milk-borne outbreaks generally involve the consumption of raw milk, include Campylobacteriosis , Listeriosis , Brucellosis and salmonellosis are well established as illnesses that may be contracted from milk and milk products.

- Environmental source:

Gram positive thermophilic organisms from contaminated equipment and utensils. Thermophilic bacteria affect the microbiological quality of pasteurized milk.

If the milk is refrigerated immediately following milking and stored for days, the spoilage consist usually of bitter, rancid, fruity flavors due to putrefaction and predominantly caused by the gram negative psychrotrophic rods, such as *Pseudomonas*.

If the raw milk is **not** refrigerated soon, growth of mesophiles predominates e.g: *Lactococcus*, *Lactobacillus*, *Enterococcus*, *Bacillus* causing changes like souring and curdling of milk due to fermentation.

Preservation techniques:

1-Use of heat:

- a- Steam under pressure: Evaporated milk is canned and heat processed by steam under pressure. Sealed cans of evaporated milk are processed at 115-118°C for 14-18 minutes resulting in sterile products.
- b- Pasteurization and ultra-Pasteurization: To kill all pathogens and improving keeping quality of milk.

LTLT : Low temp. Long time 63°C 30 minutes

HTST: High temp. Short time 72°C 15 seconds

UHT : Ultra high temp., 130-135 °C 1 second

2- Use of low temperature:

- a- Refrigerated storage : The raw milk for pasteurization: cooled to 10°C or less within 2 hrs . Newly pasteurized milk is to be cooled to 7.2°C or less
- b- Freezing: Ice cream & other frozen dessert dairy are stored at frozen temperature. Butter is kept at – 7 to – 18 °C

3- Use of preservatives :

- a- Sorbic acid in cottage cheese & yoghurt
- b- Sugar by reducing a_w value making moisture unavailable for microbes
- c- NaCl in Cheese & salted butter
- d- H₂O₂ :combined with mild heat treatment for certain kind of Cheese

Pasturized Milk:

Pasteurized milk contains various thermotolerant bacteria like *Micrococcus*, *Enterococcus*, *Lactobacillus*, *Streptococcus*, *Corynebacterium*, spores of *Bacillus* and *Clostridium*. The spoilage pattern of pasteurized milk is the same as described for raw milk. Flavor defects from their growth are detectable when the population reaches $\geq 10^6$ cells/ml. Growth of Gram- positive psychrotrophic

Bacillus spp. (*Bacillus cereus*), has been implicated in the spoilage of pasteurized refrigerated milk can cause sweet curdling of milk at higher pH than required for acid curdling. The spoilage of pasteurized milk products usually associated with Gram-negative psychrotrophs (*Pseudomonas*, and *Flavobacterium spp.*) can cause bitter, rancid, fruity, or unclean flavor

2-Spoilage of Canned Foods :

Canned foods are heat treated to kill microorganisms present and the extent of heat treatment is predominantly dependent on the pH of a food.

Canned goods are classified as (a) **low acid**, (b) **acid** or (c) **high acid** products and each group has characteristic spoilage microorganisms, whose growth is most often due to inadequate processing.

- A. Low Acid canned foods (most prod.): **pH 5-6.8**
e.g. meat, poultry, fish, milk, many vegetables. Because of the concern over *C. botulinum* growth, these foods must receive the highest heat treatment.
- B. Acid foods: **pH 4.5-3.7**
e.g. tomatoes, pears, orange, apricot. Undergo flat-sour and gaseous spoilage.
- C. High acid foods : **pH 3.7-2.3**
e.g. Pickle and fermented products . Spoilage is usually due to non-spore-forming mesophiles like yeasts, molds and lactic acid bacteria.

Causes of Spoilage in Cans:

A. Chemical spoilage:

Is due to production of H₂ gas produced in can because of acid action of food on iron of can. This spoilage is termed as Hydrogen swell. It occurs due to following factors:

- a) Increased storage temperature.
- b) Increased acidity of food
- c) Improper exhaust
- d) Presence of soluble sulfur and phosphorous compounds

B. Biological spoilage:

Occurs due to the action of various microorganisms. Spore-forming bacteria, e.g., *Clostridium*, *Bacillus* represent the most important group of canned food spoiling microorganisms because of their heat resistant nature (thermophilic nature). In addition, there are other microorganisms, which are not heat resistant (mesophilic) but enter through the leakage of the container during cooling and spoil the food.

Microbial spoilage occurs due to three main reasons:

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

Thermophilic Sporeformers

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

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

2. Thermophilic Anaerobe (TA) Spoilage : This type of spoilage occurs due to the growth of anaerobic *Clostridium thermosaccharolyticum* which leads to the production of large quantities of H₂ and CO₂ gas and swelling of cans.

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

Mesophilic microorganisms:

Bacillus spp., *Clostridium spp.*, yeasts and other fungi, which are mesophilic are mainly responsible for this type of canned food spoilage. As stated earlier, these organisms enter through the leakage of the container during cooling.

Clostridium butyricum result in butyric acid type of fermentation in acidic (tomato juice, fruits, fruit juices ...etc.) or medium acidic foods with swelling of the container due to the production of CO₂ and H₂.

Bacillus subtilis have been reported spoiling canned sea foods, meats ...etc. Other mesophilic bacteria, which have been reported in cans, are *Bacillus spp.*, *Streptococcus sp.*, *Pseudomonas*, *Proteus* etc. Yeasts and molds have also been found present in canned foods. Yeasts result in CO₂ production and swelling of the cans.

3- Cereals and their Products:

Cereals are important foods which provide bulk of our dietary requirements. They are also source of carbohydrates which are metabolized by body for energy generation. Besides cereals also provide minerals, proteins and vitamins.

The grains are low moisture commodities due to which they are less susceptible to spoilage and have greater shelf-life. The spoilage mainly occurs due to moisture absorption during storage leading to fungal growth at high temperature and humidity. Before bulk packaging and storage, the whole grains are **fumigated** to reduce microbial load and increase storage period. Soil, air, insects and Natural microflora of harvested grains are the main sources of contamination in cereals

Cereal Grains and Flours

At initial stages, the grains are contaminated by *Pseudomonas*, *Micrococci*, *Lactobacillus* and *Bacillus*. The initial bacterial population may vary from 10³ to 10⁶ cells per gram while mold population may be more than 10⁴ spores per gram. Due to low moisture content grains and flours usually have long shelf life if these are properly harvested or stored under proper conditions as microbial growth is not supported. If due to any reason they attain moisture, the microbial growth may occur with molds growing at initial stages of moisture while yeasts and bacteria may grow with increasing moisture.

Spoilage of stored grains by molds is attributed to the following factors:

- Type and number of microorganisms
- Moisture content of more than 12-13%

- Storage temperature
- Physical damage

Most common species of molds are *Aspergillus*, *Rhizopus*, *Mucor*, *Fusarium*. A significant aspect of spoilage of molds is production of mycotoxins, which may pose danger to health. The process of flour making such as washing, milling reduce the microbial content. Moisture content of less than 15% does not allow growth of molds. Most molds and bacteria in flours can grow only above 17% moisture, thus moistening of flours is essential for spoilage by microbes.

Spoilage of bread

1- The a_w of breads is normally low enough (0.75 - 0.9) to prevent growth of bacteria. However, some molds (***bread molds***: *Rhizopus stolonifer*) can grow, especially if moisture is released because of starch crystallization during storage. Molds are killed during baking; however, spores can get in from air and equipment following baking.

2- A specific type of bread spoilage, designated as ***ropiness*** and characterized by soft, stringy, brown mass with fruity odor, caused by the growth of some mucoid variants of *Bacillus subtilis*

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

4- ***Red or Bloody bread*** ----*Serratia marcescens*

- ***Refrigerated Dough (biscuits, rolls, and pizza)***: Susceptible to spoilage (**gas formation**) from the growth of psychrotrophic heterolactic species of *Lactobacillus* and *Leuconostoc* then the gas can blow the containers, especially when the storage temperature increases to 10°C or above
- ***Pastas*** : Anaerobic packing and refrigeration storage can prevent mold growth and slow down the growth of yeasts----- anaerobic and facultative anaerobic psychrotrophic bacteria
- ***Pastries***: They can spoilage by microorganisms coming with the ingredients that are added after baking such as icing, nuts, and cream Due to low a_w , most products will allow only molds to grow.