Fermented milk products

Fermented milks are products prepared from milks (whole, partially or fully skimmed milk, concentrated milk or milk reconstituted from partially or fully skimmed dried milk), homogenized or not, pasteurized or sterilized and fermented by means of specific organisms.

Now a day a wide range of fermented milks is produced. They differ in aroma and flavour, fat content, presence of a variety of fruits and consistency.

Fermented milks are popular products used allover the world, its popularity due to its therapeutic value, simple technology for production, low cost and long shelf-life.

Therapeutic value of fermented milks:

(1) High-acid producing organisms suppressed toxin-producing bacteria in the large intestine of the human and prevented putrefaction and autointoxication of the individual.

(2) Alleviation of lactose mal-digestion by the reduction of lactose content in the product and auto-digestion of lactose by the acid producing organisms (starter) drive β-glactosidase.

(3) Has anti-carcinogenic activity by removal of dietary pro-carcinogens and stimulation of host immune system. (it has been suggested that some lactobacilli produce anti-carcinogenic compounds and may metabolise and destroy known carcinogens e.g. nitrosamines).

(4) Reducing blood cholesterol.

(5) Has nutritional enhancement by synthesis of B-complex vitamin and increased calcium absorption.

(6) Recently researches have discovered acidophilin, lactocidin, lactolin, nisin and diplococcin which are types of antibiotics produced by bacteria used in milk fermentation. So, it can be used for liver complaints, T.B. and renal malfunction because it reduces level of toxic amines.

(7) Fermented milks used as modern comestics.

Types of fermented milks:

Distinct forms of fermented milks exits, although many are similar with respect to technology. Fermented milks may be classified according to the type of starter microorganism used which give specific taste or uses.

(1) Mesophilic lactic fermentation:

a. Cultured butter milk
b. Cultured cream

(2) Thermophilic lactic fermentation

a. Yoghurt

(3) Therapeutic lactic fermentation

a. Acidophillus milk

(4) Lactic yeast fermentation

a. Kefir
b. Koumis

(1) Cultured buttermilk: (Bulgarian fermented milk)

The name (buttermilk) is used to denote that product separated after churning fermented cream into butter. It is a short shelf life product. The modern substituent is cultured buttermilk. It is prepared from pasteurized skim or whole milk that has been fermented by a lactic culture and by aroma bacteria (Strept. lactis, Strept. diacetylactis, Strept. cremoris and Lact. citrovorum)

Manufacture:

Milk is heated to about 88 ^{0}C with homogenization for 30 minutes and cooling to 20-25 ^{0}C before addition of starter, which is added at a level of 1-2 %, fermentation proceeding for 16-20 hours at 25 ^{0}C to an acidity 0.9 % lactic acid, gelatin is sometimes added as stabilizer.

(2) Cultured cream:

Cultured or sour cream is acid gel of delicate flavour resulting from the growth and activity of lactic acid streptococci and flavour-producing leuconostoc bacteria in light cream. Cultured cream is used on salads, as a dressing for vegetables, in filling for cakes or consumed directly. The fat content of cultured cream is standardized between 12-30 % depending on the required properties. The starter culture is similar to that used for culture is similar to that used for cultured buttermilk.

Manufacture:

Cream is heated to 82 ^{0}C for 30 minutes. It is homogenized while hot, then cooled to about 21 ^{0}C and inoculated with 0.5-1 % of butter starter. Incubation is continued at 21 –25 ^{0}C for 8-14 hours until the acidity reaches about 0.6 % lactic acid.

(3) Yoghurt (Yogurt, Dahi, Zabady):

It is the most common type of fermented milks consumed in our country. It is delicious, agreeable in consistency, and high in nutritive value and of good flavour.

Manufacture:

High quality raw milk must be used, heated at 80-85 ^{0}C for 20-30 minutes or at 95 ^{0}C for 10 minutes, then cooled to about 48 ^{0}C and inoculated with 2-3 % of yoghurt culture (Lactobacillus bulgaricus and Streptococcus thermophillus **1:1**) and incubate at 44-45 ^{0}C (42 ^{0}C) for about 3 hours tell formation of a firm gel curd and the pH is 4.6-4.8 and titratable acidity 0.85 – 0.90 % is preferred.

The yoghurt is cooled to about 5 ^{0}C, in refrigerator and held at this temperature until distributed to the consumer. Under these condition the product can be kept satisfactory for 1-2 weeks.

Traditionally the product was made from milk concentrated by boiling, in practice the treatment applied varies from HTST pasteurization to a full UHT process. Such treatment is

recommended: To denatures the whey proteins, which increase the capacity of dairy mass to bind water and subsequently improves the texture (increase the total solids (8.5-15 %), to kill all pathogenic bacteria and high percentage of saprophytic ones.

Types of yoghurt:

(1) Plain yoghurt (natural yoghurt)

Produced from milk and starter culture only without any addition of additives.

(2) Flavoured yoghurt:

Sugar, fruit concentrates various essences such as vanilla and natural colors used in this type of yoghurt.

N.B.

- Yoghurt is recommended as a replacement for milk in the diet of persons suffering from lactose intolerance, because the fermentation of lactose by the action of lactic acid bacteria (starter) lower the lactose content (20-30 %).

- ***There are other forms of yoghurt e.g***.
    1. ***Drinking yoghurt***
    2. ***Dried yoghurt***
    3. ***Frozen yoghurt.***

(4) Acidophillus milk:

- It is produced by lactobacillus acidophillus bacteria which they have the ability to implant themselves in the large intestines.
- This type of fermented milk is prescribed for patients with various stomach disorders including constipation, non-ulcerative colitis and diarrhea.

Manufacture:

- Skim milk or partially de-fatted milk or whole milk is sterilized in an autoclave at 120 ^{0}C for 20 minutes, then cooled to 38 ^{0}C.
- 5 % inoculation of active Lactobacillus acidophilus starter is added.
- The mixture is incubated at 38 ^{0}C for 18-24 hours until a curd forms with about 1 % titratable acidity
- It is cooled to 10 ^{0}C before agitating and pumped to a filler and bottled.
- The acidophilus milk is chilled to 4 ^{0}C and distributed rapidly.

(5) Kefir:

- Kefir originated in the Caucasian Mountains.
- It is made from the milk of the goats, sheep, or cow.
- The distinctive feature of kefir is the application of ***"Kefir grains"*** to sustain the fermentation.
- ***Kefir grains*** are lyophilized cultures, gelatinous whitish or yellowish, irregular granules about the size of a walnut or wheat grains, in which bacteria and yeast cells exist together symbiotically. They are insoluble in water and ordinary

solvents. When it is immersed in milk it swell and turn white, and initiate the dual lactic acid and alcohol fermentation.

- The dominant microbial flora of kefir consists of Saccharomyces kefir, Torula kefir, Lactobacillus caucasicus, Leuconostoc spp. and Lactic acid streptococci. Yeast represent 5 to 10 % of microbial population.

Manufacture:

- Whole milk is pasteurized at 85 ^{0}C for 30 minutes and cooled to 22 ^{0}C.
- Kefir grains then seeded into this milk which is inoculated at 20 – 25 ^{0}C for 20 hours.
- The curdled milk is strained through a clean wire sieve to recover the grains, then chilled and the milk is ready for consumption.
- A good kefir milk foams and fizzes like beer, it is foamy effervescent drink with lactic acid about 0.8-1%, ethyl alcohol 1 % and carbon dioxid.

(6) Koumiss:

- It is lactic acid-alcohol fermented milk of considerable commercial and public health significance to Russia.
- It is made from mar's milk, but similar products are made from whole or skimmed cow's milk.

Manufacture:

- Milk is pasteurized to 70 ^{0}C for 30 minutes and cooled to 30 ^{0}C.

- A 10 % culture containing Lact. bulgaricus, Lact. acidophilus and Saccharomyces lactis is added to milk with 2.5 % beet sugar.
- The mixture is incubated at 27 ^{0}C until firm curd forms with titratable acidity of 0.8 %, then stirred and bottled, cooled to 4 ^{0}C.
- The acidity and ethanol content differ according to the incubation period from 12 hours to 1-3 days, acidity ranges from 0.6 % to 1 % lactic acid and ethanol ranges from 0.7 % to 2.5 %.
- This type of fermented milk in Russia used for treatment of pulmonary T.B.

Defects and spoilage of fermented milks:

(1) Excessive whey:

It is due to:

- Insufficient heating of milk to evaporate ¼ of its water percent i.e. heated at low temperature or short time of heating.
- Short period of incubation.

(2) Excessive acidity:

It occurs due to

- Addition of more starter.
- Long period of incubation
- Failing of cooling after incubation.
- Store at relatively high temperature or exposure to sunlight.

(3) Off-taste:

It is due to:

- Impurity of starter (bad quality starter) which gives abnormal flavour due to presence of saprophytic bacteria and coliforms.
- Insufficient heating of milk.
- Contamination of formed fermented milk with different microorganisms.
- Absorption of different surrounded abnormal odour.

(4) Bitterness:

It is due to:

- Death of starter microorganisms and release of proteolytic enzyme.
- Contamination of fermented milk with proteolytic microorganisms.
- Animal feedstuffs.

(5) Yeast and mold growth:

(6) Soft curd:

It occurs due to:

- Presence of antibiotics, pesticides and insecticides residue.
- Insufficient heating of milk.
- Calcium salt equilibrium (calcium defect).

Fermented milk as carriers of pathogens:

- Although is it too acid to permit growth of most pathogens, sour milk has incriminated in a few out-break of disease, such as Salmonella, Shigella and Coliforms.
- Yoghurt with large number of yeast leads to digestive troubles.

Concentrated milk products

- It is a very valuable products in that it consists of milk which is reduced in bulk and given a very long keeping quality, reduction in transport and storage costs, as well as the need to supply milk to locations where is shortage of fresh milk.
- Concentrated milks may be whole or skimmed milks which has been concentrated by removed of apart of its water (40-50 %) with or without addition of sugar, there are two kinds of concentrated milks (evaporated and condensed).

Composition of concentrated milk

Type	Fat %	MSNF %	Sucrose %	Water %
Unsweetened evaporated milk	**8**	**18**	**0**	**74**
Sweetened condensed milk	**8**	**20**	**45**	**27**

MSNF = Milk solids non fat

Manufacture

(A) Condensed milk:

{1} Inspection of raw milk: (Total solids, fat %, sanitary and keeping quality tests)

- Milk must be of good keeping quality and of normal chemical composition.

{2} Pretreatment of milk:

- Clarification, cream separation.

{3} Standardization:

- The ratio of fat % to the total solids is particularly well controlled in the production of the kind of milk (full fat or skimmed).

{4} Preheating to raw milk (Pasteurization):

- By HTST (at 72 ^{0}C for 15 seconds or at 105-120 for 1-3 minutes) to destroy all pathogenic microorganisms and the higher percent of saprophytic one and also, to inactivate the milk enzymes.

{5} Addition of sugar (sucrose):

- Milk is cooled to 40-50 ^{0}C then sugar is added (16-18 kg /100 kg milk).
- Sugar should be obtained in a very pure condition, but it must be stored dry in order to avoid contamination with yeast and moulds, which would ferment the finished product.
- Sugar is dissolved completely by thorough mixing.

{6} Evaporation or condensation or concentration:

- This process performed by using vacuum pan system at which milk boils at a temperature below the boiling point to decrease the physical and chemical changes of milk, i.e. ranges between 51-54 ^{0}C, this process continues until the content of dry matter reach to 72 %.

{7} Cooling:

- Condensed milk is rapidly cooled to 30-34 ^{0}C to avoid crystallization of lactose which create a gritty taste (Sandiness) and this considered a fault in manufacture.
- Another method to avoid this fault (Sandiness) by seeding the partially cooled milk (25-30 ^{0}C) with very fine lactose crystals or lactose powder with vigorous agitation for one hour to induce the formation of very high numbers of minute lactose crystals. (Undetectable crystals, less than 30 μ).

{8} Packing:

- Condensed milk does not require sterilization.
- The sugar content make as a preservation because it raises the osmotic pressure in milk to level at which many bacteria cannot develop, but other microorganisms especially yeast and moulds are able to develop. So, the

containers used for filling should be sterilized by gas flame or stream or ultraviolet light and the air space in the can should be minimal to prevent mould growth.

(i) Vacuum method:

- Cans are filled and sealed in vacuum sealing chamber by entering the uncovered cans to the vacuumed, covered and sealed or covered cans enter the vacuum chamber then pored, vacuumed and sealed.

(ii) Atmospheric method:

- Cans are completely filled with milk without leaving any space inside, covered and sealed.

(B) Manufacture of Evaporated milk:

{1} Inspection of raw milk: (Total solids, fat %, sanitary and keeping quality tests)

- Milk must be of good keeping quality and of normal chemical composition.

{2} Pretreatment of milk: Clarification, cream separation.

{3} Standardization:

- The ratio of fat % to the total solids is must be 1:3.4 in evaporated milk and separation of fat in case of skim milk.

{4} Preheating to raw milk (Pasteurization):

- By HTST (at 72 ^{0}C for 15 seconds or at 105-120 for 1-3 minutes) to destroy all pathogenic microorganisms and the higher percent of saprophytic one and also, to inactivate the milk enzymes.

{5} Homogenization by using Homogenizers: The milk is forced to pass in the homogenizing vulve in the form of spray under certain pressure rendering the fat globules small in size, loosing its ability to rise up to the surface and remaining homogenous in the milk.

{6} Evaporation:

- As in condensed milk but in case of evaporated milk 60 % of the water has been removed and the dry matter became 25 %.

{7} Cooling:

- Evaporated milk is cooled at 14 ^{0}C, stabilizers as disodium phosphate or sodium citrate up to 0.1 % is added to prevent the protein precipitation during long storage of the product.

{8} Packing:

- By atmospheric method and the filled and sealed cans are sterilized at 110-120 ^{0}C for 15-20 minutes, then cooled at 20 ^{0}C.

Defects (faults) of concentrated milks:

(I) Microbial defects

(1) Gassy fermentation (Gassiness or Blowing):

- Gas fermentation must be sufficient in some cases to make the can bulge or even burst, the contents are mainly highly acidic, lumpy and unfit for consumption due to its bad odour and taste.
- The internal surface of the affected can is usually discoloured and dark.

Causes:

{A} Certain types of coliform organisms such as Enterobacter aerogenes or Klebsiella aerogenes. Although preheating (pasteurization) destroys these organisms, it may be enter the product after pasteurization through various sources of contamination.

{b} Certain types of yeast, such as Torulopsis spherica (Torula lactis condensi) which grows well in media containing high sugar content. The yeast may survive preheating process or enter through sugar contamination or utensils

contamination. In general vacuum treatment inhibits the growth of such organisms.

{c} Certain types of anaerobes, such as Clostridium sporogenes and Cl. butyricum, which survive preheating, process and can, grow in an aerobic condition.

(2) Thickening:

- Certain types of cocci or bacelli as Micrococcus ferundei or aerobic spore former e.g. Bacillus may cause this defect, they produce rennin like enzyme, which causes aggregation of casein micelles into a three-dimensional network.
- Lower temperature storage and improved plant sanitation have been found helpful in combating this defect.

(3) Buttons:

- Development of small reddish brown pieces of coagulated casein firm in consistency may be found on the surface of the can.
- The causative organism is mould (Aspergillus repens) which, produce enzyme causing localized coagulation with disagreeable odour and taste.

(4) Rancidity:

- It may be caused by the presence of high amount of lipase enzyme in milk from which the product is manufactured or the presence of lipolytic microorganisms as yeasts and moulds.
- The defect developed after 1-2 months after canning.

(II) Non- microbial defects:

(1) Grittiness: (Sandiness)

- The product is gritty, instead of being normal smooth or homogenous in texture.
- The fluid is characterized by the presence of large numbers of coarse crystals of sugar (lactose) due to slow cooling, which leads to formation of large (detectable) crystals of lactose.

(2) Lumpiness:

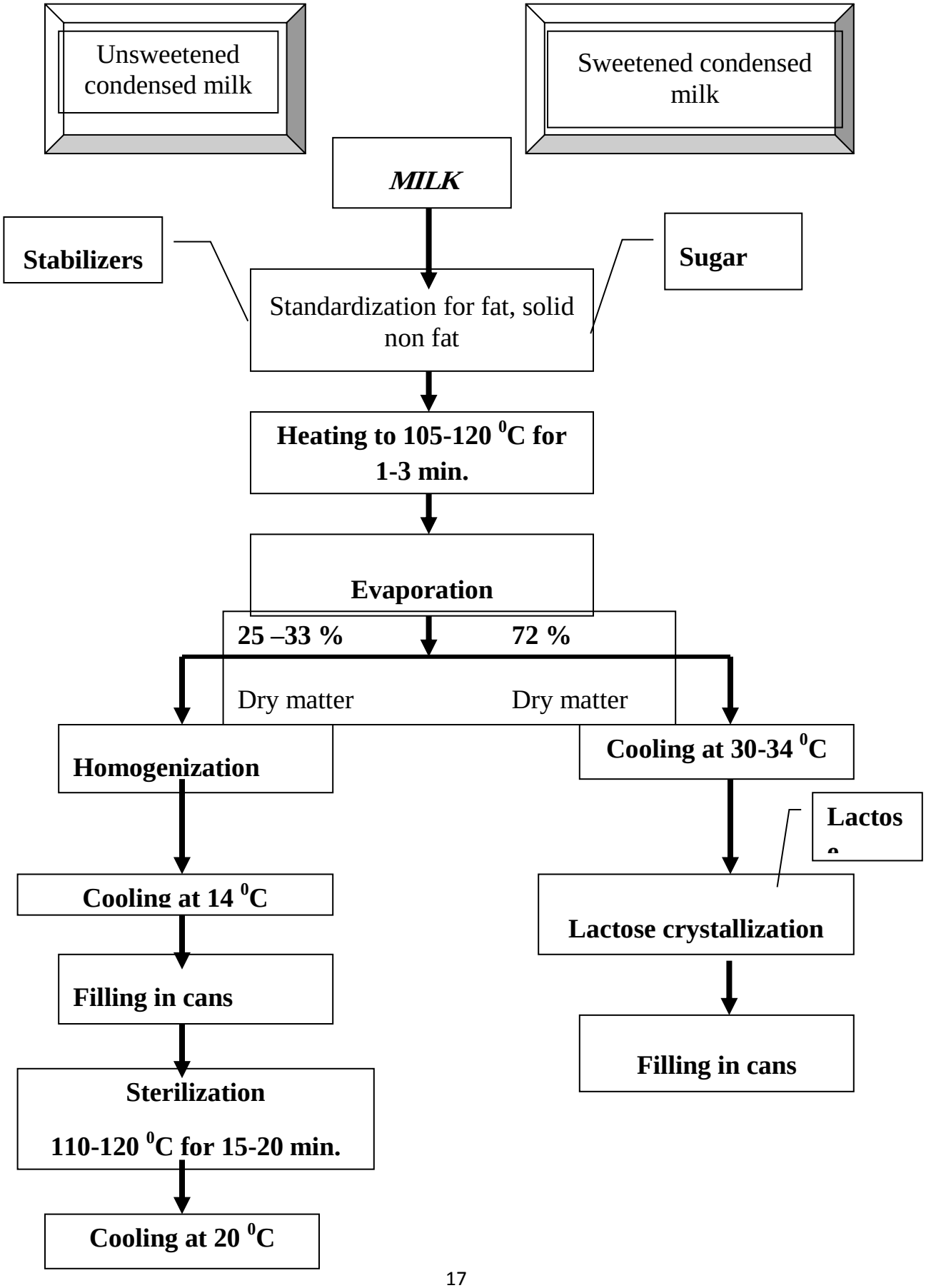
- Appearance of numbers of lumps, either soft or cheesy, floating in the product.
- These lumps are white in colour, mainly caused by using a milk of unusual high content of albumin and globulin (mastitic milk).
- If acid flux soldering material is used in sealing of the cans, reddish lumps well developed in the product.

(3) Thickening:

- Due to change in the colloidal constitution of albumin and casein, mostly due to high temperature used for preheating, condensation and storage.

(4) Brown colouration:

- Condensed milk usually becomes darker in colour during storage at high temperature.
- This change is exaggerated or advanced until exhibiting or involving all contents of the can.
- The cause may be interaction between sucrose, lactose and milk proteins. The acidity and temperature are factors. (high temperature during processing)
- Prevention of this defect is possible, if cans are stored at suitable temperature.


Unsweetened condensed milk
Sweetened condensed milk
MILK
Stabilizers
Sugar
Standardization for fat, solid non fat
Heating to 105-120 0C for 1-3 min.
Evaporation
25 –33 %
72 %
Dry matter
Dry matter
Homogenization
Cooling at 30-34 0C
Lactos
Cooling at 14 0C
Lactose crystallization
Filling in cans
Filling in cans
Sterilization
110-120 0C for 15-20 min.
Cooling at 20 0C

M I L K POWDER (DRIED MILK)

Drying process of milk is considered as a method of preservation of milk as organisms cannot multiply without moisture content as most of them are destroyed by long storage without performance of their biological and vital processes.

Milk powder is prepared by the removal of water from milk, by heat, to produce a solid contains 3 – 5 % or less water but not exceed 5% . Whole, partially skimmed or skimmed milk are used for this purpose, also milk by-products as buttermilk or whey may be used.

MANUFACTURE OF MILK POWDER

I- SPRAY DRYING PROCESS

(1) Milk supply

➲ After receiving milk

- It is tested for → fat content
  → and keeping quality through determination of its acidity as well as bacterial counts, specially for the thermoduric and spore-formers using standard plate technique.
- Standardization or separation of the milk.

(2) Pre-heating

- Low-heat non-fat milk → pasteurized at 72°C for 15 seconds
- High heat non-fat powder in addition to pasteurization → receives a further heat-treatment of 85°C for 20 minutes.
- Whole milk and non fat milk are heated to 88°C or above prior to concentration

(3) Concentration

- The concentration of milk is done in an evaporator to bring the total solids up to the desired level.

4-DRYING

- Concentrated milk is sprayed either by jet through nozzel or atomized by a rotating atomizer in a hot chamber with hot dry air current at 160 °C to 250 °C where the finely divided milk particles are dried rapidly ➔ then fall to the bottom and removed either by rotating knives or by suction.
- The particles are then softened & sieved to remove coarse particles.
- Instantizing ➔ is the process of forming agglomerates of powder which improves the wetting and dispersing properties of the basic powder. The process may involve ➔ the recycling of a newly made powder back to the atomizer head ➔ brought into intimate contact with the moist droplets ➔ thus forming agglomerates (constitute microbiological hazard)

(5) Packaging

@ Vacuum method

- Which is used for high fat products. Powder is packed in cans then replacing air inside by an inert gas (as N & CO_2) by means of partial vacuum.➔then the cans are sealed completely.

@ Atmosphere method

- Which is done under strict hygienic measures to prevent contamination.

➲ Powder prepared by spray drying process is regular, spherical or rounded particles with a diameter ranges from 5 - 10 micron.

II- ROLLER DRYING PROCESS

(1) Milk supply

- The raw milk is received, bulked, clarified, homogenized & then standardized.
- Some manufacturers pasteurize the milk after bulking but prior to standardization.

(2) Concentration

- Milk is fed to the evaporators for pre-concentration prior to drying.
- It is a more economic method for the removal of moisture.
- Total solids vary from 16 up to 28 %.

(3) Drying

- Concentrated milk is fed to the roller driers, which vary from single to double drum types operating either at atmospheric pressure or under vacuum conditions.
- The drums are ➔ supplied with steam up to 150 °C
  ➔ Rotated at speed between 12 and 17 rpm for about 6 to 30 seconds.
- Milk dries rapidly on the hot surface-of the drum and is removed by a sharp plade (doctor's knife or scraper knife) in close contact with the surface.
- The powder is then falls into the collecting through situated parallel to the drum.

(4) Milling

- The product is usually passed through either a keg milk or brush sifter, which breaks the product into a relatively uniform powder prior to packing.
- The powder is packed into 25 kgm sacks or alternatively into retail units.

➲ In vacuum-drum driers, the roller is enclosed in an atmosphere of reduced pressure to give partial vacuum. Milk is subjected to lower drying temperature,

54 -62 °C. Dried milk in this method is known as dried flakes. It gives better solubility and no change in milk constituents.

❖ **Properties of milk powder :**

1- Colour ➔ dark yellow is due to more carotene content, while the brownish colour, especially in roller drying powder is due to mainly to the exposure of milk to high temperature.

2- Milk powder has the property of taking up moisture from air (hygroscopic property). It is prevented by packaging cans in an air-tight moisture proof containers.

3- Solubility of milk powder ➔ is the degree of dispersing of the powder in water.

➲ Spray drying and vacuum-drum powders are

1-readily dispersing in water and acquire many properties of raw milk.

2-No sediment is formed and can pass through filter paper as fluid milk;

3- The solubility degree ranges from 98-99%.

➲ The flakes of roller drying are

1- Disperse in water more slowly and less completely.

2- reconstituted milk when allowed to stand relatively larger amounts of sediment settle to the bottom.

3- On filtering the mixture ➔ larger portion remains on the filter paper.

4- The solubility degree ➔ 80 – 85 %

MICROBIOLOGY OF MILK POWDER

I- SPRAY DRYING MILK

1- Raw milk quality ➔

- The milk used should be of good hygienic quality with special attention to thermodurics & thermophilic organism.

2- Preheating of milk ➔

- Resulted milk powder of high bacteriological quality.

3- Drying air

- Filtration of the air prior to heating using special filter & heating of air usually sufficient to avoid any serious contamination.

4- packaging process

- Should done under strict hygienic measures as well as replacing oxygen with nitrogen or carbon dioxide.

5- Organisms that may gain entrance to powder are Micrococci, Streptococci as Str.thermophilus and Str.faecalis, aerobic spore-formers as B subtilis, Corynebacterium, Coliforms and S.aureus as well as Salmonellae as pathogens.

6- Laterly, there has a move towards the UHT-temperature heat-treatment of milk for processing into milk powder. Such action results in near-sterile powder with only casual post-heat treatment contaminants being present.

II- ROLLER DRYING POWDER

- Have more bacteriological quality due to higher temperature to which the product exposed.
- The drying drums result in a reduction of viable organism in the production with the net result that powder taken from rol1er surfaces shows only thermoduric bacteria with aerobic spore-formers predominating
- Post – drying contamination is the main source of microorganisms to roller drying powder especially during manual collection of the powder from the drum & during manual packaging of the products ➔ result in contamination especially with Staphylococci & Salmonella.

- Using disposable plastic gloves is one method of reducing the contamination when manual procedures employed.
- So mechanical packaging under strict hygienic measures should be done.
- Micrococci, aerobic spore-formers and Sarcina species predominate in the mesophilic range.
- While aerobic- spore formers make up the microbial population in the thermophilic range.

DEFECTS OF MILK POWDER

♥ The presence of any defects along the manufacture processes may lead to change in the physical and chemical properties of milk powder.

1- TALLOW FLAVOUR:

- It is the major storage defect of full cream powder due to oxidation of milk fat
- Factors influence the fat oxidation
  - → Moisture content
  - → Presence of light
  - → More acidity →increase oxidation of fat
  - → Traces of heavy metals (copper & iron → catalyst) so stainless steel equipment are used.
  - → Storage temperature ➔ each increase in temperature by 10 C → increase the rate of deterioration by 2.2 %
- Prevented by ➔ Avoiding package in transparent package
  - ➔ Packaging under vacuum (using inert gases)
  - ➔ Addition of antioxidant (prohibit in some countries)

e.g. Ascorbic acid → add in concentration 0.03 % in liquid milk → improve the K.Q by several months but disappear during storage.

Esters of gallic acid → as ethyl or propyl gallate add at level of 0.07 % → improve the K.Q by about 2 years.

2- **Stale flavour** → protein change (galactase enzyme)

3- **Fishy odour** → due to hydrolysis & oxidation of lecithin

→ High moisture is the main predisposing factors.

4- **Lactose glares (lumpiness)** →due to crystallization of alpha lactose monohydrate.

5- **Rancidity** →due to hydrolysis of fat resulting in liberation of butyric & other fatty acid.

Ice cream and related products

It's a smooth, sweet, cold food prepared from a frozen mixture of milk products and flavorings, containing a minimum of 10 percent milk fat and eaten as a snack or dessert.

Typical composition of ice cream contains:

10 %	Fat,	11%	Milk solids-non- fat
14%	Sugar,	0.5 %	Emulsifier & Stabilizer
64.5%	Water		

(1) Ingredients:

Dairy and non dairy ingredient:

{A} Dairy ingredient:

- Include whole fresh milk, skimmed milk, milk powder, and concentrated milk, fresh cream (source of both fat and solids – non- fat.
- Function of milk fat:
    1. imporove body and texture of ice cream.
    2. Provides a rich flavor to ice cream.
    3. Milk fat may be replace by vegetable fat of melting point below 37 C to avoid fatty mouth- feel
- Function of milk solids–non-fats (SNF):
    1. Provides body texture and contributes to sweetness and air incorporation.

{B} Non dairy ingredients:

{1} Sugar: Sucrose or glucose , sorbitol

Function: Sweeting agent, decrease freezing point, improves texture

{2} Stabilizers:(Gelatine, agar agar, gum, carboxy methyl cellulose, sodium alginate).

Function: combined with the water ⟶ gel formation

Improve mix viscosity, air incorporation, texture and melting qualities and prevent the formation of large ice crystals

{3} Emulsifiers: (egg yolk, whole egg, mono or diglycerides)

Function: dispersion of the fat throughout the mixture so prevent churning during freezing, improve whipping quality and texture.

{4} Flavoring agent: (vanilla, chocolate, fruit, fruit juice, nut etc..)

{5} colouring matter: It improves appearance and reinforces flavours.

{6} Cornflouer or custard.

Manufacture of ice cream

On large scale

1. Ingredients:

- Select ingredient of superior quality.

2. Calculation of the mix of the ice cream which depends on:

- Legal standard, preference of the consumer, need of the market and economic consideration.
- Adjust the fat to the sugar ratio to avoid fatty mouth- feel
- Adjust the T.S to the water ratio to avoid both lactose crystal formation and ice crystal formation.

3. Mix blending:

The ingredients are weighed and blended together to produce what is known as the "ice cream mix". Blending requires rapid agitation to incorporate powders, and often high speed blenders are used.

- **In small-scale,** Ingredients are blended in the pasteurization vat during heating at LTLT using an agitator or in some cases, a blender-emulsifier to facilitate dispersion and mixing of ingredients.

- **In large scale,** it is necessary to blend the mix before heat treatment (HTST or UHT) due to short exposure during heating.
- Ingredients such as dried milk powder and gum cannot be used without heating the mix.

4. Heat treatment :

The mix is then **pasteurized**. Pasteurization is the biological control point in the system, designed for the destruction of pathogenic bacteria. In addition to this very important function, pasteurization also reduces the number of spoilage organisms such as psychrotrophs, and helps to hydrate some of the components (proteins, stabilizers).

Both batch pasteurizers and continuous (HTST) methods are used.

Batch pasteurizers lead to more whey protein denaturation, which some people feel gives a better body to the ice cream. In a batch pasteurization system, blending of the proper ingredient amounts is done in large jacketed vats equipped with some means of heating, usually steam or hot water. The product is then heated in the vat to at least 69 ^{o}C (155 F) and held for 30 min to satisfy legal requirements for pasteurization, necessary for the destruction of pathogenic bacteria. Various time temperature combinations can be used. The heat treatment must be severe enough to ensure destruction of pathogens and to reduce the bacterial count to a maximum of 100,000 per gram. Following pasteurization, the mix is homogenized by means of high pressures and then is passed across some type of heat exchanger (plate or double or triple tube) for the purpose of cooling the mix to refrigerated temperatures (4 C). Batch tanks are usually operated in tandem so that one is holding while the other is being prepared. Automatic timers and valves ensure the proper holding time has been met.

Continuous pasteurization is usually performed in a high temperature short time (HTST) heat exchanger following blending of ingredients in a large, insulated

feed tank. Some preheating, to 30 to 40 C, is necessary for solubilization of the components.

5. Homogenization / Emulsification:

The mix is also **homogenized**, which forms the fat emulsion by breaking down or reducing the size of the fat globules found in milk or cream to less than 1 µm. Two stage homogenizations is usually preferred for ice cream mix. Clumping or clustering of the fat is reduced thereby producing a thinner, more rapidly whipped mix. Melt-down is also improved. Homogenization provides the following functions in ice cream manufacture:

- Reduces size of fat globules
- Increases surface area
- Forms membrane
- makes possible the use of butter, frozen cream, etc.

By helping to form the fat structure, it also has the following indirect effects:

- makes a smoother ice cream
- gives a greater apparent richness and palatability
- better air stability
- increases resistance to melting

Homogenization of the mix should take place at the pasteurizing temperature. The high temperature produces more efficient breaking up of the fat globules at any given pressure and also reduces fat clumping and the tendency to thick, heavy bodied mixes. No one pressure can be recommended that will give satisfactory results under all conditions. The higher the fat and total solids in the mix, the lower the pressure should be. If a two-stage homogenizer is used, a pressure of 2000 - 2500 psi on the first stage and 500 - 1000 psi on the second stage should be satisfactory under most conditions. Two stage homogenizations is usually preferred for ice cream mix. Clumping or clustering of the fat is reduced

thereby producing a thinner, more rapidly whipped mix. Melt-down is also improved.

- Homogenization is necessary in large plant producing ice cream of high fat content and / or high overrun, but emulsification is an alternative in small-scale operations where ice cream is of a relatively low fat content and / or overrun.
- Emulsified mix produce fat of larger size compared to homogenized mix, of variable size of fat globules.

6. Cooling and ageing:

Rapidly cooling to 4 ^{0}C for 1.5 hours to stop the growth of M.Os, the mix is then aged for at least four hours and usually overnight. This allows time for the fat to cool down and crystallize, and for the proteins and polysaccharides to fully hydrate. Aging provides the following functions:

- Improves whipping qualities of mix and body and texture of ice cream

It does so by:

- providing time for fat crystallization, so the fat can partially coalesce;
- allowing time for full protein and stabilizer hydration and a resulting slight viscosity increase;
- allowing time for membrane rearrangement and protein/emulsifier interaction, as emulsifiers displace proteins from the fat globule surface, which allows for a reduction in stabilization of the fat globules and enhanced partial coalescence.

Aging is performed in insulated or refrigerated storage tanks, silos, etc. Mix temperature should be maintained as low as possible without freezing, at or below 5 C. An aging time of overnight is likely to give best results under average plant conditions. A "green" or unaged mix is usually quickly detected at the freezer.

- Cooling the mix to – 1 ^{0}C to 2 ^{0} C permits the use of shorter ageing periods.

7. Freezing: **Two stages**

a) In the first stage the temperature is reduced to be – 9 to – 10 ^{0}C accompanied with air incorporation to increase the volume of the product up to 100% and may be 120%, this process called **Overrun** . Overrun may be calculated either by volume or weight according to the following:

By volume:

% Overrun = (Vol. of ice cream - Vol. of mix used)/Vol. of mix used x 100%

Example : 500 L mix gives 980 L ice cream, (980 - 500)/500 x 100% = 96% Overrun

80 L mix plus 10 L chocolate syrup gives 170 L chocolate ice cream, (Note : any flavours added such as this chocolate syrup which become homogeneous with the mix can incorporate air and are thus accounted for in this way : (170 - (80 + 10))/(80 + 10) x 100% = 88.8% Overrun

By weight:

% Overrun = (Wt. of mix - Wt. of same vol. of ice cream)/Wt. of same vol. of ice cream x 100%

Must know density of mix (wt. of 1 L), usually 1.09 - 1.1 kg. /L.

Example : If 1 L of ice cream weighs 560 g, % Overrun = (1090 - 560)/560 x 100% = 94.6% Overrun

b) The second stage (hardening) , which is much slower, involves no incorporation of air and takes place in a hardening room at – 20 to – 25 ^{0}C. for 10-12hrs, or hardening at – 30 to – 35 ^{0}C for 2-5hrs.

(H) Finishing and packaging:

- After hardening process the ice cream may be finished by enrobing with chocolate or another candy product, by addition of chopped nuts etc., or by combining the ice cream with water ice. Where necessary the ice cream is then packaged.

(I) Storage and distribution:

- Best temp of –13 to – 18 ^{0}C are used during transport and short-term display, while a temperature of – 20 to - 25 ^{0}C is used for long-term storage.
- Avoid fluctuation of temp during storage to avoid large crystal formation.

(B) At home:

- Milk, sugars, flavouring and custard should be mixed in cooled water and frozen the mixture with mixing to prevent formation of crystals.

(C) On small-scale (small vendors):

- The milk added gradually to a starchy material to form a paste.
- The remaining milk is added and mixed. Sugar is added and the mixture is left to cool overnight. This period may allow multiplication of pathogenic organisms, if present.
- After cooling, flavour extract is added and the mixture is frozen by freezing mixture (ice and salt) using hand-operating freezer or using their hands or rotatory machine for rotating the mixture.

Types of ice cream

1- Ice cream:

2- Milk ice: As ice cream but contains 2.5 – 3 % fat.

3- Custard ice cream:

They are made with eggs or egg yolk solids and must contain at least 1.4 % (w/w) egg yolk solids.

4- Water ice:

It is made from dilute fruit juice with sugar and added acid. Stabilizer and added colours and flavours may also, be present.

5- Sherberts and Sorbets: They are both similar to water ice, but contain small quantities of milk solids and in some cases whipping agents to give a higher overrun.

6- Mousse:

It is a frozen confection of whipped cream, sugar and flavor with high fat content.

7- Soft ice cream:

a frozen product served directly to the consumer at $-6.7\ ^{0}C$, sugar 2-3%.

8- Dietetic ice cream:

Ice cream of low sodium content for cardiac patient and using sorbitol instead of sucrose.

9- Diabetic ice cream: Low lactose non-fat dry milk may be used (36 %), , sorbitol instead of sucrose.

10- Mellorine: Using vegetable fat instead of milk fat have similar melting point.

Microbiology of ice cream

Salmonella species and Listeria monocytogenes are main organisms that contaminate ice cream which may be derived from contaminated fruits or gelatin or eggs that used in the manufacture of ice cream.

Defects of ice cream

The defects in ice cream commonly are:

1) **Off – flavour:**
   1- Cooked: Caused by using milk products heated to too high temperature or by using excessively high temperatures in mix pasteurization.
   2- High Acid: Use of dairy products with high acidity (usually due to bacterial spoilage) or holding mix too long and at too high a temperature before freezing.

3- **Egg:** Caused by using too much egg in an ice cream that is not specified as a custard ice cream.

4- Salty: Ice cream too high in milk solids-not-fat. Too much salt may have been added to the mix. using salted butter used instead of sweet butter.

5- Oxidized: Caused by oxidation of the fat or lipid material such as phospholipid, similar to fluid milk oxidation. Induced by the presence of copper or iron in the mix or from the milk itself.

6- Rancid: Caused by rancidity of milk fat. May be due to use of rancid dairy products or due to insufficient heat before homogenization of mix.

(2) Body and texture defects:

1- **Coarse/Icy Texture:** Due to the presence of ice crystals of large size which

2- Gummy(Sticky) Body

3- **Sandiness (Crystallization of lactose)**: One of the most objectionable texture defects but easiest to detect. It is caused by Lactose crystals, which do not dissolve readily and produce a rough or gritty sensation in the mouth. This can be distinguished from "iciness" because the lactose crystals do not melt in your mouth. Caused due to

- Slow cooling
- Increase solid non fat more than 11%.
- Fluctuation of temperature

4- Weak Body:

5- Crumbly Body: A flaky or snowy characteristic caused by:

(3) Colour defects: