Dairy
- Milk and Milk Products

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What is milk?

- Milk is a whitish liquid containing proteins, fats, lactose various vitamins and minerals that is produced by the mammary glands of all mature female to nourish their young for a period beginning immediately after birth.

- Milk and any of the foods made from milk, including butter, cheese, ice cream, yogurt etc. are the products of milk.

- The term *milk* is also used for white colour, non-animal beverages resembling milk in colour & texture such as soy milk, rice milk, almond milk, & coconut milk.
Composition of Milk

Water: 87-88 %

Carbohydrate: Approx. 5 %
- mainly Lactose, which converts to Lactic acid by bacterial fermentation
- In condensed milk, there is also lactulose which is a little sweeter.

Fat: 3-4 % in whole milk
- contains fat soluble vitamins, pigment carotene & Xanthophylls.
- contains cholesterol & phospholipids but is primarily Tri-glycerides (95%).
- The fat in milk occurs in the form of droplets or globules, surrounded by a membrane and emulsified in the milk serum part (the whey part or the watery part).
- Milk is an oil/water emulsion which is not naturally physically stable that is why creaming occurs if it is left to stand.

Protein: 3-4 %

1. Casein (80% of milk protein)
- The casein is arranged in super-structures called micelles, which consist of protein together with phosphate, citrate and calcium.
- The caseins are actually a group of similar proteins, which can be separated from the other milk proteins by acidification to a pH of 4.6
- The casein micelles also may be coagulated by addition of the enzyme rennin.
2. Whey protein (20% of milk protein)
   - lactalbumin, lactoglobulin & immunoglobulin.
   - Whey proteins are more hydrated than casein and are denatured and precipitated by heat rather than by acid.

3. Other protein components
   - include enzymes such as lipase, protease, & alkaline phosphatase, which hydrolyses triglycerides, proteins, & phosphate esters, respectively.

   The milk proteins are of high BV & are readily used by the body

Vitamins and Minerals

- Vitamins A, B6, B12, C, D, K, E, thiamine, niacin, biotin, riboflavin, folates, and pantothenic acid.
- Vitamin A is naturally in the fat component of whole milk and more may be added prior to sale.
- whole milk is generally (98%) fortified with vitamin D because it is naturally present only in small amounts.
- Ca & P approx. 1% of milk
- Ca is present as calcium caseinate, calcium phosphate & calcium citrate.
- Other minerals present are chloride, magnesium, potassium, sodium, and sulfur.
Composition of Milk from different species

<table>
<thead>
<tr>
<th>Nutrient (in 100g)</th>
<th>Cow</th>
<th>Human</th>
<th>Buffalo</th>
<th>Goat</th>
<th>Sheep</th>
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<tbody>
<tr>
<td>Water(%)</td>
<td>87.99</td>
<td>87.50</td>
<td>83.39</td>
<td>87.03</td>
<td>80.70</td>
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<tr>
<td>Calories</td>
<td>61</td>
<td>70</td>
<td>97</td>
<td>69</td>
<td>108</td>
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<tr>
<td>Protein(g)</td>
<td>3.29</td>
<td>1.03</td>
<td>3.75</td>
<td>3.56</td>
<td>5.98</td>
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<tr>
<td>Fat(g)</td>
<td>3.34</td>
<td>4.38</td>
<td>6.89</td>
<td>4.14</td>
<td>7</td>
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<tr>
<td>CHO(g)</td>
<td>4.66</td>
<td>6.89</td>
<td>5.18</td>
<td>4.45</td>
<td>5.36</td>
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<tr>
<td>Cholesterol(mg)</td>
<td>14</td>
<td>14</td>
<td>19</td>
<td>11</td>
<td>193</td>
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<tr>
<td>Ca (mg)</td>
<td>119</td>
<td>32</td>
<td>169</td>
<td>134</td>
<td>193</td>
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<tr>
<td>Phosphorus(mg)</td>
<td>93</td>
<td>114</td>
<td>117</td>
<td>111</td>
<td>158</td>
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<td>Sodium(mg)</td>
<td>49</td>
<td>17</td>
<td>52</td>
<td>50</td>
<td>44</td>
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<tr>
<td>Potassium(mg)</td>
<td>152</td>
<td>51</td>
<td>178</td>
<td>204</td>
<td>136</td>
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<td>Vit C(mg)</td>
<td>0.94</td>
<td>5.00</td>
<td>2.25</td>
<td>1.29</td>
<td>4.16</td>
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<tr>
<td>Vit A (IU)</td>
<td>126</td>
<td>241</td>
<td>178</td>
<td>185</td>
<td>147</td>
</tr>
<tr>
<td>Riboflavin(mg)</td>
<td>0.162</td>
<td>0.036</td>
<td>0.135</td>
<td>0.138</td>
<td>0.355</td>
</tr>
</tbody>
</table>
Physical properties of Milk

- **Acidity:** fresh milk pH is 6.5-6.7 at 25°C.

- **Viscosity:** depends on the amount of fat, size of fat globules & extent of clustering of globules.
  - Homogenisation & ageing increases the viscosity of milk.

- **Freezing point:**
  - -0.55°C, addition of 1% of water to milk decreases the FP by -0.0055°C.

- **Boiling point:** 100.2°C.
Nutritive Value of Milk

- **Good quality protein** & BV is over 90%. Lysine is abundance.
- **Easily digestible fat** containing 2.1% linoleic acid, 0.5% linolenic acid & 0.14% Arachidonic acid.
- Only substance that contain lactose which is essential for:
  - Synthesis of myelin sheath (galactose)
  - Favors the growth of lacto bacillus in intestine & decrease the pH thus favouring Calcium absorption.
  - Also increases the permeability of Small Intestine for Ca+2.
- Poor source of iron & vit. C.
- Not a good source of niacin but **excellent source of tryptophan**.
- Major source of Calcium & riboflavin.
Flavour of Milk

• The flavour of milk is mild & slightly sweet. The characteristic mouth-feel is due to the presence of emulsified fat, colloidally dispersed proteins, the carbohydrate lactose, & milk salts.
• Fresh milk contains acetone, acetaldehyde, methyl ketones, & saturated fatty acids that provide aroma.
• “Flavour treatment” to standardize the odour and flavour typically follows pasteurization. In this treatment process, milk is instantly heated to 195 °F (91°C) with live steam (injected directly into the product), and subsequently subject to a vacuum that removes volatile off-flavours and evaporates excess water produced from the steam.
• Less desirable, “barny” or rancid flavours, or other “off-flavours,” may be due to the following:
  1. Slightly “cooked” flavour from excessive pasteurization temperatures.
  2. Animal feed, including ragweed and other weeds, or wild onion from the field.
  3. Lipase activity causes rancidity of the fat, unless destroyed by the heat of pasteurization. (Or, the short-chain butyric acid may produce an off-odour or off-flavour due to bacteria rather than lipase in the emulsified water of milk.).
  5. Stage of lactation of the cow.
Contamination of milk and milk products

• Milk is sterile at secretion in the udder but is contaminated by bacteria even before it leaves the udder.

• Further infection of the milk by microorganisms can take place during milking, handling, storage, and other preprocessing activities.

Few types of microorganisms which found in milk are:

1. *Streptococcus lactis*  
2. *Achromobacter*  
3. *Bacillus subtilis*  
4. *Coliform bacteria*
Milk Products

Milk →
- Curds
  - Separate out the protein
  - Skim off the fat
- Whey
  - Heat
- Cream
  - Churn
  - Lowfat, Skimmed
- Milk
  - Ferment with probiotic bacteria
- Yogurt
  - Sour
  - Strain
  - Culture

Curds →
- Cheese
  - Drained & salted
  - Heat
  - Press
c  - Fresh
- Ricotta
  - Re-cooked

Whey →
- Heat

Cream →
- Butter
  - Churn
  - Buttermilk
  - Creme fraiche
  - Soured cream
  - Cream cheese
- Milk
  - Skimmed

Yogurt →
- Cultured buttermilk
- Greek yogurt
- Kefir

Cheese →
- Mozzarella
- Cottage cheese
- Paneer
- Feta
- Havarti
- Gouda
- Cheddar
- Parmesan
- Brie
- Blue cheese

Butter →
- Whipped cream
- Butter milk

Milk →
- Skimmed
Different Milk Products

1. Fermented milk products
2. Non-Fermented milk products
1. Non-Fermented milk products

- **Whey protein concentrate**: ultrafiltration technology is used to concentrate protein in whey to various levels between 20-80%. High BV & PER.

- **Skim milk**: fat content reduced to 0.5-2% by centrifugation. Extensive use in bakery & confectionery. Also used for low calorie diets & children who need high protein.

- **Evaporated milk**: 50-60% water evaporated, clarified raw milk is concentrated in vacuum pan at 74-77°C. Fortified with Vit D, sterilised in cans at 118°C for 15 minutes & cooled. As per PFA condensed milk should contain 26% milk solids of which 8% is fat.

- **Sweetened condensed milk**: not sterile, made from pasteurized milk concentrated 7 sweetened with 65% sucrose. Contains 9% fat out of 31% milk solids.
• **Toned milk:** 7% fat; mix of reconstituted from skim milk powder with buffalo milk.
  - Fat content >5% & SNF 8.5%

• **Double toned milk:** admixture of cow’s or buffalo’s milk or both with fresh skimmed milk or by admixture with skim milk reconstituted from skim milk powder.
  - Should be pasteurised & show negative phosphatase test.
  - Fat content <1.5% & SNF >9%.

• **Recombined milk:** It is the liquid milk obtained by adding skim milk powder (SMP) to water and adding milk fat separately to achieve the desired fat and total solids content.

• **Filled milk:** homogenised product prepared from refined vegetable oil & MSNF & water.
  - Fat content > 3% & SNF 8.5%
- **Malted Milk** is a powdered gruel made from a mixture of malted barley, wheat flour, and whole milk, which is evaporated until it forms a **powder**.

- Malt powder comes in two forms:
  - Diastatic malt contains enzymes that break down starch into sugar; this is the form bakers add to bread dough to help the dough rise and create a good crust.
  - Nondiastic malt has no active enzymes and is used primarily for flavor, mostly in beverages. It sometimes contains sugar, coloring agents, and other additives.

- A **lactose-free milk** is available for people who are lactose-intolerant. This modified milk is made by filtering regular milk to remove half the lactose. The enzyme lactase is then added to the milk to break down the remaining lactose into simpler forms which the body can absorb.

- **Flavoured milk** is a dairy drink made with milk, flavourings and sugar, often enriched with vitamins and calcium.
- **Ultra-high temperature (UHT) processed milk**: packed & aseptically sealed in containers under aseptic conditions.
  - can be stored Unrefrigerated for at least 3 months.
  - Cooked flavour due to denaturation of β-lactoglobulin.
- **Standardised milk**: fat is maintained 4.5% and SNF 8.5%. Mix of buffalo & skim milk.
- **Dry milk**: made with whole milk or skimmed milk dehydrated to about 97% by spray drying & vacuum drying. Good shelf life. Highly hygroscopic & can be reconstituted to fluid milk.
- **Khoa**: semi-solid obtained from milk by evaporating in open pans with continuous stirring in circular motion. Yield is about 20% of weight of milk used.
- **Rabri**: concentrated sweetened product comprising several layers of clotted cream. Sugar is added to milk reduced to 1/3 of its original volume.
- **Chhaina**: major heat & acid coagulated product. Used in sweets like rasmalai, rasogolla, etc.
**Ice-cream**: frozen dairy product consisting of whole milk, skim milk, cream, butter, condensed milk products or dried milk products. Milk fat (MF) & milk solid non-fat (MSNF) constitute 60% of total solid giving it a rich flavour, improved body & texture.

- Also contains sugar, stabiliser, emulsifier, flavoring material, water & air.
- Sugar provides sweetness, smoothness & lowers the freezing point.
- Stabiliser prevent formation of ice crystals. Forms gel with water & thereby improve body & texture. e.g., gelatin, sea weed, china grass & CMC.
- Emulsifier help disperse fat globules throughout the mix & prevent clump formation, further help make ice-cream dry & stiff.
Cream

- *Cream* is the high-fat component separated from whole milk as a result of the creaming process. It has a higher proportion of fat droplets to milk than regular fluid milk; and according to federal standards of identity, cream must contain 18% milk fat or more. Due to this high fat content of cream compared to milk, some yellow, fat soluble pigments may be apparent.

- Various liquid creams available for use in foods include the following:
  - Light (coffee) cream: 18–30% butterfat.
  - Light whipping cream: 30–36% butterfat.
  - Heavy cream: 36% butterfat, minimum.
  - “Half-and-half” cream diluted with non-fat milk: 10.5% butterfat.
  - Whipping cream packaged under pressure in aerosol cans; may be non-fat or contain various levels of fat, sugar, flavouring, emulsifiers, and a stabilizer.
2. Fermented milk products

**Butter**
- Fat content is generally about 80%.
- Made from sweet or sour cream.
- *Butter* is a concentrated form of fluid milk produced through churning of pasteurized cream. **Churning** involves agitation that breaks fat globule membranes so the emulsion breaks, fat coalesces, and water (buttermilk) escapes.
- The original 20/80 *oil-in-water* type of emulsion of milk becomes a 20/80 *water-in-oil* emulsion.
- Milk is churned to form butter and the watery buttermilk. Butter may have a yellow color due to the fat-soluble animal pigment, carotene, or an additive.
- Butter spoil as a result of hydrolysis of TG molecules releasing free butyric & caproic acids.
• **Ghee**, a type of clarified butter, is prepared by simmering butter and removing the residue. The texture, colour, and taste of ghee depend on the quality of the butter and the duration of the boiling.

• **Buttermilk** was the liquid left behind after churning butter out of cream. It is beneficial to health as it contains probiotic microbes also fat content of buttermilk is far lower than milk or curd.

• **Curd** prepared by cooling boiled milk to body temperature & adding 5-10% starter. After 6-8 hours an acidity of 0.9-1% is formed which coagulate the casein & curd is set.
  ▫ Easily digested than normal milk. Contains more vit B than milk.
  ▫ Used as marinating & souring agent in cookery
• **Yogurt** is a variety of curd. Whole, low fat, skim milks & even cream can be used to make yogurt.
  - In production of yogurt, a mixed culture of *Streptococcus thermophilus*, *Lactobacillus acidophilus* is usually added to the pasteurised milk & incubated at 42-46°C.
  - Increase in folic acid concentration during fermentation.
  - Fermented milk is useful for a wide variety of disorders like colitis, constipation, diarrhoea, gastroenteritis, diabetes & hypercholesteremia.

• **Shrikhand:** fermented product made by concentrating dahi by removing whey & to which sugar, flavor & condiments are added.

• **Cheese** is made by the coagulation of milk protein casein. Varieties of cheese are differentiated according to their ......
  - Flavour – Texture – Type of Milk – Salts & seasoning added
  - Types of bacteria & mould species used in ripening
  - Manufacturing & processing method.
Production of Cheese

- **Curd formation**: pasteurised whole milk is brought to a temperature of 31°C, starter & required colouring matter is added. After 30 min rennin is added, stirred & allowed to set curd.

- **Curd cutting**: into small cubes

- **Curd cooking**: heated to 38°C & held for 45 min. curd is stirred to prevent matting.

- **Curd drainage**: whey is drained off & curd is allowed to mat.

- **Cheddaring**: cutting matted curd into blocks turning them at 15 min interval & then piling. It is then passed to curd mill which cuts the slab into strips.

- **Salting the curd**: to draw out the whey from curd & as preservative.

- **Pressing**: overnight
Ripening: 60 days to 12 months depending on the flavour required under controlled conditions of temperature & humidity.

Changes from a bland tough rubbery mass to a full flavoured soft product.

Rennin splits protein into peptones & peptides.

Increases the B-vitamins & improves cooking quality.

Cheese has limited keeping quality & requires refrigeration, should be kept cold & dry i.e., wrapped in wax paper or metal foil.
Milk Processing

- Clarification
- Homogenization
- Pasteurization
- Fortification
- Bleaching
- Dehydration

Processing is required to produce milk of low bacterial count, good flavor & sufficient keeping Quality.
1. Clarification and Clearing

- **Clarification**: removal of small particles
  - straw, hair etc. from milk; 2 lb/2,642 gal
  - based on density
- **“Bactofugation”**: Centrifugal separation of microorganisms from milk:
  - Bacteria and particularly spores have higher density than milk
  - Two-stage centrifugation can reduce spore loads up to >99%
  - Optimal temperature for clarification is 55-60ºC
- **Microfiltration**
  - Micro-filter membranes of 1.4 μm or less can lead to reduction of bacteria
  - and spores up to 99.5-99.99%.

2. Homogenization

- **Function**: to prevent *creaming*, or the rising of fat to the top of the container of milk.
- The process of homogenization permanently *emulsifies* the fine fat globules by a method that pumps milk under high pressure [2000–2500 lb/in² (psi)] through small mesh orifices of a homogenizer.
- Homogenization *mechanically increases the number & reduces the size of the fat globules*. The size is reduced to 1/10 of their original size.
- **Resulting** in the milk that maintains more uniform composition with improved body and texture, a whiter appearance, richer flavor, & more digestible curd.
3. Pasteurisation

- Pasteurisation is a relatively mild heat treatment, sufficient to destroy disease-causing microorganisms and inactivate enzymes to extend its shelf life.

- It should be followed by immediate cooling of product to the temp. sufficiently low to check the growth of microorganisms which are resistant to temp. used.

- Pasteurisation causes minimal sensory and nutritive changes in the food. Some vitamin levels are reduced, mainly vit B1 & vit C.

**Different pasteurisation methods**

1. **Low-temperature-longer time (LTLT)**
   - 65°C for 30 minutes, called the Holding or Batch method

2. **High-Temperature-Short-Time (HTST)**
   - Heat treatment of 72°C for 15 seconds is applied, followed by rapid cooling to below 10°C. Also called the continuous system or flash pasteurisation.

3. **Ultra High Temperature (UHT)**
   - 149.5°C for 1 second or 93.4°C for 3 sec.
Alkaline phosphatase test:
• Enzyme Alkaline Phosphatase present in raw milk serves as a built-in-indicator to gauge the adequacy of pasteurisation.
• Inadequate pasteurization of raw milk reveals the presence of a high alkaline phosphatase activity.
• It is so sensitive that it gives positive in presence of 0.1% raw milk added or if the pasteurisation temp. is less by 1 degree F.

4. Fortification
• The addition of fat-soluble vitamins A and D to whole milk is optional but must for Low-fat milk & non-fat milk (usually before pasteurization) to carry
  - 2000 IU or 140 retinol equivalents (RE) vitamin A per quart.
  - Vitamin D to reach levels of 400 IU’s per quart is optional but routinely practiced. Evaporated milks must be fortified.

• To increase the viscosity and appearance, as well as the nutritive value of low-fat milk, (MSNF) may be added to milk.
  This addition allows milk to reach a 10% MSNF (versus 8.25% usually present), and it will state “protein fortified” or “fortified with protein” on the label.
5. Bleaching

- *Bleaching* carotenoid or chlorophyll pigments in milk may be desirable.
- The FDA allows benzoyl peroxide or a blend of it with potassium alum, calcium sulphate, or magnesium carbonate to be used as a bleaching agent in milk.
- Vitamin A or its precursors *may be destroyed* in the bleaching process; therefore, sufficient vit A is added into the milk, or in the case of cheese making to the curd.

6. Dehydration

<table>
<thead>
<tr>
<th>Spray Drying</th>
<th>Drum Drying</th>
<th>Freeze Drying</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pasteurized milk is first concentrated in an evaporator to approximately 50% milk solids. The resulting concentrated milk is then sprayed into a heated chamber where the water almost instantly evaporates, leaving fine particles of powdered milk solids.</td>
<td></td>
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</tr>
<tr>
<td>Milk is applied as a thin film to the surface of a heated drum, and the dried milk solids are then scraped off. However, powdered milk made this way tends to have a cooked flavor, due to caramelization caused by greater heat exposure.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Same as drum drying but involves freezing which retains more amount of nutrition.</td>
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<td></td>
</tr>
</tbody>
</table>
**Applications of Milk**

- Milk has long been a popular beverage, not only for its flavour but because of its unique nutritional package.

**Bone health**
Milk and milk products are providers of calcium, phosphorus, magnesium and protein which are all essential for healthy bone growth and development.
Adequate consumption of milk and dairy from early childhood and throughout life can help to make the bones strong and protect them against diseases like osteoporosis.

**Teeth**
The amounts of calcium and phosphorus in milk and products are also beneficial for the development and maintenance of healthy teeth.

- Used in lotions, facial creams and makeup to your skin,
Reference for further reading


2. **Video link...**
   
   [https://www.youtube.com/watch?v=21L3LABPqZg](https://www.youtube.com/watch?v=21L3LABPqZg)