For most of us, the day starts with milk. Either milk bottles or packets land at your doorstep or it means an early morning sojourn to the nearest dairy or booth. Humans have been using milk as a food since ages. From a physiological perspective, milk is a secretion of the mammary glands to nourish the newborns of mammals. It forms a complete food in their early life. It is an excellent combination of different nutrients dispersed suitably in water.

Milk contains milk fat, which is composed of various fatty acids and furnishes all essential fatty acids to our body. Milk fat imparts a rich and pleasing flavour to the food items that it is present in. Milk fat is a strong antioxidant and has anticancerous effects. Milk proteins are complete proteins as they contain all essential amino acids required by the human body, and mend the wear and tear of our body.

Milk is also a good source of different minerals, particularly bone and teeth forming Calcium and Phosphorus. It is a good source of different vitamins also particularly Vitamin A. Moreover, the digestibility of these nutrients present in milk, including proteins, fats and minerals is higher than vegetable proteins and fats or inorganic mineral supplements.

This nutrient richness and diversity does not go unnoticed by some microorganisms too, which also find it a suitable medium for growth. These microorganisms grow and secrete acids and other substances that coagulate the proteins resulting in the destruction of the colloidal nature and the curdling of milk. Fermented milk products like Dahi and yoghurt have therapeutic value as they promote the growth of desirable microbial populations in the intestines.

Milk is thus a source of different nutrients that need to be maintained in various products and under various processing conditions. Dairy Technologists view milk as an emulsion in which various components are present in different phases. Fat and fat associated substances are present in emulsion phase, proteins are present in colloidal phase, minerals and sugars are present in true solution phase.

Processing Milk

Earlier, in India as elsewhere, milk giving animals like buffalo and goat were domesticated by families or groups of families. For some, it soon emerged as an occupation – breeding and rearing animals and supplying milk to customers. As the diversity of milk products and quality and safety concerns expanded, the scale and technology used in dairy operations also increased.

Today, most cities in India have "milk schemes" that employ specialized dairy technologists who subject milk to various dairy processes. A Dairy Technologist has to ensure that milk remains fit for human consumption.
Milk plants have immense capacity of processing large quantities of milk (Courtesy: Delhi Milk Scheme, Govt. of India)

Above: Milk being packed in polyethylene packages (Courtesy: Delhi Milk Scheme, Govt. of India)

Above extreme left: Dairy processes ensure that certain criteria of quality and safety are satisfied in the milk product (Courtesy: Delhi Milk Scheme, Govt. of India)

Above middle: Inside a Milk Plant (Courtesy: Delhi Milk Scheme, Govt. of India)

Left: Quality Control Tests being conducted (Courtesy: Delhi Milk Scheme, Govt. of India)
Milk plants sell milk in poly packages that have information regarding the quality of the milk, date of packing and best before use etc.

consumption in a desirable state with its maximum nutritive value intact. He or she has also to see that the nutrients are conserved through the manufacturing and transport of various milk products until their consumption.

The milk goes through several processes that can be termed as "Dairy Processes". Dairy processing is an industrial operation in which milk components are separated and re-constituted to produce desired milk products. From milking to consumption, milk may undergo a lot of dairy processes depending upon the product desired. Let us look at some of these processes.

Cooling: Milk secreted in the udder of a healthy animal is sterile. But as soon as it reaches the teat canal a large variety of microorganisms may gain entry into it. As these microorganisms proliferate in stagnant milk, their growth is prevented by immediately chilling the milk to five degree Celsius or below. At this temperature, milk will retain its freshness for three to four days. Cooling in a dairy plant is done by the Ice Immersion method (a can of milk is dipped into ice and the milk is immediately chilled) or using a Plate Heat Exchanger (milk is chilled with the help of chilled brine circulating in alternate plates).

Standardization: Standardization is the process of increasing or decreasing a particular constituent in milk or milk product so that it conforms to the desired industrial or legal standards. For example, if milk has to be sold as buffalo milk, the minimum fat percent should be standardized to 6% for most of the states in India. Milk may be standardized to Full Cream Milk; Toned milk, Double Toned Milk etc. Full Cream Milk should contain minimum 6.0% fat and 9.0% Solids Not Fat (SNF) while Standardized Milk should contain minimum 4.5% Fat and 8.5% SNF. Toned Milk and Double Toned Milk should contain minimum 3.0% Fat and 8.5% SNF and minimum 1.5% Fat and 9.0% SNF, respectively. In dairy processing, low fat milk can be standardized to high fat milk (and vice versa) by adding the required milk components in appropriate quantities.

Pasteurization & Homogenization

Recently, there has been some criticism that processed milk, particularly ultra high temperature pasteurization (used in the West) and homogenization (treatment at ultra high temperatures) affect the taste and smell of milk, as well as destroy important nutrients such as amino acids. Homogenization, by breaking milk into smaller globules that increase the surface area, makes milk more prone to oxidation. Oxidized milk fats lead to a variety of oxidative stress-based diseases. These criticisms are being evaluated by further scientific research, and dairy processes are being tuned in light of the findings.

Pasteurization: The microorganism that had gained entry into milk may be either pathogenic (disease causing) or spoilage type. Pasteurization kills all pathogens and most of the spoilage type of microorganisms. For this purpose milk is heated to such a time-temperature combination that ensures destruction of even the most heat resistant pathogen. Mycobacterium (TB germ) is the most heat resistant pathogen and it is taken as the index for deciding pasteurization temperature. Pasteurization may be done by two methods – Low Temperature Long Time (LTLT) or High Temperature Short Time (HST). Nowadays, the HST method is mostly used. After pasteurization, the milk must be immediately cooled down to five degree Celsius or below so that the surviving microorganisms do not multiply further.

Cream Separation: In cream separation, fat is removed from the milk by passing it through a cream separator in which it is rotated at a very high speed (around 8000 revolutions per minute) in thin films. Milk cream or fat, being lighter (specific gravity 0.9), remains in the centre while the skimmed milk, being heavier (specific gravity 1.036), goes towards the periphery in the cream separator. The separated cream and milk are collected from different outlets provided in the cream separator.

Homogenization: The fat in milk is present in the shape of fat globules that are of different sizes. The size may range from 0.1 to 22 microns and generally it is from 2-8 microns. The fat globules being lighter rise to the top and thus the fat separates out, particularly in products that are rich in fat. Homogenization is the process in which fat globules are broken down mechanically to a size of about one micron. This leads to increase in surface area of the fat globule, thereby interaction of the fat globule membrane with the water molecules in milk surrounding it increases. The interactions become so high that it does not allow the fat globules to separate out. Homogenization is generally used in reconstitution of milk and fat rich products like ice cream, condensed milk, sterilized flavored milk etc. Homogenized milk does not stick to the container and gives a viscous appearance and rich mouth taste.

Sterilization: When milk has to be stored for longer periods it must be free from all types of microorganisms to prevent spoilage. Some types of microorganisms are able to ward off unfavorable conditions by forming spores. These are thick-walled structures with minimum biological activities and thus dormant forms of bacteria. Spores may not get destroyed even by boiling of milk. They are destroyed through sterilization, which is the process of heating milk to 120 degree C for 30 minutes or 150 degree C for 2-3 seconds so that a shelf life of six months of milk at room temperature is ensured.

Fermentation: Some desirable bacteria convert lactose of milk into lactic acid and some other flavour-producing compounds and are helpful in producing different products like dahi, yoghurt, kefir, kumis etc. Conversion of milk into various cultured products by these bacteria is known as fermentation and these products are known as fermented milk products.

Re-engineering Milk

Since milk is a perishable product, it is received – that is, subjected to various tests to ascertain its quality as it arrives. When the milk reaches the milk plant a grader receives the milk and subjects it to "Platform Tests". Platform tests are tests that are conducted to accept or reject a particular consignment of milk.

They may be organoleptic, which are conducted with the help of our sense organs like smell, visual appearance, touch etc. Chemical tests include Clot-
on-Boiling, Alcohol Test etc. Platform tests are not used as comprehensive indicators of quality but they are used to decide if the batch of milk can be accepted for further processing. When the milk is received in insulated tankers in a chilled state, the platform tests also help to determine if the insulated tankers can wait for longer periods without deterioration in milk quality.

More comprehensive quality tests include Fat content, Solids Not Fat (SNF) content, Acidity, etc. From the storage tank milk is sent to different sections in the Dairy Plant for processing into different products. The surplus fat is removed with the help of Cream Separators and converted into butter and ghee. The remaining milk is sent to one of the following sections:

- Fermented product section (to make Dahi, Yogurt etc.),
- Coagulated milk product section (to make Paneer and Chhana),
- Heat desiccated milk product section (to make khoa, Burfi, Peda, Rabri etc., or dried to make milk powder),
- Cheese section (to make various kinds of Cheese like Cheddar, Mozzarella, Processed etc.),
- Frozen Product Section (to make ice cream, kulfi etc.).

After processing, milk or milk products have to be suitably stored. The fluid milk packed in polythene packages is stored in a cold room at 5 degree C or below. Ice cream is stored below –18 degree C. Powders are stored at room temperature under dry storage conditions.

Next, the milk products are dispatched to the market in appropriate transport vehicles depending on the type of product.

Creating Milk Products
In dairy processing, the creation of milk products is better understood from a milk component perspective. The major portion of milk is water (around 85% in buffalo milk and around 87.5% in cow milk). If water is removed then the remaining portion of milk is known as Total Solids. Total solids are further composed of Fat and Solids that are not fat (abbreviated as SNF or solids not fat).

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When Fat is removed from milk through a Cream Separator, the remaining milk is known as Separated Milk or Skimmed Milk or Skim Milk. Skim milk contains all the constituents except Fat, which is present in trace amounts. If we evaporate water from Skim Milk we get SNF in dry form. This is known as Skim Milk Powder. The drying is done in Spray Dryers where milk is sprayed in the form of mist in a hot chamber where milk is dried.

The SNF is composed of proteins, lactose, mineral matter and other minor constituents of milk. The proteins can be further divided into casein and whey protein. When milk is coagulated the casein gets curdled and traps some other material of milk in its coagulum. When this coagulum is removed the watery portion remaining after that is known as whey. Whey is composed of lactose and whey proteins (proteins that are not casein and are only about 20% of the total percentage of casein). Apart from its nutritional use, casein is used in pharmaceuticals and some other industries.

Milk powder prepared from whole milk i.e. containing Fat, is also known as Whole Milk Powder. Whole Milk Powders have legal standards that need to be maintained. Dairy Whiteners are also dried powders that do not have any legal standards to be maintained in respect to fat content. Therefore, they can be prepared from milk with desired Fat content.

When Fat is removed from milk through cream separator it cannot be removed in isolation and some Skim Milk also comes along with Fat – this is known as Cream. Generally 60% Fat is present in Cream. The Cream can be converted into Butter (having more than 80% Fat). Butter can be converted into Butter Oil (nearly 99% Fat). Ghee, an inseparable part of Indian cuisine, is composed of mainly milk fat and obtained by a different method – making Dahi then Makehun (Desi Butter) and then Ghee. Nowadays Ghee is also prepared in cities by heating the Cream (60-65% Fat) and removing all moisture and then filtering the Residue (Ghee Residue).

Baby Milk Powders are mainly Milk Powders with some other ingredients. Dahi is a product obtained by adding some desirable bacteria to milk under standard conditions. Yoghurt is quite similar to Dahi but the bacteria used are different than Dahi. Paneer is a product obtained by coagulating the heated milk with acid and then filtering, pressing and cutting the coagulum. Cheese is a coagulated product but different from paneer due to the different types of bacteria used to cure Cheese. It may take a few months to years to prepare different types of Cheese. Flavoured Milk is a product created by adding desired flavours, colour and sweetener to milk. Colour may also be added to match the flavour like Strawberry, Mango, Pineapple, Pista etc.

Dairy processing represents an alternative paradigm to the disappearing reality of home and community owned cows and making milk products at home. Unlike milk sold loose to consumers, milk plants sell milk in poly packages that have information regarding the quality of the milk, date of packing and best before use etc. Dairy processes ensure that certain criteria of quality and safety are satisfied in the milk product. This also minimizes chances of adulterants finding their way into the milk.

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Adulteration in Milk

Recently, the Food Safety and Standards Authority of India found that 70% of the milk sold in the country is adulterated. In urban areas, 68.9% of milk samples had been adulterated, compared to 31% of samples in rural areas. The regulator found that 70% of the samples collected in New Delhi contained substances other than milk. Although buying packed milk was a safer bet than loose milk, the regulator found that one in three packed milk samples in cities were adulterated.

There are various ways and means of adulteration that are encountered in the market milk. However, the chances of adulteration are much more in loose milk than in packaged milk.

The most common adulterant is water. This is added to increase the volume of milk during loose milk distribution. The second category of adulterants is the one that are added to mask the adulteration of water in milk. These are added to increase the SNF level. The number of such adulterants is very large. The most common are starch, maltodextrins, sugar, salt, urea and a lot more.

In addition, traders may also add other chemicals to milk. When milk is transported to farther places for distribution, the bacteria in milk deteriorate it producing lactic acid. This lactic acid destabilizes the proteins in milk and when such milk is heated, it gets coagulated. To prevent such curdling, traders add alkaline neutralizers like caustic soda and sodium bicarbonate so that the developed acidity is neutralized and milk does not curdle on heating.

Another class of additives to milk may be preservatives. These are substances that have bacteriostatic or bactericidal effects and prevent the growth of microorganisms. This enhances the shelf life of milk. But addition of these preservatives is illegal and such substances are harmful for human health. The most common preservatives are Hydrogen Peroxide (H2O2) and Formalin.

Milk is tested for all these substances in the quality control lab of a milk plant before receipt and hence the chances of these adulterants in packaged milk are very less in comparison to loose market milk.