

## GRAVITY AND CENTRIFUGAL SEPARATION

### Separation of Milk

Cream is a fatty product of milk, and creams of different fat contents can be prepared by the separation of milk fat from non fat solids portion of milk. Market creams for retail sale are made to different fat contents according to intended use. Cream is a richly flavored product, which makes it desirable for use in applications such as desserts, cakes and some chocolate confectionery. It is also used in some beverages like coffee and cream liqueurs.

In dairy industry, the process of separating milk into cream and skim milk is known as separation. Cream comprises of fat concentrate in milk. Milk fat can be removed in the form of cream and the remaining portion is serum referred to as skim milk. The skim milk contains predominantly SNF and is having very little fat.

### Principles of Cream Separation

Separation of cream can be done either by gravity (*malai*) or by applying the centrifugal force. Separation of milk is possible because of difference in density between the fat (0.93) and the skim milk (1.036). When the milk fat in the form of globules rises to the surface of the milk, the globules maintain their identity at the temperature below their melting point, thereby forming fat concentrate referred to as 'Malai'.

Fat is present as globules whereas the SNF form an ionic solution (e.g. certain salts), true solution (e.g. lactose and whey proteins), or a colloidal solution (e.g. casein micelles) in the water part of milk. Thus, milk represents an emulsion in which the relatively large fat globules are dispersed in the continuous aqueous phase (serum). Since fat globules are lighter as compared to other solids, they tend to readily separate out from the serum (or skim milk), as can be seen in the formation of a 'cream' layer on the top of milk held undisturbed in a container for a few hours. Cream is that portion of milk, which is rich in milk fat, but poorer in SNF. This suggests that much of the fat can be easily separated in the form of cream from milk, leaving behind the skim milk containing very little fat. Cream separation enables the processor to manufacture a variety of fat-rich dairy products such as cream of various types, butter, ghee, etc. Cream separation also makes it possible to adjust the composition of milk with respect to its fat and SNF contents. Such compositional modification (vide Sec) may be desired for products

manufacture as also for meeting the legal requirements of different types of fluid milk

### **i. Methods of Separation**

Two methods of separation of cream from milk are commonly used:

- (i) gravity separation and
- (ii) (centrifugal separation.

Both these methods rely on the basic principle of separation of two immiscible liquids having different densities, under the influence of gravitational or centrifugal force.

**Gravity Separation:** As mentioned above, when milk is allowed to stand undisturbed for some time, a layer of cream (or 'malai') forms on the top due to rising of the fat globules which are initially dispersed throughout the bulk of milk. The upward movement of the lighter fat globules (density, 0.93 g/cc at 20°C) in the heavier serum (density, 1.035 g/cc) takes place owing to gravity. Creaming may become evident in as short time as half an hour.

The rate of cream separation is directly proportional to the difference between the densities of fat and serum and to the square of fat globule diameter, and inversely proportional to the viscosity of serum. Thus, for a given sample of milk, the creaming rate will be maximum when the density difference is maximum and viscosity is minimum. Both these factors are, in turn, affected by temperature of milk. As the temperature rises, the ratio of the density difference and the serum viscosity increases favouring the separation process. This increase is particularly prominent between 10°C and 30°C and much less above 50°C. Cream separation by gravity is, however, a very slow and inefficient process. It is of little practical value for commercial purposes. Hence, mechanized cream separation employing a centrifugal machine is most commonly used in the dairy industry. Even for a very small scale separation involving, say 10-20 litres of milk, a centrifugal separator is used, be it hand-driven or motor-driven.

#### **Separation by gravity**

Earlier, this technique was used in dairies to separate fat from milk. Milk was left in a vessel where, after some time (hours), the fat globules aggregate and float on the surface forming a layer called 'malai' on top of the milk. There are two types of gravity separation as discussed below:

##### *(a) Shallow pan method*

The milk is poured into the pans, immediately after milking. The pans, which are four inches deep, are placed preferably in a cool place. Skimming is done at the end of 24 h, and by this time, the milk below the cream is coagulated. Skim milk from the shallow pan system contains 0.5-1.5% fat.

*(b) Deep setting method*

In this method, milk is set in 20 inches deep cans which are 8"-15" in diameter, maintained at 8-10°C. Glass strips are inserted in the wall of the can, one near the bottom and other near the top, to absorb cream. Due to low temperature better quality product results. After 12-14 h of storage, the fat layer from the top is skimmed off leaving skim milk in the container.

**Centrifugal Separation:**

In principle, this method of cream separation is similar to gravity separation but gravity as the driving force is replaced by the centrifugal force for which a rotational machine is used. Since the latter force is much larger than the gravitational force, separation is greatly accelerated. The centrifugal separator is similar to the clarifier discussed in the earlier section, but milk entering through the bottom of the separator bowl holding a stack of conical discs rises up through holes located somewhere in the middle of the inner and outer edges of the discs. The milk between discs is subjected to a centrifugal force in the rotating bowl and thereby tends to fly out from the centre. The skim milk fraction, being heavier, moves away and forms a layer on the outer edge of the discs, whereas the fat globules gather on the inside edge. The incoming un-separated milk forces the separating layers further and upward out at the top of the bowl. Thus, there are two outlets in a cream separator, one for skim milk and the other for cream, the cream outlet being nearer to the centre.

The rate of cream separation in case of a centrifugal separator is influenced by the same factors affecting gravity separation, but the speed of the separator bowl and the disc diameter are also very important here. The higher the speed of the bowl or larger the diameter of discs, the greater will be the separation rate.

**Advantages of Centrifugal Separation over Gravity Separation**

- Speed of separation is greater (instantaneous) for centrifugal separation.
- Bacteriological quality of cream and skim milk is superior in centrifugal separation than gravity separation.

- Greater fat percentage of cream is possible using centrifugal separation (25-80%) vs. gravity separation (10-25%).
- Fat recovery in cream is 99-99.5% for centrifugal separation. Such value for gravity separation is about 75% or so.