Unit V – Topic I

HOMOGENIZATION - DEFINITION AND THEORIES

23.1 Introduction

Homogenization implies mechanical treatment to break fat globules into smaller size of 2µm or less and uniformly disperse them in milk. Homogenization in the dairy industry is used principally to prevent or delay the formation of a cream layer in full cream milk by reducing the diameter of the fat globules. After homogenization, size of fat globules becomes less than 2µm. The average size of milk fat globule in milk is 2-12µm. The number of fat globules is 3-4 billion in a milliliter of milk.

In the past, pasteurized milk usually was not homogenized, although the flavor of the milk becomes fuller by homogenization. A certain amount of cream was permitted to form to show the consumer clearly the full cream character of milk. Sterilized milk, evaporated or condensed milk and cream are generally homogenized.

23.2 History

Homogenization was introduced by Buttenberg (1903) of Germany, and later developed in 1904 in London and the milk produced by this process was known as 'Gaulin milk'.

23.3 Definition

Homogenization can be defined as the process in which fat globules in milk are broken down to a size small enough to prevent the formation of a cream layer. Homogenizer is a machine, which disintegrates the fat globules of milk.

According to the United States Public Health Services (USPHS), 'homogenized milk is one that has been treated in such a manner as to ensure the break-up of the globules to such an extent that after 48 hours of quiescent storage, no visible cream separation occurs in milk and the fat percentage of the milk in the upper 10% portion, i.e., in the top 100 ml of milk in a quart bottle or of proportionate volumes in containers of other sizes, does not differ by > 10% of itself from the fat percentage of the remaining milk, as determined after thorough mixing'.

The number of fat globules in homogenized milk is about 10,000 times greater than those in unhomogenized milk. The size of fat globule is reduced to < 1 micron, while normal fat globule size averages 2 – 12µm in milk. The number of fat globules will be increased, but total volume of fat globules will remain almost same. The surface area of newly formed smaller fast globules is increased by 4-6 folds.

23.4 Merits of Homogenization

- No formation of cream layer/plug
- Fat will not churn
- Thick body and rich appearance

- Produces soft curd, easily digestible
- Less susceptibility to oxidation

23.5 Demerits

- Increased cost of production
- Fat from returned homogenized milk is difficult to salvage.
- Sediment is greater
- May produce rancidity if temperature is not kept adequately high.

23.6 Principles of Homogenization

In raw milk, the diameter of the fat particles varies from 2 to 12μ, while a diameter of about 2μ or less is required to keep the fat from rising in stored condition (Fig 23.1). The milk is forced at high pressure through a narrow slit (spring loaded valve), which is only slightly larger than the diameter of the globules. The velocity of milk in the narrow slit can be 100 - 200 m/s. This can cause high shearing stresses, cavitations and micro-turbulence. The globules becomes deformed, wavy and then breakup.

23.7 Homogenizer

The homogenizer consists of a high pressure, reciprocating pump driven by a powerful motor, and a back pressure device i.e. homogenizer head. It is equipped with a set of valves and valve pressure screws that enable the exposure of liquid products to very high pressures. To withstand the high pressure and velocity and to prevent the wearing of the head, a special metal alloy 'stellite', which is noted for its hardness, is used for making the homogenizer valve. The power source is an electric motor built into the unit. The motor drives the crank and piston assembly either by a pulley or by a set of gears, both of which greatly reduce rpm to provide a suitable speed for the pistons. The gears, cranks, and drive shafts run in an oil bath. The pistons (commonly three sometimes five or seven in number) are usually straight rods giving a small displacement. The pistons extend from the crank shaft in the crank housing, into the pressure chamber in the homogenizer head. Each piston passes through a packing gland especially designed both to prevent product leakage, despite high operating pressures and to facilitate sanitation. The parts of homogenizer head are precisely ground and made to fit together in correct position in order to avoid any leak. The wear and tear of homogenizer head is also frequently checked because if there is any shell gap the fat globules may escape through it and lower the efficiency of homogenization.

23.8 Process

The high velocity of milk confers high kinetic energy. The energy is dissipated into heat and since the passage time through the slit is small (< 0.1 m/s), the average energy density is very high. Such high energy densities lead to very intense turbulence (Reynolds number > 40,000). The pressure fluctuations are not desirable.

When the flow velocity in the valve slit is at its maximum, local pressure is less than zero. A negative pressure may cause cavitations (i.e. the formation and sudden collapse of vapor bubbles). The collapsing process creates huge shock waves, which may disrupt particles. The degree to which this happens in homogenizers varies. In most cases, globule disruption primarily is caused by turbulent eddies. The small globules do not rise to the top of milk but remains suspended in the milk or rise very slowly. Immediately after the globules are broken down, they show a tendency to cluster and rise to the top of the milk. Two-stage homogenization prevents this. The second stage breaks up any clusters, thus ensuring better dispersion on the fat throughout the milk.

Theories of Homogenization

1 Shattering & impact

The fat globules are shattered by impinging them on the retaining value or impact ring.

2 Explosion

With the release of high pressure, the fat globules explode.

3 Shearing & grinding

The fat globules are subjected to unequal forces as milk flows at different velocities in a fluid stream. As a result of the shearing action between globules, it deforms the fat globules beyond its yield point.

4 Cavitation

The vapor bubbles or cavities are formed within the medium and as they collapse subsequently, energy in the form of shock waves is released breaking up of fat globules.

5 Attenuation

The fat globule disruption is attributed to violent changes in the velocities of milk as it passes through the unit rendering a fragmentation slight effect on the mean particle size.