

***Physico -chemical changes in
concentrated milk***

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Changes Caused by Concentration

1. Increases of most of the solute concentrations and the water activity decreases.
2. **The Calcium ions activity increases only slightly** because calcium phosphate, which is saturated in milk, turns into an undissolved state. As the **water content decreases, association of ionic species increases** and also ionic groups of proteins are neutralized.
3. When **milk is highly concentrated**, the solvent quality decreases. Thus, **the tendency of the protein molecules to associate and to attain a compact conformation is increased.** Coalescence of casein micelles causes them to increase in size.

4. This increase is smaller if the milk has been intensely preheated, presumably because β -lactoglobulin and other serum proteins have become associated with casein.
5. Osmotic pressure, freezing point depression, boiling point elevation, electrical conductivity, density and refractive index increase and heat conductivity decreases
6. The viscosity increases and the liquid become non-Newtonian and finally solid-like.
7. The diffusion coefficient of water decreases.

Effect of viscosity in Evaporated Milk

Effect of sterilization on viscosity of product

- Viscosity of fresh milk changes by the preheating of milk.
- The condensing operation causes a slight but definite increase in viscosity. This is due to **increase in concentration of milk solids.**
- The increase in viscosity that gives the finished product its full body, however occur during process of sterilization.
- In general **HTST yields a thin body and low viscosity**, while **LTLT process yield a full body and little more viscosity.**

Increase in viscosity by progressive coagulation of milk proteins

The proportion of **milk proteins coagulated** while sufficient to **increase viscosity**, is too limited for curd to become visible. The **increase in viscosity which milk undergoes toward the end of sterilizing process** has to do with **progressive coagulation of the milk proteins.**

Viscosity changes during successive steps in manufacture of evaporated milk

Stage of manufacture	Viscosity Retardation
Fresh milk before fore warming	15.24
Fresh milk after fore warming	15.26
Evaporated milk before sterilization	20.20
Evaporated milk just after sterilization	150.00

- For a heavy creamy body, the heat stability of milk should not exceed 30–40 minutes.
- Milks with **heat stability in excess of 50 min** will be **exceedingly thin at the end of sterilization** at 115°C for 30 min unless an increase in solids content is depended upon to build up body.

The **viscosity produced during sterilization is controlled mainly by the heat stability of milk**. Therefore, factors which affect the heat stability of milk will certainly affect the viscosity of milk.

Following factors gives low heat stability, high viscosity and very thick body and vice-versa:

- (1) **High acidity of fresh milk**
- (2) **Low fore warming temperature**
- (3) **High concentration**
- (4) **High homogenizing pressure**
- (5) **Excessive holding of evaporated milk at ordinary temperature before sterilization**

The heat stability, sufficient to avoid visible coagulation or curdling during sterilization process is required but maximum heat stability is not desirable because such high stability results into objectionably thin milk.

Effect of storage on viscosity

Evaporated milk becomes thinner with age. This loss of viscosity increases with the temperature of storage. **The decrease in viscosity begins immediately.** The rate at which viscosity is lost is accelerated at high storage temperature. Thus it is observed that **at or above 30°C, evaporated milk loses as much as 40% of viscosity** (original) during first 10 days of storage. While **at 15.6°C or below, the age thinning is very slight.** It is reduced after which the rate of thinning is much more gradual. Age thinning of evaporated milk may therefore be definitely retarded and the attainment of final viscosity delayed by use of relatively low storage temperature. A study shows **viscosity loss upon storage for 110 days of 58.75% at 26°C, 40% at 15.6°C & 11.25% at 7.2°C.** But this depends upon quality of raw material (milk) used. **Better grade milk lost less viscosity** than the low grade initial milk with the same temperature and time of storage.

Gel formation on storage

- In case of some **evaporated milks, the viscosity increases later in the storage period even to the gel formation**. This tendency is greatest with milks that had received **relatively light heat treatment and those of high solids concentration**. These results of **gel formation in prolonged storage**.
- Further it is observed that **evaporated milks that have been sterilized by the HTST process (135°C for 0.5 min) thicken quickly during storage**. When the **gel is broken** before it **becomes firm, the product wheyed off**.
- When **sterilized in the conventional** manner (115.6°C for 20 min), **gel formation is slow and holds the water better than from the HTST process**.
- It was observed that the **more severe heat treatment** of commercial process (115.6°C for 20 min) that **retards thickening in storage** is commercially preferable.

- Neither the mechanism underlying age thinning nor that responsible for age thickening appears to be well understood.
- It may be due to **insufficient time** for the attainment of new solubility equilibrium of the Calcium and Magnesium salts when using HTST method of sterilization.
- When solutions of these salts are heated, it takes considerable time to attain that. Their peculiarity of being less soluble at higher temperature may be contributing to the reaction of these salts.
- In the HTST method of sterilization, conditions are thus less favourable than those of the LTLT procedure (115.6°C for 20 min). This suggests the possibility that, less of Ca and Mg content is rendered insoluble.
- This condition might encourage the protein particles to swell and to form a gel or it may be as low continuation of the coagulation process accompanied by an operation of caseinate molecule which finally produces an irreversible gel structure.

Protein separation during storage

The proteins of some evaporated milks have a tendency to settle during storage. This is found more common in evaporated skim milk than evaporated whole milk.

Homogenization retards protein separation in evaporated whole milk. It is observed that, fat in evaporated milk is a factor to maintain a normal dispersion of milk constituents during long period of storage. It is observed in this respect that fat acts to counter balance the protein settling to bottom.

Fat Separation in Storage

During age thinning and before age thickening sets in, there is definite **tendency to objectionable fat separation**. This tendency emphasizes importance of efficient homogenization that ensure **reduction of at least 90% of fat globules to 2 μ or smaller**. Such efficiency can be obtained by taking following care:

- Daily check up of homogenization Valve
- Keeping the clearance surface of valve and valve seat smooth and intact by regrinding or resurfacing
- Making sure of the continued accuracy of the pressure gauge
- Examining fat globule size

It is observed that **HTST sterilization provides** little opportunity to control body hence through **a heavier body**, control of the extent of fat separation can be achieved. Again here the LTLT procedure (115.6°C for 20 min) proves helpful. **Fat separation in this more viscous body is slower and less intense**. In case of LTLT, **fat layer get re-emulsified easily** than in case of HTST sterilization process.