

Physico chemical properties of ice cream-I

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Ice cream mix

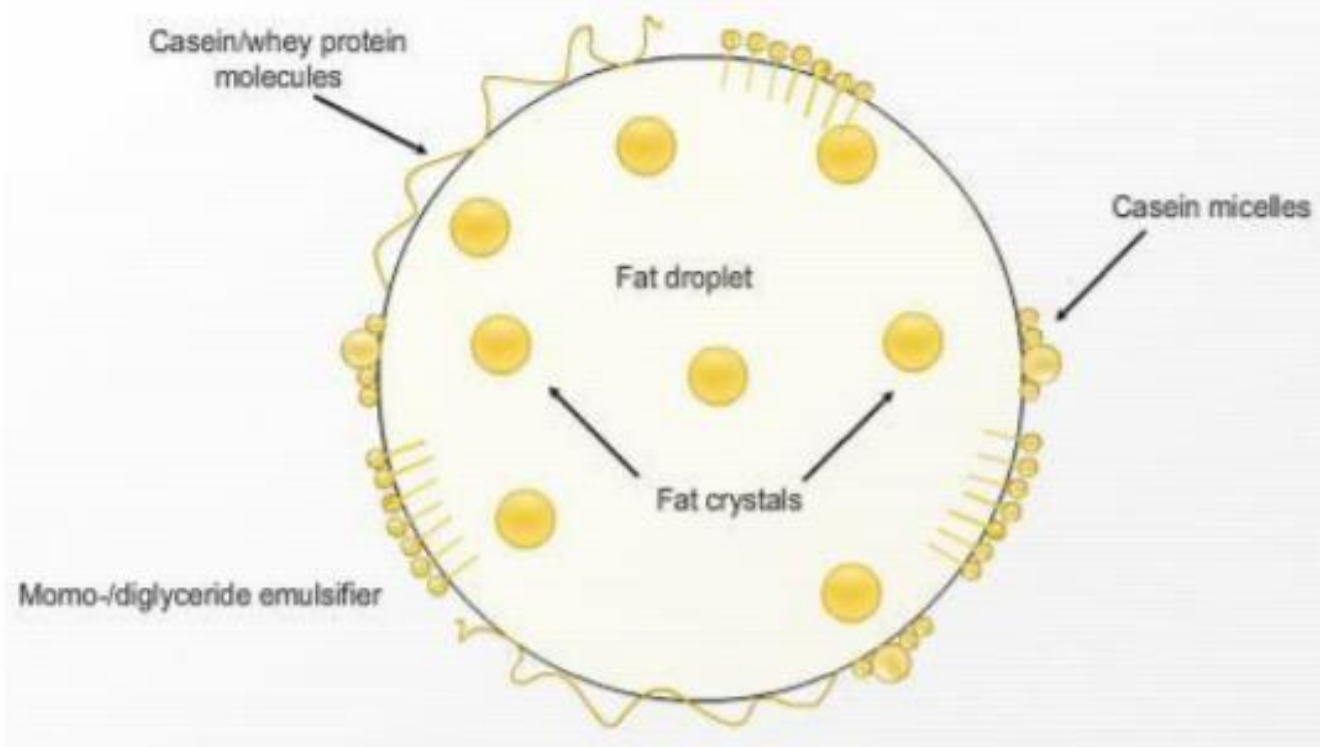
- The ice cream mix is a complex colloidal system consisting of both emulsion and a foam.
- The milk fat exists in tiny globules that have been formed by the homogenizer.
- The fat globules are in coarse dispersion.
- Some constituents occur in true solution (sugar, lactose and salts) others are colloidally suspended (casein micelles, stabilizers, insoluble sweetener solids and some calcium and magnesium phosphates).

Ice Cream mix Stability

- After homogenization, the size of the relatively large fat globules reduced to fine particles (mean size 0.5 – 1.0 μ and a maximum size of about 2 μ) with a high degree of dispersion.
- These fat globules are kept from creaming due to their small size after homogenization, the increased density (due to the addition of protein and stabilizers), and the high viscosity in the mix due to the addition of proteins and stabilizers.
- The optimum stability allows the mix to pass through the processing stages specially through pasteurizer, while permitting whipping and freezing process to destabilize an adequate amount of fat.
- The displacement of proteins by emulsifiers helps create this optimum in stability by weakening the emulsion

- Protein stability depends on the state of the proteins and the appropriate balance in the solution of pH and salts.
- Excessive heat in pasteurization, e.g. may denature the whey proteins, leading to their adsorption to casein micelle and eventual precipitation.
- Any change in solvent conditions may lead to enhanced protein precipitation.
- Phase separation between milk proteins and polysaccharide stabilizers results whey separation from mix.
- Stabilizers tend to move apart from each other (even though they are hydrophilic) leading to formation of clear serum layer in the mix after standing or to leakage in serum from ice cream during melting. To prevent this from happening carrageenan is normally added as a secondary stabilizer

A fat droplet during ageing, showing adsorption of milk proteins and emulsifiers



Density of mixes

- The density or specific gravity (density relative to water) of ice cream mix varies with its composition.
- Measurements of specific gravity can be made with a hydrometer and of density by weighing a known volume of mix at a known temperature on a gravimetric balance.
- Density can also be calculated based on composition. The density of mix may vary from 1.0554 to 1.1232 g/ml, with an average of 1.1 g/ml (with 10% fat).

The density (D) of the mix can be calculated as follows

$$\text{Density of mix} = \frac{100}{\frac{\% \text{ Fat}}{0.93} + \frac{\% \text{ MSNF}}{1.58} + \frac{\% \text{ Water}}{1}}$$

Acidity of Mixes

- The normal titratable acidity of mixes varies with the percentage of MSNF and may be calculated by multiplying the percentage of MSNF by the factor 0.017.
- Thus, a mix containing 11% MSNF would have a normal titratable acidity of 0.187% lactic acid.
- The normal pH of ice cream mix is about 6.3.
- The acidity and pH are related to the composition of the mix – an increase in MSNF raises acidity and lowers pH.

- The apparent or natural acidity of ice cream mix is caused by milk proteins, mineral salts (mostly citrates and phosphates) and dissolved carbon dioxide.
- Developed acidity is caused by the production of lactic acid by bacterial fermentation of the lactose in dairy products.
- A high acidity is undesirable as it contributes to excess mix viscosity, decreased whipping rate, inferior flavour and a less stable mix.
- The latter may contribute to 'cook on' during processing and pasteurization, because heat and acidity accelerates the denaturation of proteins.

Freezing point

- The freezing point of ice cream is dependent on the concentration of soluble constituents and varies with composition.
- The freezing temperature can be calculated with a cryoscope or a vapour pressure osmometer.
- An average mix containing 12% milk fat, 11% MSNF, 15% sugar, 0.3% stabilizer and 61.7% water has a freezing point of approximately -2.5°C .
- The freezing point of mixes with higher sugar and MSNF contents may range downward to -3°C while for mixes with high fat, low MSNF or low sugar content it may range upward to -1.4°C .
- The initial freezing point of ice cream mix is highly dependent on the sweetener content of the mix.
- When latent heat is removed from water and ice crystals are formed, a new freezing point is established for the remaining solution since it has become more concentrated in respect to the soluble constituents.

A typical freezing curve for ice cream shows the percentage of water frozen at various temperatures.

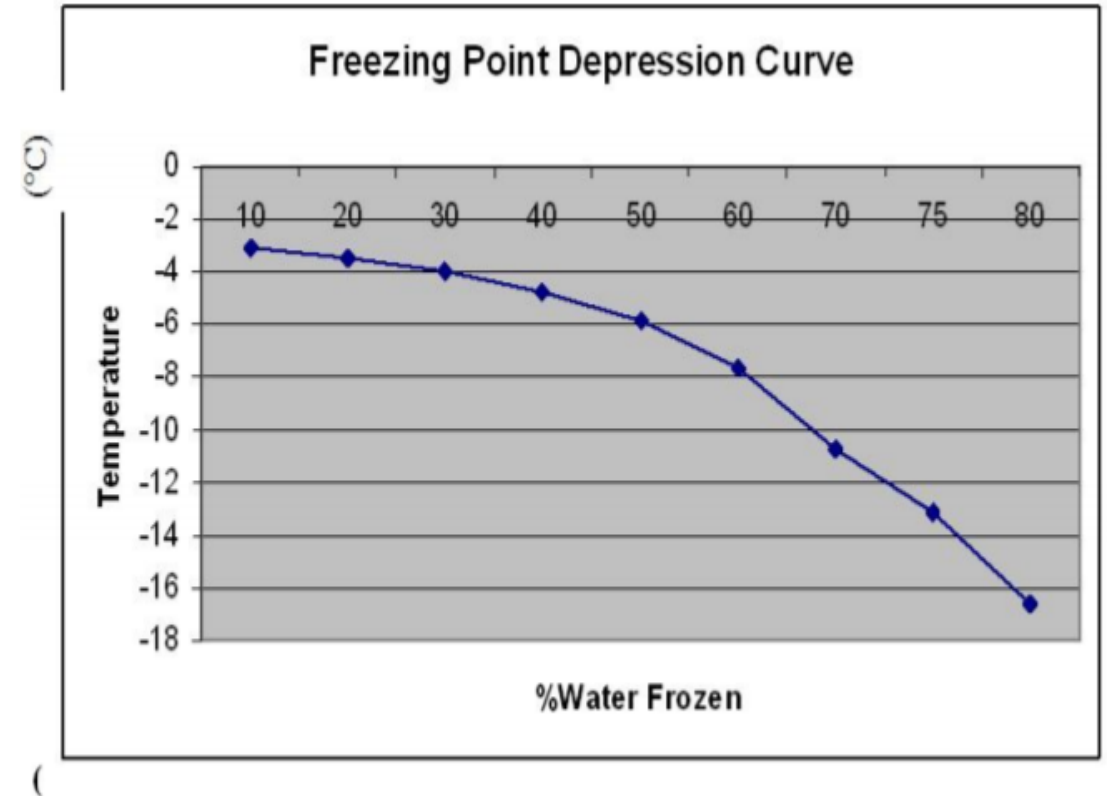
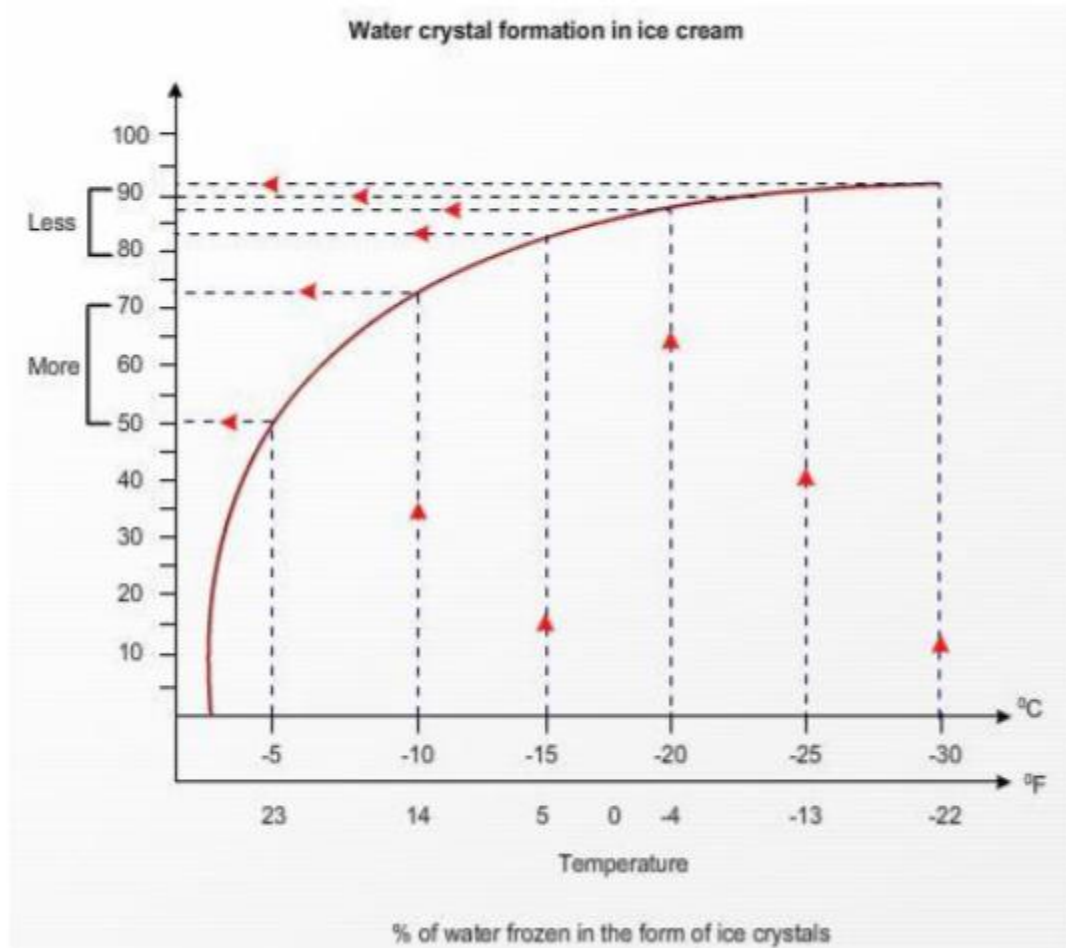


Fig.16.3: A typical freezing point curve for ice cream mix

Freezing point depression

- When a solute is added to water the physical properties of freezing point and boiling point change.
- Water normally freezes at 0°C and boils at 100°C.
- As more solute is added, the freezing point drops (—freezing point depression||).
- The freezing point depression ΔT_f is a colligative property of the solution, and for dilute solutions is found to be proportional to the molal concentration c_m of the solution:

$$\Delta T_f = K_f c_m$$

Where,

K_f = freezing-point-depression constant.

MIX VISCOSITY

- If the liquid is too viscous, it is difficult to beat and therefore to incorporate the air; if it is not viscous enough, the film between the air bubbles rapidly drains, and the bubbles coalesce.
- Ice cream mix is pseudoplastic in nature. As the shear rate increases, the viscosity decreases. Thus, to characterize the viscous behavior of an ice cream mix, both the underlying viscosity and the shear rate dependence are necessary.
- Ice cream mix also exhibits thixotropy, which means that its apparent viscosity also decreases with time of applied shear stress. A defined pre-shearing time is thus required before the underlying viscosity can be measured.

- Instruments used to measure viscosity of ice cream mix are
 1. Falling Ball Viscosimeter
 2. Haake Viscosimeter
 3. Brookefield Viscometer
 4. Ostwald viscometer

Factors affecting viscosity of ice cream mix

A certain level of viscosity is essential for proper whipping and retention of air.

- 1. Composition:** viscosity increases with increasing concentration of stabilizer, protein, corn syrup solids, fat and total solids, with the contribution of each decreasing in that order (i.e. stabilizer has more influence on mix viscosity than does fat). Also heat and salts (such as calcium, sodium, citrates, phosphates) can affect viscosity due to their effect on casein and whey proteins
- 2. Processing and handling of the mix:** elevated pasteurization temperatures, increasing homogenization pressures and ageing for up to 4 hours will each increase viscosity of the mix.
- 3. Temperature:** as with all fluids, viscosity is temperature dependent, so decreasing storage temperature will result in increased mix viscosity.

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