

ICE CREAM - PART II

MACHINERY & EQUIPMENT

Machinery and equipment for the manufacture of ice cream is available in a variety of types and sizes. They range from very small manually operated domestic machines to fully automated large industrial plants. In this document, discussion will be limited to small-scale ice cream manufacture.

Selection of properly designed machinery, fabricated with appropriate materials of construction is very important for a successful ice cream industry. All parts of machinery and equipment that come into direct contact with food material should be constructed of materials that are non-toxic, non-corrosive and that do not impart any flavours or odours to the food material. The use of stainless steel of proper grade and gauge is strongly advocated. The design of the machine should be that all parts are easily accessible for cleaning and keeping bright. If necessary, the machine should be easy to dismantle and re-assemble. Machinery, equipment and vessels used should not have any sharp corners in them. All corners should have a curvature of a minimum radius of 0.5 mm. Joining of materials by riveting and overlapping of plates should be totally avoided. All joints should be butt-welded and the welded joints polished to a smooth finish. Some of the common machinery used in the ice cream industry is described briefly below.

Vats and Vessels

All vats or vessels used for mixing and composing the mix should be made of stainless steel of proper grade and gauge. They should be properly designed for easy cleaning. Aging vats are stainless steel vessels with heating and motorized stirring facilities attached to it.

Cream Separator

When fresh milk is mixed with the ingredients used for making ice cream, the milk contains a large amount of water. This water is separated from the milk by the cream separator. The cream separator is a bowl or shell within which are mounted a series of conical rotating disks, the clearance between each disk being less than 0.5 mm. The rotational speed of the discs can be controlled and usually varies between 3,000 to 20,000 rpm. The milk enters the separator through a central tube and is subjected to centrifugal force by the rotating discs. The lighter density cream is attracted towards the axis of rotation, while the heavier density milk serum is thrown outwards.

Cream separators are available in capacities of 75 litres per hour upwards. The types of separators vary from simple manually/electrically operated machines to large-scale electrically operated industrial machines. A simple electrically operated farm type cream separator is shown in figure 1.

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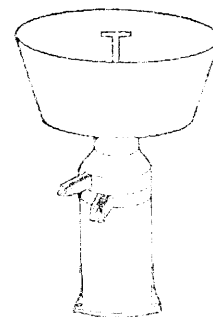


Figure 1 - Cream Separator

Homogenizer

The ice cream mix is very complex, having a large amount of water in it. The fat globules in the mix are broken down into smaller particles by the homogenizer. This process helps in the uniform distribution of the fat globules in the mix. The homogenizer is a machine that uses high pressure to break down the fat globules into smaller particles. This process helps in the uniform distribution of the fat globules in the mix.

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Homogenization is carried out by forcing the ice cream mix through a very small orifice at a very high velocity and pressure under a suitable temperature. The main components of the homogenizer are a high-pressure pump for delivering the mix and a homogenizing head where the size of the fat globules is reduced. The homogenizing head consists of an orifice surrounded by an impact ring, against which the mix leaving the orifice impinges. Break up of fat globules are caused by three factors, viz. (i) the shearing forces exerted while the mix passes through the orifice, (ii) the impact of the globules by the impact ring and (iii) the sudden release of pressure, below the vapour pressure of fat, subjecting to very powerful explosive forces.

Pasteurizer

Pasteurizing is carried out to destroy any pathogenic and disease-causing microorganisms present in the mix, making the ice cream fit for consumption. It is a thermal process where the mix is heated to a pre-determined temperature and held at that temperature for a calculated period.

Pasteurizers can be of the batch type or continuous type. The batch type consists of a stainless steel vat with facility for controlled heating and agitation. Heating may be by gas, electricity or steam. Agitation is necessary for even heating. Figure 2 gives the sketch of a batch type pasteurizer.

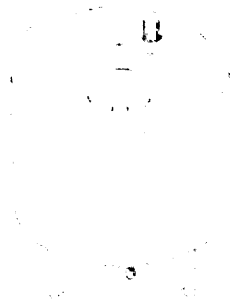


Figure 2 - Batch Pasteurizer

In large industries continuous type plate heat exchanger pasteurizers are used. Plate heat exchanger pasteurizers consist of a series of rectangular stainless steel plates usually supported in a vertical plane on a frame. The plates are criss-crossed with grooves to facilitate turbulent flow of liquid. The ice cream mix is made to flow rapidly over the plates and hot water or steam is passed over the other side of the plate in an opposite direction, transferring heat to the ice cream mix. The holding time of pasteurization is controlled by the flow rate of the mix.

Ice Cream Freezer

The ice cream freezer is the heart of the ice cream industry. The functions of the ice cream freezer are as follows:

- To freeze a portion of the water in the mix. The rate of freezing should be quite rapid so that the ice crystals formed are small and are evenly distributed. The ice crystals should be less than 40
- To incorporate a calculated amount of air, uniformly, to achieve the desired over-run and
- To mix fruits, flavours, colours and other secondary ingredients evenly while freezing.

Ice cream freezers are basically of two types, the batch freezer and the continuous freezer. The batch freezer consists of a cylindrical chamber fitted with a dasher. The dasher is fitted with scraper blades, rotating at a speed of about 170 to 250 rpm and a rotating beater moving in the opposite direction. The function of the dasher are to scrape the frozen ice cream from the sides of the freezer chamber and move it towards the center of the freezer and circulate it, to bring about fast and uniform freezing, to beat the mix incorporating air and to eject the frozen ice cream.

The ice cream mix is placed in the freezer chamber and the refrigeration unit and the dasher are turned on. The temperature of the refrigerant should be maintained very low to effect fast formation of ice crystals. When the refrigerant temperature reaches about -5°C the refrigeration is shut down and the dasher is allowed to run a further few minutes. This is the temperature at which the maximum amount of air is absorbed. The frozen ice cream is then drawn out and transferred to the hardening chambers.

The continuous freezer operates on similar principle except that under pressure air is pumped into the mix at controlled rate.

There are also manually/electrically operated domestic type ice cream freezers. It consists of two concentric containers. The outer container is filled with a mixture of ice and salt, while the inner container is filled with the ice cream mix. In the middle of the inner container runs a vertically mounted shaft with blades, which is rotated by hand using a cranking mechanism or by an electric motor. When proper freezing is accomplished, the ice cream is withdrawn manually.

A manually operated domestic type ice cream freezer and an industrial type ice cream freezer are illustrated in Figures 3 and 4.

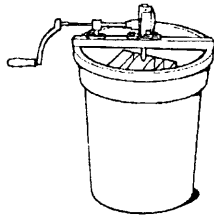


Figure 3 - Domestic type ice cream freezer

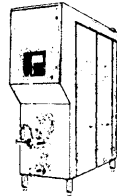


Figure 4 - Industrial type ice cream freezer

Hygienic and Quality Aspects

Ice cream should be 100% safe and fit for consumption and it is the right of the consumer. Therefore, it is the duty of the manufacturer to safeguard this right.

Considering the nature of raw materials used in the manufacture of ice cream and their susceptibility to spoilage, utmost care should be exercised from the procurement of raw materials until the ice cream reaches the consumer. Factors of extreme importance in the production of quality ice cream include

- Personnel hygiene of everyone involved in the manufacture, storage and sale of ice cream
- Clean and pleasant environment,
- Quality raw materials,
- Proper methods of processing,
- Use of proper equipment and maintenance of them,

Personnel hygiene and discipline is a very important factor. Even the most modern ice cream industry could be ruined by a single person if he or she does not adhere to hygienic rules. For maintenance of personnel hygiene, sufficient facilities should be provided. Facilities should include:

- ❖ Adequate means of hygienically washing and drying hands. People should wash their hands at the start of commencing operations, after using the toilet and after handling raw food or any material suspected of contamination

- ❖ Toilets of appropriate hygienic design; and
- ❖ Adequate changing facilities for personnel
- ❖ Specially designated place, away from processing area for the staff to have their meals.

These facilities should be located and designated at easy to reach places.

Everyone engaged in food handling activities should abstain from habits that could cause food contamination, which include smoking, spitting, chewing or eating, sneezing or coughing over unprotected food, etc. They should refrain from wearing or bringing personal effects such as jewellery, watches, pins or other items. The maintenance of personal hygiene of all should be monitored by scheduled programme. This should include medical examination of all food handlers at stipulated intervals

A routine programme also should be in place to ensure adequacy of cleaning of machinery, equipment, premises and surrounding.

Cleaning should be conducted according to recommended methods. All detergents and other cleaning agents used should be those recommended for food processing operations. Water used should be potable water. The water should be tested for suitability at regular intervals.

The factory walls and floors should be properly laid with easily cleanable white coloured tiles. White colour is recommended for easy detection of dirt. There should not be any cracks or crevices where dirt can accumulate. At the end of each day, the processing area should be washed with the recommended dosage of detergents and disinfectants. The same applies to equipment and machinery.

All incoming raw materials should be checked for conformity to recommended standards. Raw material should be stored properly and First-In-First-Out (FIFO) method followed. The residence time of raw materials in storage should be kept as minimum as possible.

The subject of hygiene in food handling establishment is a specialized subject and it is not possible to discuss it fully in this document. Readers are encouraged to do further reading and to follow special training programmes conducted by relevant authorities.

Practicing 5S, the Japanese method of good housekeeping and implementing quality and food safety systems as given in ISO 9001: 2000, ISO 22000 and HACCP are strongly recommended.

Troubleshooting

Every ice cream manufacturer may from time to time encounter problems with respect to the quality of ice cream produced. A good quality ice cream should satisfy the following properties.

- Typical pleasant flavour
- Smooth and uniform body and mouth feel (texture)
- Proper melting qualities
- Hazard free (low microbial count)

- Proper over- run
- Uniform colour

Deviation from any of the above properties will result in the degradation of the quality of ice cream proportionately. Quality defects will lead to re-processing or rejecting the batch, involving heavy additional costs. Some of the common defects that could occur during ice cream manufacture, their causes and remedies are given in the troubleshooting table below. The first preventive measure for avoiding defects in ice cream is to follow Good Manufacturing Practices (GMP). The defects given in the troubleshooting table are those that may occur even after observing GMP.

DEFECT		CAUSE	REMEDY
Flavour Defects	High flavour	Excessive amount of flavouring material	Reduce the quantity of flavouring material to the correct amount
		Poor quality flavouring agent	Always use reputed and tested brands of flavouring agent purchased from reputed dealers
	Low flavour	Insufficient amount of flavouring material	Use the recommended quantity
		Poor quality flavouring agent	Always use reputed and tested brands of flavouring agent purchased from reputed dealers
		Adding flavour at the wrong processing point	Always add flavour after pasteurizing and cooling, preferably after aging
		Wrong choice of ingredients	Choose ingredients that do not mask the flavours
	Acidic flavour	Formation of lactic acid due to fermentation of milk	Avoid the use of stale raw materials
			Avoid storage at high temperature and storage for prolong periods
		Contamination with acidic substances	Store under extreme hygienic conditions
	Cooked flavour	Over heating while pasteurizing	Store systematically and process under careful conditions to prevent contamination
Employ proper pasteurizing temperature and holding time			
			During pasteurizing slowly and constantly agitate the mix

Texture Defects	Greasy texture	High fat content	Re-calculate the formulation and adjust the recipe
		Large fat globules	Homogenize the mix properly
	Icy texture	Slow freezing	Avoid freezing at high temperature
		Insufficient stabilizer	Use the proper grade and quantity of stabilizer
		Improper hydration of proteins	Age the mix properly
		Low solid content	Re-calculate the formulation and adjust the recipe
	Fluffy texture	Excessive amount of air bubbles or large air bubbles	Adjust the machine for proper over-run control
	Sandy texture	Low solid content or incorrect composition of mix	Re-calculate the formulation and adjust the recipe
		Formation of lactose crystals due to high MSNF	Adjust the MSNF content of the mix
		High sugar content	Reduce the sugar content or blend with invert sugars
	Heavy or soggy body	Low over-run	Control over-run production
		Excessive emulsifiers	Re-calculate the quantity of emulsifier
High solid content		Re-calculate the formulation and adjust the recipe	
Melting Defects	Foamy melt down	High over-run	Reduce the over-run
		High emulsifier	Adjust the quantity of emulsifier
	Does not melt properly	High stabilizer/emulsifier content	Adjust the quantity of emulsifier/stabilizer
		Improper homogenizing	Use proper homogenizing temperature and pressure
Colour Defects	Improper colour	Use of inferior quality colouring agents	Use good quality colouring agents obtained from reputed dealers
		Careless use of colours	Add correct amount of colouring agent at the correct point
		Presence of foreign matter	Use care to prevent contamination
		Inferior quality raw materials	Use quality raw materials. Adopt proper incoming material inspection techniques
Storage Defects	Shrinkage on storage	Porous packaging materials	Use packaging materials which are impermeable
		Improper storage or hardening temperature	Store at proper temperature
		Excessive over-run	Reduce over-run
		Excess sugar	Re-formulate the recipe

Conclusion

This document gives the reader only a very brief introduction to the manufacture of ice cream. Anyone who wants to study the subject in detail or those who want to start manufacturing ice cream commercially or otherwise are advised to do further reading. They

are also encouraged to attend special training classes on this subject conducted by relevant organizations. Further information on this subject could also be obtained from the Director, Technical Services Division of the Industrial Development Board, Katubedde.