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Title: Ice Cream Product Integrity and the Importance of the Cold Chain

Ice Cream Product Integrity and the Importance of the Cold Chain

Ice cream originated in China and was introduced to the West by Marco Polo. As of 2012, it accounts for a nearly $7 billion product category in annual sales[1], and the average American consumes nearly 5 gallons of ice cream annually[2]. It is a product with strong connotations of indulgence, pleasure, richness, holidays, and the good life. To ensure that it gets to consumers with those associations—as well as the product's integrity—intact, distributors and retailers must take strict precautions to maintain what is referred to as the *cold chain,* which is the maximum

[1] www.idfa.org/news--views/media-kits/ice-cream/ice-cream-sales-and-trends
[2] smallbusiness.chron.com/ice-cream-industry-18216.html

temperature *below* which the product must be kept in every stage of its distribution from the manufacturer to the consumer.

Ice cream maintained at the proper temperature can have a shelf life of 12 to 24 months. More sensitive variations of the product such as cones, sandwiches and other “novelty” types are mostly limited to 6 to 9 months of shelf life. The majority of ice cream sold in the US is produced and marketed regionally, which somewhat lessens the challenge of maintaining the cold chain throughout the distribution process; however, at every step along the way, there are potential obstacles to keeping the product within the proper temperature range.

Maintaining proper temperature for any perishable product always requires care in handling and transportation from the producer to the consumer—with ice cream, adherence to its cold chain requirements is all the more critical due to the very nature of the product. The primary ingredients of ice cream include the following: air, water, sugars, fat, proteins (from milk solids for traditional ice cream), stabilizers and emulsifiers, flavors and fruits, and color additives. This complex mixture of components makes the quality of the product particularly susceptible to changes in temperature.

Composition	Water Ice	Sorbet	Ice Milk	Ice Cream	Premium Ice Cream
% Fat	0	0	2-6	7-12	12-16
% MSNF*	0	0	7-9	8-11	8-11
% Sugars	18-20	20-25	15-18	15-18	15-18
% Total Solids	20-22	30-32	30-32	33-40	40-44
% Water	78-80	68-70	68-70	60-67	56-60
% Overrun (air)	0	50-60	70-90	90-100	30-100
Products	Sticks, Novelties, Cheap Products	Bulks (high content of fruits)	Sticks, Cups, Bulks	All Products	Bulks (pint – 500 ml)

*MSNF = Milk Solids Non Fat

Ice cream composition by product type

Air may account for half or more of the volume of ice cream; therefore, the quantity and distribution of air throughout the product determines its texture to a great extent. Water typically makes up from 60 to 70% of the weight of the product. At the recommended serving temperature for ice cream—from -5°F (-20°C) to -0°F (-18°C)—80 to 85% of the water in it is frozen, which also contributes to the texture.

Other factors that influence the taste and consistency of ice cream include various sweeteners, fats, and fruits. Sugars present may include—alone or in combination—the following: sucrose, glucose (sometimes used in combination with fructose), or lactose. One of the effects of these sugars is their influence on the viscosity and crystallization of the product: for example, sucrose and glucose (syrup) act as an anti-crystallizing agent.

Along with texture, fats affect other physical properties of ice cream— they impart its characteristic richness, palatability, and food value. Inclusions largely determine the flavor and texture of varieties of ice cream to which they are added.

Proteins put the “cream” in ice cream. Cream is usually made from milk of some kind, whether it is fresh milk, condensed milk, milk powder, or lacto-replacers (a blend of milk solids and non-milk proteins). These milk-based products contribute to ice cream’s structure and influence its texture both with respect to body and creaminess. Due to a phenomenon known as *fat globule membrane formation,* proteins help maintain both its integrity during store and its food value.

Stabilizers and emulsifiers, as the name suggests, act to stabilize the product. They are typically used in low concentrations. Hydrocolloids, or gums, are one type of stabilizer, the principle property of which is its ability to bind to water. Benefits of stabilizers include increased viscosity and stability. They also help the product to retain air during the manufacturing process, and they promote the formation of ice nuclei, which slows down the growth of ice crystals. On top of all that, they provide the finished product with a fine, creamy texture that has good melting properties, thus preventing the various other ingredients from separating out as the product warms.

The other additive, emulsifiers, reduces something called the *interfacial tension* between immiscible oil and water phases. This improves the distribution of fat globules, and along with stabilizer, controls de-emulsification, which occurs during melting. Emulsifiers also contribute a number of other benefits that have to do with the distribution of fats; incorporation of air; resistance to shrinkage; and smoothness and consistency. They also help in the manufacturing process when extruding the product during freezing.

Manufacturing and Distribution

An essential aspect of the production process is the hardening of the product. During production, hardening is a continuous process that is carried out by the passage of the product mixture through a ventilated tunnel at a temperature lower than -31°F (-35°C). As the hardening mixture reaches the packaging container, it is rapidly cooled further to below 5°F (-15°C), preventing the growth of ice crystals. At this temperature, as noted above, most of the water in the mixture is frozen, thus optimizing the quality of the product during storage.

From this point on, heat shock must be avoided. Variations in the ratio of frozen water to liquid water cause the formation of crystals within the product. The hydrocolloids mentioned earlier slow crystal growth and reduce the effect of heat shock. Ideally, ice cream should be stored at -18° F (-28°C), with a maximum fluctuation of no more than 3°F (2°C) plus or minus.

During distribution, ice cream must be kept below -13°F (-25°C). At the point of sale, however, a somewhat higher temperature is permissible. In fact, according to some manufacturers' guidelines, display cases can be run at up to -8° F (-22°C), with the top of the case being no warmer than -4°F (-20°C). Store layouts typically place dairy and frozen food products toward the back of the store, so that for most shoppers, these are the last items they get before heading to check out. Once they've left the store, however, they often have some distance to go before reaching home and putting their ice cream into their own freezer. So the colder the product is before it leaves the store, the better and more satisfied the customer. Additionally, the colder the product is kept, the more likely it is to remain sellable if there is ever any temporary problem with the case or refrigeration.

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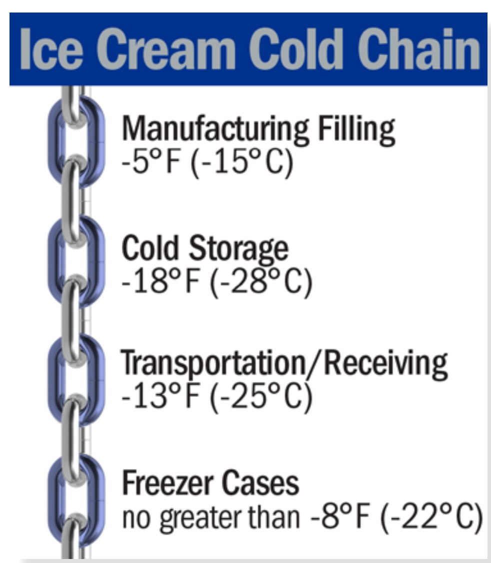
The Cold Chain



During the entire transportation process in which the product is moved from the manufacturer to the retailer, the rule is simple and well known: at no time should the product ever be warmer than the maximum allowable temperature of **-4°F (-20°C)**. This can only be accomplished if the air temperature during transport is maintained at or below **at least -13°F (-25°C) or colder** to accommodate for heat exchange, air fluctuation, door openings, defrost cycles, etc. At every stage of the process, care must also be taken to avoid *heat shock*, which is any fluctuation in temperature that has a detrimental effect on the product's texture. If the temperature of the ice cream is allowed to cycle from warmer to colder and back—no matter how small the range of the temperature fluctuation may be—the product's texture can be irreversibly damaged. And bear in mind that the smaller the ice cream package, the more susceptible it is to heat shock.

Maintaining the quality of an ice cream product depends on its time-temperature history. Every step along the cold chain has an impact on this history.

Any break in the cold chain will result in irreversible damage to the product, risking both customer dissatisfaction and loss of the product.

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