THE USE OF PALM AND PALM KERNEL OILS IN ICE CREAM AND WHIPPED CREAM PRODUCTS*

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INTRODUCTION

Food oils and fats all have the same basic chemical structure, being esters of fatty acids with glycerol. The physical and chemical properties vary however, depending on the actual fatty acids and the way in which they are combined. When selecting a fat for use in a particular food product, it is necessary first to establish some information on the physico-chemical functions of the ingredients, so that the correct choice may be made. In ice cream and whipped cream the lipid components play a key role in the formation and stability of the structure. This paper therefore first presents general information on the structure of the products and then develops the specifications of the fat component.

COMPOSITION

Typical compositions of milk, ice cream and cream products are given in *Table 1*.

Initially these products are emulsions of oil in water. The aqueous phase contains milk solids in solution or in the colloidal state and, in the case of ice cream and whipping cream, a carbohydrate-type stabilizer is also in solution.

The final product is a foam, with an emulsion of somewhat modified composition as the continuous phase. The ice cream foam is required to be stable at about -5°C, when some 50% of the water is in the frozen state, whereas whipped cream is required to be stable, at least for a limited period, at room temperature.

NATURE OF THE EMULSION

The natural emulsion of milk, as produced by the cow, consists of fat particles ranging in size up to 20 microns, with an average diameter of about 4 microns (μm). The surface of the fat globules is covered by a layer of absorbed milk proteins, which is not very firmly held. The emulsion is only moderately stable, and on standing a cream with an enhanced content of fat forms an upper layer. In modern dairy practice cream is obtained by centrifugation, and the fat content can be controlled as indicated in *Table 1*. Ice cream mix, processed cream and synthetic cream are usually homogenized, resulting in a much smaller particle size, averaging 1 μm or less, and therefore a much greater stability. During homogenization, a large new area of fat surface is created and the originally absorbed protein, the 'natural milk fat globule membrane' is removed. After homogenization protein is again absorbed to the surface, but this is now mainly the casein component.

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STRUCTURE OF ICE CREAM

The homogenized ice cream mix is stored at 5°C for three hours or more and is then ready for the combined freezing and aerating step. This takes place in a scraped surface heat exchanger where the mix is rapidly chilled to -5°C at the same time as about 50% by volume of air is introduced, with strong agitation. The product leaving the freezer is essentially in the finished form, but for storage it is chilled further to -18°C or lower.

The dimensions and numbers of some of the components of frozen ice cream are given in *Table 2.* Under the electron microscope, it can be seen that the surface of each air cell is coated with a continuous layer of liquid oil and that this is surrounded by an outer layer of discrete fat globules with the size distribution of the original emulsion.

This formation plays an important role in ensuring the stability of the ice cream structure. The continuous phase of the frozen ice cream contains, apart from ice crystals, numerous fat globules, either single or loosely clumped together. In addition casein micelles and micellar sub-units can be identified.

If a conventional ice cream formula is made using a liquid oil a different microscopic structure is obtained. There are no discrete fat globules to be seen. All the emulsion has been broken during freezing and all the oil has migrated to the air bubble interface. Such an ice cream is not stable.

TABLE 1. COMPOSITION OF ICE CREAM AND RELATED PRODUCTS (%)

	Ice Cream	Milk	Cream Single	Cream Double	Cream Imitation
Fat	9 - 12	3.9	21.2	48.2	28
Milk solids other than fat	10 - 11	8.3	7.1	4.7	3.5
Sugar (added)	13 - 16.5	-	-	-	10 - 20
Emulsifier	0.4 - 0.7	-	-	-	1.0
Stabilizer	0.1 - 0.2	-	-	-	0.1 - 0.2
Inorganic salts	1.0	0.7	-	-	-

STRUCTURE OF WHIPPED CREAMS

Microscopic examination of whipped creams shows that the structure is essentially the same as that described above. The air cells have a continuous surface layer of fat, where some traces of crystallinity have been observed, while the continuous phase contains numerous unchanged fat globules. Some of the fat has however agglomerated into regions of crystalline fat.

The factors controlling structural stability are somewhat different by comparison with the case of ice cream. Cream has a much higher fat content, it is not frozen, and it needs to be stable at room temperature. Continuous regions of free fat in a partly crystalline state are important in the structure. If excessive shear forces are used during the whipping of cream, it is rather easy to get too much churning, leading to the separation of 'butter'. Cream and imitation cream are offered to the consumer in a number of different forms, for examples:

- Natural fresh cream
- Homogenized canned cream
- Imitation cream – pasteurized
- Imitation cream – UHT treated
- Cream in aerosol packs
- Frozen whipped cream
- Toppings or creams in the form of spray-dried powder.

In order to get satisfactory whipping properties and structural stability, the formula and processing require adjustment for each of these product types.

Before being aerated, the cream and ice cream mix emulsions need to be stable. The structure at the surface of the fat globules is complex. The surface active materials, natural or added, are oriented at the

TABLE 2. DIMENSIONS AND NUMBERS OF FROZEN ICE CREAM COMPONENTS

	Diameter µm	Number per g
Air cells	5 - 300 (mean 60)	8.33×10^{6}
Fat globules	0.04 - 3.0	1.53×10^{12}
Ice crystals	(mean 34)	7.8×10^{6}
Casein micelles	up to 0.2	

surface with polar functional groups towards the aqueous phase. Protein is absorbed and partly denatured at the fat globule surface. Some hydrophobic regions of the protein probably penetrate the fat surface. The more saturated glycerides are partly crystallized at the interface. This crystallization is promoted by the presence of saturated surfactants such as glyceryl monostearate.

However, during the whipping process the emulsion is required to destabilize partially. This is achieved partly by the mechanical action of the rotary beaters and partly by the action of the emulsifying agent. The extent of destabilization can be controlled to some degree by selection of the emulsifier type and its concentration. However, both in ice cream and in whipped cream the fat and its behaviour during processing are among the most important parameter for a satisfactory product.

TABLE 3. SOLID FAT CONTENT (%) OF ICE CREAM FATS

Product	Temperature						
	-5°C	0°C	5°C	10°C	20°C	25°C	35°C
Palm kernel oil	86.1	84.2	78.9	72.2	45.5	21.5	0
Palm oil	82.4	78.6	69.5	54.6	23.2	13.7	6
Palm oil blend	87.2	84.2	78.8	70.8	NA	NA	NA
Butterfat 1	75.7	72.5	66.0	52.2	NA	NA	NA
Butterfat 2	71.6	68.2	61.7	46.9	26	18	6
Hardened palm kernel oil	NA	NA	NA	89.9	70.4	47.3	6.7

NA = not available

REQUIREMENTS OF THE FAT INGREDIENTS

The broad specification of the fat for ice cream is:

1) Partly solid at +5°C and at -5°C
2) Substantially liquid at 37°C
3) Good 'melt in the mouth' properties

The corresponding requirements in the case of whipped cream are:

1) Partly solid at +5°C
2) Solids content at ambient temperature related to stability requirements
3) 'Melt in the mouth' properties particularly important due to the higher fat content.

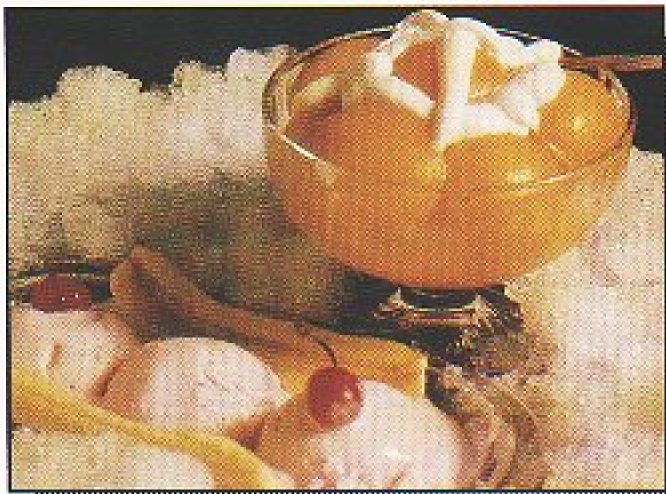
The solids contents of some vegetable oils suitable for ice cream are compared with data for butterfat in *Table 3*. Figures for hardened palm kernel oil are also included for comparison.

Compared with butterfat, palm oil has a very similar solids contents, while palm kernel oil melts more sharply.

While all three fats have been and are used commercially in ice cream manufacture, it has been found that some freezing processes, which use lower temperatures, cause too much destabilization of the emulsion when the palm oil is used. In these processes either palm kernel oil or a blend of palm oil with some hydrogenated palm oil have been given improved results.

The higher fat content of creams makes the melting characteristics of the fat very important. A solids content of a few per cent at mouth temperature results in a greasy residue on the palate, which consumers do not like. For this reason palm kernel products are superior. However, palm kernel oil and butterfat give aerated creams that are somewhat lacking in structural stability at ambient temperatures.

In this respect the use of partly hydrogenated palm kernel oil gives an improvement. The extent of



hydrogenation can be carefully adjusted for stability at higher ambient temperatures, but increased hydrogenation inevitably raises the solids content at 37°C and leads to some reduction in palatability. Recent research has found that for hotter climates an economic fat blends for creams with acceptable mouthfeel and good whipping properties can be made by interesterifying 66 parts of hydrogenated palm kernel oil (iodine value 1.1) with 34 parts palm stearin (iodine value 19). The solid contents of this blends at 37°C was very similar to that of the hardened palm kernel oil, but between 37°C and 25°C it was somewhat higher, conferring greater stability on the whipped cream.

To sum up – the traditional fat in ice cream and whipped cream is natural butter. Where it is desired to use a vegetable oil, it has been found that palm and palm kernel oil are satisfactory in ice cream, and both these oils have been use extensively in commercial products. In most cases they are interchangeable depending on price. In whipped cream products additional stability is obtained by using hydrogenated palm kernel oil. Palm oil is less suitable in these products because of its slower 'melt in the mouth' behaviour.

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