Co-op Work Term Report

" Effect of Type and Amount of Emulsifier on Protein Adsorbed to Fat Globules in Ice Cream"

By

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Abstract

The amount of protein adsorbed to fat globules in ice cream samples was studied with varying amounts and types of emulsifier. Two nonionic surfactants were considered: glycerinmonostearate (oil-soluble; GMS) and polysorbate-80 (water-soluble; P-80). This investigation focused on 6 ice creams which had the same basic composition but different types and percentages of emulsifier. It was found that, using only GMS and using GMS and P-80 together reduced the amount of adsorbed protein. More protein was displaced as the concentration of emulsifier was increased. Samples containing both emulsifiers had less protein adsorbed than the samples containing only GMS. This study showed similar amounts of adsorbed protein for the 0.15%GMS+0.04%P-80 and 0.15%GMS+0.06%P-80 samples, and these samples seemed to have the least amount of adsorbed protein (22.78% and 23.64% of total protein respectively). When the ice cream samples were compared with the mix samples, the ice cream samples were found to have more adsorbed protein than the mix samples for total adsorbed protein and for each type of protein. A possible cause for this phenomenon could be entrapment of protein in the fat network that forms as the ice cream is frozen.

Keywords: adsorbed protein, emulsifier, protein displacement

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Introduction:

1.The Definition of Ice Cream

Ice cream is a frozen mixture of a combination of milk ingredients, sweeteners, stabilizers, emulsifiers and flavoring. Other ingredients such as egg products, colorings and starch hydrolysates may also added . The mixture of ingredients called a mix, is pasteurized and homogenized before freezing. Freezing involves rapid removal of heat while agitating vigourously to incorporate air (Marshall and Arbuckle, 1996).

Ice cream and related products are common dessert or sweet snack products around the world. There are a wide range of available products, including, in addition to conventional ice cream: premium ice cream, ice milk, lowfat ice cream, sherbet and sorbet, water ice, and frozen yogurt. The components and process, however, are similar for all and thus conventional ice cream will be considered in detail (Goff, 1997b).

From the review by Goff (1997a), ice cream could be defined as complex food colloid (which is defined as a system of discrete particles of size from 1 nm to 1μm in continuous phase) that relies on partial coalescence in structure development. Its structure consists of air bubbles, fat globules, ice crystals, and unfrozen serum phase.

2. The Composition and Ingredients of Ice cream

Ice cream has the following composition (Goff, 1997b):

- greater than 10% milkfat by legal definition, and usually between 10% and as high as 16% fat in some premium ice creams
- 9 to 12% milk solids-not-fat: this component, also known as the serum solids, contains the proteins (caseins and whey proteins) and carbohydrates (lactose) found in milk
- 12 to 16% sweeteners: usually a combination of sucrose and glucose-based corn syrup sweeteners
- 0.2 to 0.5% stabilizers and emulsifiers
- 55 to 64% water which comes from the milk or other ingredients

The ingredients to supply the desired components are chosen on the basis of availability, cost, and desired quality. These ingredients will now be examined in more detail.

- Butterfat is important for ice cream for the following reasons: increases the richness of flavour in ice cream, produces a characteristic smooth texture by lubricating the palate, helps to give body to the ice cream, aids in good melting properties, and aids in lubricating the freezer barrel during manufacturing (Non-fat mixes are extremely hard on the freezing equipment). The best source of butterfat in ice cream for high flavour is fresh sweet cream from fresh sweet milk.

- The serum solids or milk solids-not-fat (MSNF) contain the lactose, caseins, whey proteins, minerals, and ash content of the milk from which they were derived. They are an important ingredient for the following reasons: they improve the texture of ice cream, help to give body and chew resistance to the finished product, are capable of allowing a higher overrun without the characteristic snowy or flaky textures, associated with high overrun, and may be a cheap source of total solids. The best sources of serum solids for high quality products, are concentrated skim milk, and frozen condensed skim milk. The limitations on their use include off flavours which may arise from some of the products and an excess of lactose which can lead to the defect of sandiness prevalent when the lactose crystallizes out of solution. Excessive concentrations of lactose in the serum phase may also lower the freezing point of the finished product to an unacceptable level.
- The proteins, which make up approximately 4% of the mix, contribute much to the development of structure in ice cream including: emulsification properties in the mix, whipping properties in the ice cream, and water holding capacity leading to enhanced viscosity and reduced iciness
- The sweeteners improve the texture and palatability of the ice cream, enhance flavors, and are usually the cheapest source of total solids.
- The stabilizers are a group of compounds, usually polysaccharides, that are responsible for adding viscosity to the unfrozen portion of the water and thus holding this water so that it cannot migrate within the product. This results in an ice cream that is firmer to the chew. Without the stabilizers, the ice cream would become coarse and icy very quickly due to the migration of this free water and the growth of existing ice crystals. The functions of stabilizers in ice cream are: to produce smoothness in body and texture, retard or reduce ice crystal growth during storage, provide uniformity of product and resistance to melting, aid in suspension of flavouring particles, produce a stable foam in the ice cream and easy cutoff and stiffness for packaging, prevent shrinkage in the frozen product, and slow down moisture migration out of the frozen product.
- The emulsifiers are a group of compounds in ice cream which aid in developing the appropriate fat structure and air distribution necessary for the smooth eating and good meltdown characteristics desired in ice cream. Since each molecule of an emulsifier contains a hydrophobic portion and a lypophilic portion, they reside at the interface between fat and water. As a result they act to reduce the interfacial tension or the force which exists between the two phases of the emulsion. The emulsifiers actually promote a destabilization of the fat emulsion which leads to a smooth, dry product with good meltdown properties. The original ice cream emulsifier was egg yolk but today, two emulsifiers predominate most ice cream formulations:1) mono- and di-glycerides, derived from the partial hydrolysis of fats or oils of animal or vegetable origin; 2) polysorbate 80, a sorbitan ester consisting of a glucose molecule bound to a fatty acid, oleic acid (Goff, 1997b).

3. The Manufacturing Process and Physical Change During Manufacturing Process of Ice Cream

The basic steps in the manufacture of ice cream are generally as follows: blending of the mix ingredients, pasteurization, homogenization, aging the mix, freezing, packaging, and hardening respectively (Goff, 1997b).

First the ingredients are selected, weighed and then blended together to produce what is known as the "ice cream mix". The mix is then pasteurized. Pasteurization is the biological control point in the system, designed for the destruction of pathogenic bacteria. In addition to this very important function, pasteurization also reduces the number of spoilage organisms such as psychrotrophs, and helps to hydrate some of the components, such as proteins and stabilizers. Pasteurization regulations are heating at 69° C for 30 min or 80° C for 25 seconds(Goff, 1997b).

After pasteurization, the mix is at a temperature sufficient to have melted all the fat present, and the fat passes through one or two homogenizing valves. Homogenization converts the mix into a fat emulsion by breaking down or reducing the size of the fat globules found in milk or cream to less than 1 μm. Two stage (two valves) homogenization is usually prefered for ice cream mix (Goff, 1997a), as the 2^{nd} stage presents fat globule clustering. Immediately following homogenization, the newly formed fat globule is practically devoid of membranous material and readily adsorbs amphiphilic molecules from solution. The immediate environment supplies the surfactant molecules, which include caseins, undenatured whey proteins, phospholipids, lipoprotein molecules, components of the original milk fat globule membrane (and any added chemical surfactants) (Goff, 1997a). Electron microscopic examination of fat globules in ice cream clearly shows a coating of casein micelles or subunits thereof. It has been demonstrated that casein is very effective in stabilizing oil-in-water emulsions (Thomas, 1981). In addition, Britten and Giroux (1991) showed that casein was preferentailly adsorbed over whey protein, to fat globules. Also Pelan et al. (1997) showed that emulsions became increasingly more stable during partial coalescence as the protein concentration was increased.

If surfactants are present during homogenization, after the aging step, the membrane will be practically devoid of protein, rendering it much more susceptible to partial coalescence when frozen. Surfactants (emulsifiers such as monoglycerides, diglycerides, or polysorbate 80) lower the interfacial tension between the fat and the water phases more than the proteins. Thus, in an emulsion created in the presence of both proteins and surfactants, it has been demonstrated that the surfactants become preferentially adsorbed to the surface of the fat, displacing most, but not all of the protein present (Goff, 1997a). The aging of ice cream mixes at low temperature (usually 4°C) also induces some changes in the physical state of lipid phase, both in the emulsified fat and in the adsorbed layer of surfactants. Lipophilic emulsifiers, such as mono and diglycerides, are thought to promote desorption of protein through the formation of a

crystalline structure around the oil droplets and/or the formation of micelles near the interface (Courthaudon et al., 1994).

The next stages in ice cream production are the concomitant whipping and freezing steps where structure development occurs. Air can be incorporated through a lengthy whipping process (batch freezers) or drawn into the mix by vacuum or injected under pressure in continuous freezers. This freezing/whipping process causes the emulsion to undergo partial coalescence or fat destabilization, during which clumps and clusters of fat globules form an internal fat structure or network in the frozen product. It is at this stage that the emulsifiers have the greatest impact. The membrane created by the addition of surfactant is fragile and allows the semi crystalline droplets to partially coalesce upon collision, setting up the internal fat matrix. The fat globule clusters formed during the process of partial coalescence are responsible for surrounding and stabilizing the air cells and creating a semicontinuous network or matrix of fat throughout the product. This fat structure results in the beneficial properties of dryness upon extrusion (aids in packaging and novelty molding, for example), a smooth texture in the frozen dessert, and resistance to meltdown or good shape retention properties (Goff, 1997a). Pelan et al. (1997) found that the melting resistance of ice cream was related not only to the amount of extractable fat, but also to the air cell stability, both of which were dependent on the type of surfactant used.

As the ice cream is drawn from the freezer, with about half of its water frozen, particulate matter such as fruits, nuts, or candy is added to the semi-frozen slurry which has a consistency similar to soft-serve ice cream. Almost the only thing which differentiates hard frozen ice cream from soft-serve is that the soft-serve is drawn into cones at this point in the process rather than into packages for subsequent hardening. After particulates have been added, the ice cream is packaged and is placed into a blast freezer at -30°C to -40°C where most of the remainder of the water is frozen (hardening). Below about -25°C, ice cream is stable for indefinite periods without danger of ice crystal growth; however, above this temperature, ice crystal growth is possible and the rate of crystal growth is dependent upon the temperature of storage. This limits the shelf life of the ice cream (Goff, 1997b).

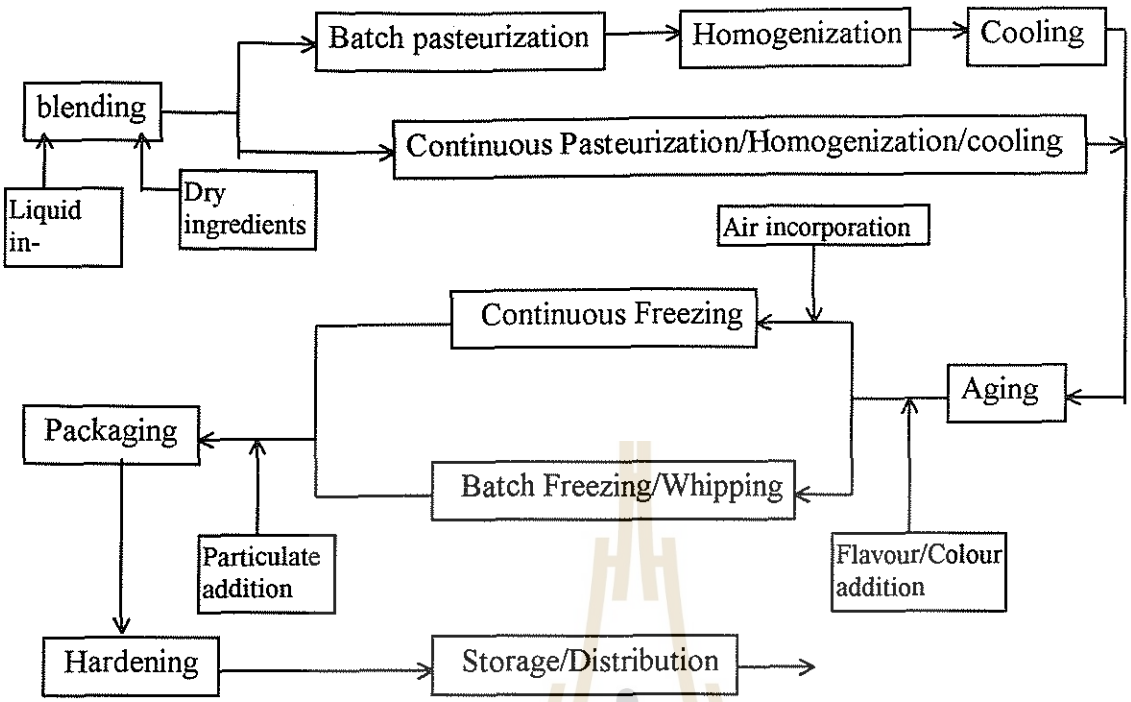

Figure 1. The manufacturing Process of ice cream (Goff, 1997b)

Objectives:

1. To study the effect of type and amount of emulsifier on adsorbed protein to fat globules in ice cream mix and frozen ice cream.
2. To study the effect of emulsifier type and amount on the desorption of the different species of milk proteins.

Materials and Methods:

Ice Cream Preparation

Six different ice cream recipes were produced in the pilot plant at GFTC (Guelph Food Technology Center, University of Guelph, Ontario) by Bolliger et al. (1998). Two nonionic emulsifiers were used: glycerinmonostearate (GMS) and polysorbate-80 (P-80). Each sample had the same basic ingredients but the amount and type of emulsifier was varied (table 1 and 2). The details of the ice cream preparation were described by Bolliger et al. (1998).

Table 1: Basic recipe for the ice creams (samples)

Basic ingredients	Content [%]
- Butterfat, anhydrous-Ghee, Gay Lea, ON	10
- Skim Milk Powder, New Dundoe, ON	10
- Sucrose, Lantic Sugar Limited, ON	12
- Corn Syrup Solids, CSS 42, Dri-Sweet 42	6
- Guar, Germantown Int. Ltd.	0.15
- Emulsifier, Germantown Int. Ltd.	as shown in separate table
- Water	added up to 100%

Table 2: Emulsifier content for sample 1 to sample 6

Sample	Glycerinmonostearate [%]	Polysorbate-80 [%]
1	-	-
2	0.075	-
3	0.15	-
4	0.15	0.02
5	0.15	0.04
6	0.15	0.06

Electrophoresis

The amount of adsorbed protein on fat globules in ice cream samples was measured by SDS-PAGE electrophoresis.

Each ice cream sample was divided into two portions for the measurement. One portion was not centrifuged prior to electrophoresis and provided the amount of total protein in the ice cream. The second portion was centrifuged prior to electrophoresis to provide the amount of adsorbed protein. For all samples, 10 gram of ice cream was melted at 40°C for 45 seconds. For the measurement of adsorbed protein, the next stage was fat phase separation. The melted ice cream samples were separated by ultracentrifugation (Beckman, preparative ultracentrifuge L8-70M, rotor TI-70) at 15000 rpm for 60 minutes at 20°C. The isolated fat phase was collected, spread on filter paper to adsorb any remaining serum and then resuspended in water back to its original concentration (10%). Sample preparation for SDS-PAGE was carried out as described by Hunt and Dalgleish (1994).

For the electrophoretic analysis, 1 μl of each sample (6 recipes → not centrifuged + centrifuged) was loaded onto a 20% homogeneous "Phastgel" (Pharmacia Biotech), and run in a rapid electrophoresis system (Phastsystem, Pharmacia Biotech) at 15°C. Subsequently, the gels were stained with a Coomassie blue solution (PhastGel Blue R, Pharmacia Biotech) and then destained with a destain solution (distilled water : acetic acid : methanol = 6:1:3). Finally, the gels were treated with a preserving solution (glycerol:acetic acid:water by 1:1:8) and dried at room temperature.

The samples with no emulsifier was analyzed twice while all other samples were analyzed three times. All replications were performed with samples from independent ice creams.

Scanning Densitometry

After electrophoresis, the dried gels were scanned with a Sharp JX-330 scanner (Sharp Corporation, Japan). The scanned images were evaluated with "Image Master" software (Pharmacia Biotech, Canada). The intensity, the size and the distance between the bands were expressed in a peak diagram. The amount of protein was expressed as the intensity and area below the peak (raw volume). The fat phase (centrifuged samples) was compared with reference samples (uncentrifuged samples) to determine the % of protein in the system which was bound to fat. Anlysis was performed for each protein found in the system and then the results were grouped into whey, casein and membrane fractions, as well as a total.

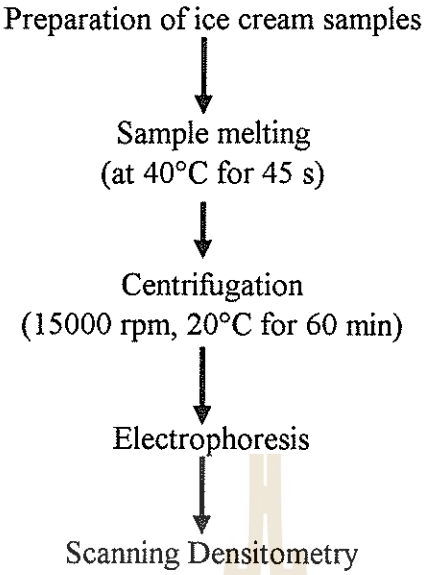

Figure. 2 Experimental step chart

Results and Discussions:

The main purpose of this investigation was to determine the effect of varying amount and types of emulsifiers on the amount of adsorbed proteins on fat globules in ice cream. It has been found, from 6 recipes of ice cream samples, that the amount of adsorbed protein in the non emulsified sample (no added emulsifier) was the most (42.05% of total protein). Subsequently, determinations used only glycerinmonosterate (GMS) as an emulsifier (0.075% and 0.15% wt.) and the amount of adsorbed protein was 30.90% and 26.98% of total protein respectively. However, when 2 emulsifiers were used together (GMS+Polysorbate-80 (P-80)), it was found that the amount of adsorbed protein decreased (table 3). The P-80 was used at three levels (0.02, 0.04 and 0.06%) in combination with GMS. The 0.02% sample had the highest bound protein of the three while the amount of adsorbed protein in the samples which had 0.04 and 0.06% P-80 were similar and they seem to be the smallest amount of bound protein overall (22.78% and 23.65% respectively). These results for ice cream samples show trends similar to the corresponding mix samples. For the mix, the highest amount of adsorbed protein was 32.18% of total protein (no emulsifier) and the amount from 0.15%GMS+0.04%P-80, 0.15%GMS+0.06%P-80 samples were similar and the lowest (18.60% and 18.75% of total protein respectively).

Table 3 : The percentage of protein adsorbed on fat globules in frozen ice cream

Samples	The amount of total adsorbed protein (% of total protein)
-no emulsifier	42.0466
-0.075% GMS	30.90683
-0.15% GMS	26.98145
-0.15%GMS+0.02% P-80	30.69625
-0.15% GMS+0.04% P-80	22.78302
-0.15% GMS+0.06% P-80	23.64832

In figure 5.1 and 5.2 , the adsorbed protein is divided into whey, casein and membrane fractions. Both of mix samples and ice cream samples had the same trends, similar to total adsorbed protein explained above. As the concentrations of emulsifier increased the amount of adsorbed protein of each type decreased. Comparing the whey protein fraction and casein fraction in ice cream samples, nearly equal amounts of both were adsorbed regardless of emulsifier. However, for the mix samples, the amount of casein adsorbed was found to be almost 2 times greater than the whey protein adsorbed to fat globules. Also a slight difference was found in the amount of casein adsorbed between the mix and ice cream samples at the same emulsifier level.

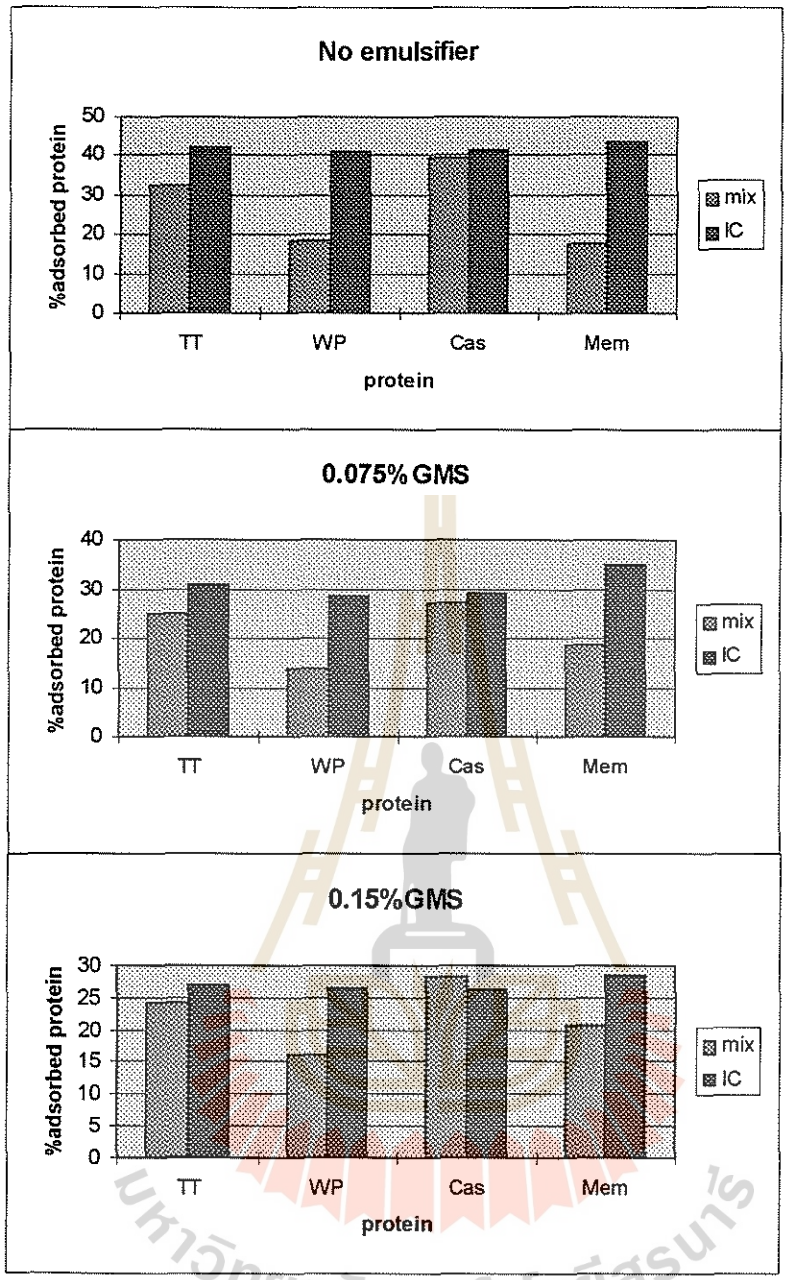

Figure 3.1 Comparison of the adsorbed protein amount for each protein type between ice cream mix (mix) and frozen ice creams (ic): TT= total adsorbed protein; WP= adsorbed whey fraction; Cas= adsorbed casein fraction and Mem= adsorbed membrane fraction, with GMS added.

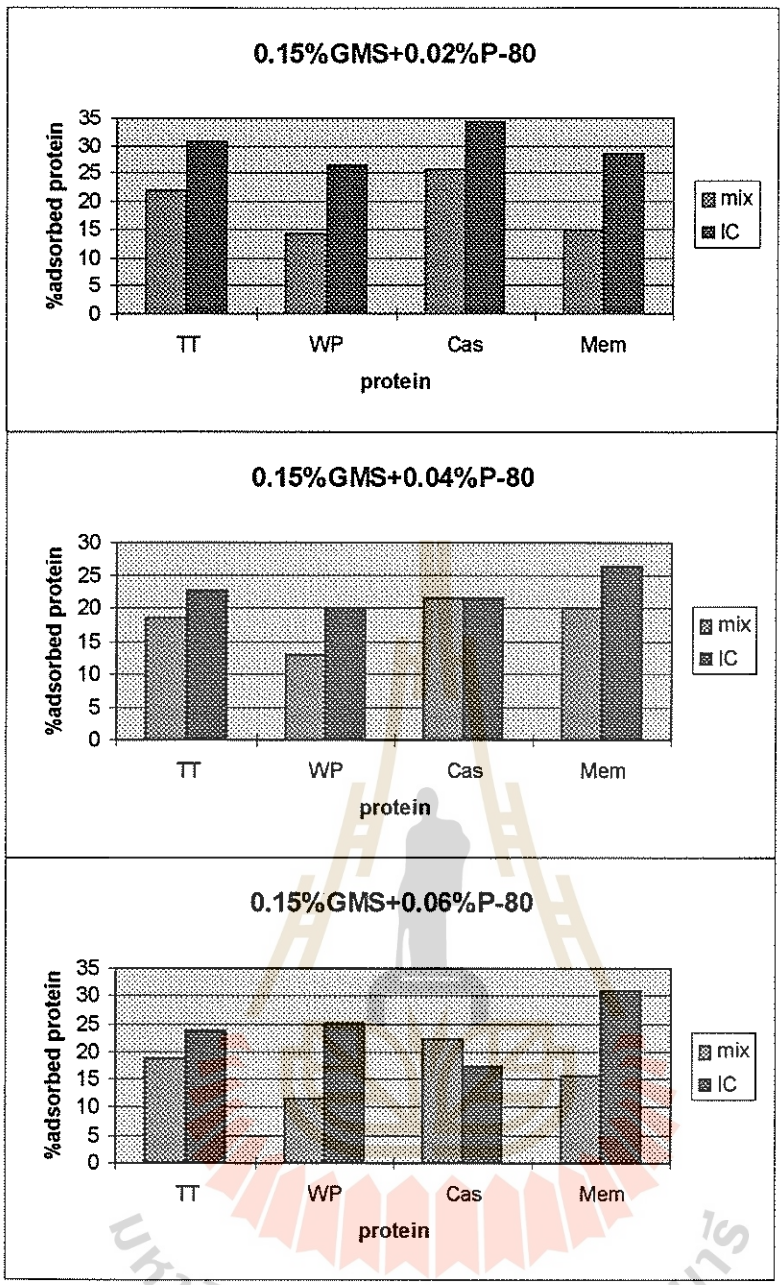

Figure 3.2 Comparison of adsorbed protein amount for each protein type between ice cream mix (mix) and frozen ice creams (ic): TT= total adsorbed protein; WP = adsorbed whey fraction; Cas= adsorbed casein fraction and Mem= adsorbed membrane fraction; with GMS+P-80 added.

The results suggest, for GMS alone as an emulsifier, when the GMS concentration increased, the amount of adsorbed protein decreased. This agrees with Euston et al. (1996), who demonstrated that at several protein concentrations, protein load decreased as GMS concentration increased to 0.6%wt. Euston et al. (1996) also showed that GMS used alone was less effective at displacing protein than when used together with P-80. This also agrees with the results of the current study.

In the study of Euston et al. (1996), it was also found that the surface protein concentrations (mg/m^2) in the presence of GMS alone was higher than in the presence of P-80 alone. This is likely due to the fact that GMS is an oil-soluble surfactant, whereas P-80 is water-soluble surfactant. The greater ability of water-soluble surfactants at displacing adsorbed protein has been well documented. In the study of Goff and Jordan (1989), it was found that P-80 produced an ice cream with the highest degree of fat destabilization, various other surfactants fell between, and a mix with no emulsifier produced the highest interfacial tension and the least fat destabilization. The powerful destabilizing agent P-80 is very effective at reducing the amount of protein adsorbed to the fat globule surface and reducing the interfacial tension. Although P-80 is the most effective, both water-soluble surfactants and oil-soluble surfactants, such as monoglycerides, can enhance the amount of fat destabilization during the freezing process. The mechanism is thought to be related to displacement of milk proteins from the fat droplet surface, thereby allowing close association of droplets and promoting the adsorption and partial coalescence of fat droplets at the interface of air and fat cells (Pelan et al., 1997).

In the current study, it was found that more protein was adsorbed in the ice cream samples than the corresponding mix samples. This result disagrees with the finding of Courthaudon et al. (1994), whose study has shown that a partial desorption of proteins from the fat globule surface occurs during the freezing step in the manufacture of ice cream. This desorption is in addition to the major displacement of protein that occurs during mix aging. Possibly, the higher levels of protein found in the ice cream samples relative to the mix in this study could be explained by entrapment of protein in the partially coalesced fat network that forms upon freezing. Another possible cause for the excessive adsorbed protein in the ice creams was error in the sampling of the ice cream. Only 10 gram portions of each ice cream were sampled and heterogeneity in the ice cream would therefore strongly affect the results. Better results may have been obtained by sampling a larger portion of the ice cream.

Conclusion:

This study has shown that, addition of surfactants (GMS, P-80) into ice cream leads to a reduction in the amount of adsorbed protein. As the concentration of emulsifier increased, the amount of adsorbed protein decreased. Addition of P-80 improves upon the protein displacement achieved with GMS. No improvement was seen when the P-80 level was increased beyond 0.04%. These trends were apparent in the ice cream mix as well as the frozen ice cream. The adsorbed protein values for the ice cream samples were higher than for the mix samples but the same trends were apparent. Sampling difficulties were likely responsible for the ice cream values being higher.

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Appendix

Table 3.1 : The percentage of protein adsorbed on fat globules in no emulsifier frozen ice cream

Type of protein	Rep.1	Rep.2	Average	S.D.
α-la	37.17718	41.24	39.20859	2.872848
β-lg	49.61011	36.42396	43.01704	9.324016
κ-cas	71.459	36.34312	53.90106	24.83068
β-cas	41.61005	27.81268	34.71137	9.756214
αs1-cas	37.90832	29.78478	33.84655	5.74421
αs2-cas	46.90964	38.70334	42.80649	5.80273
mem-1	65.05183	31.99721	48.52452	23.37315
mem-2	50.78236	28.52823	39.6553	15.73605
mem-3	47.73022	37.76683	42.74853	7.045181

Table 3.2 : The percentage of protein adsorbed on fat globules in 0.075%GMS frozen ice cream

Type of protein	Rep.1	Rep.2	Rep.3	Average	S.D.
α-la	26.58935	36.63522	20.16949	27.79802	8.29914
β-lg	34.1309	35.08772	18.43066	29.21643	9.352991
κ-cas	50.83333	43.32953	21.66667	38.60984	15.1453
β-cas	34.43913	29.71946	20.13093	28.09651	7.290859
αs1-cas	26.00289	29.90741	21.23894	25.71641	4.34133
αs2-cas	37.18051	11.05684	23.33333	23.85689	13.0697
mem-1	44.16622	44.74278	22.72727	37.21209	12.54753
mem-2	44.56929	25.81345	16.86747	29.0834	14.13744
mem-3	41.96123	51.2761	23.93617	39.05783	13.89929

Table 3.3 : The percentage of protein adsorbed on fat globules in 0.15%GMS frozen ice cream

Type of protein	Rep.1	Rep.2	Rep.3	Average	S.D.
α-la	42.25166	26.90743	20.55556	29.90488	11.15431
β-lg	23.43062	26.76301	18.85965	23.01776	3.967822
κ-cas	33.74165	33.18086	27.17391	31.36547	3.640814
β-cas	26.47649	26.64051	19.84127	24.31942	3.879062
αs1-cas	22.88421	24.42529	16.98113	21.43021	3.929309
αs2-cas	16.81748	45.4112	20.11905	27.44924	15.64286
mem-1	35.29764	30.52585	25	30.2745	5.153419
mem-2	23.55865	30.21173	19.28571	24.35203	5.506048
mem-3	34.06326	33.09524	25	30.7195	4.976824

Table 3.4 : The percentage of protein adsorbed on fat globules in 0.15%GMS+ 0.02%Polysorbate-80 frozen ice cream

Type of protein	Rep.1	Rep.2	Rep.3	Average	S.D.
α-la	42.25166	26.90743	20.55556	29.90488	11.15431
β-lg	23.43026	26.76301	18.85965	23.01764	3.967804
κ-cas	33.74165	33.18086	27.17391	31.36547	3.640814
β-cas	26.47649	26.94051	19.84127	24.41942	3.97158
αs1-cas	22.88421	24.42529	116.9811	54.76354	53.88752
αs2-cas	16.81748	45.4112	20.11905	27.44924	15.64286
?-mem-1	35.29764	30.52585	25	30.2745	5.153419
mem-2	23.55865	30.21173	19.28571	24.35203	5.506048
mem-3	34.06326	33.09524	25	30.7195	4.976824

Table 3.5 : The percentage of protein adsorbed on fat globules in 0.15%GMS+ 0.04%Polysorbate-80 frozen ice cream

Type of protein	Rep.1	Rep.2	Rep.3	Average	S.D.
α-la	18.97343	27.60898	10.38415	18.98885	8.612425
β-lg	19.8093	28.94511	14.60247	21.11896	7.260457
κ-cas	25.10373	38.68778	25.63025	29.80725	7.695266
β-cas	16.71037	21.0245	17.77463	18.50317	2.247444
αs1-cas	14.74616	24.55257	21.2536	20.18411	4.989917
αs2-cas	16.01772	18.58006	17.73897	17.44558	1.306121
mem-1	13.21979	38.06262	18.69798	23.3268	13.05224
mem-2	19.79079	34.44444	21.09745	25.11089	8.109449
mem-3	14.40108	38.12217	39.16155	30.5616	14.00507

Table 3.6 : The percentage of protein adsorbed on fat globules in 0.15%GMS+ 0.06%Polysorbate-80 frozen ice cream

Type of protein	Rep.1	Rep.2	Rep.3	Average	S.D.
α-la	22.79471	31.89415	29.60265	28.09717	4.732843
β-lg	23.102	27.94415	15.85977	22.30197	6.081784
κ-cas	26.55486	32.7852	21.21212	26.85073	5.79221
β-cas	14.71368	18.96723	13.43604	15.70565	2.895949
αs1-cas	15.02947	19.79778	8.616505	14.48125	5.610761
αs2-cas	17.52827	13.31104	7.65885	12.83272	4.952066
mem-1	18.12676	25.21522	13.13264	18.82487	6.071467
mem-2	32.53857	20.72968	33.06452	28.77759	6.974654
mem-3	42.03601	33.30827	59.54447	44.96292	13.36075

Table 4:Comparison of percentage adsorbed protein between ice cream mix and frozen ice cream

Samples	Type of protein	Mix*	Frozen
No emulsifier	Total	32.181632	42.0466
	Whey	18.562	41.1128
	Casein	39.3643	41.31367
	Membrane	17.70522	43.64278
0.075%GMS	Total	25.01161	30.90683
	Whey	13.71097	28.50722
	Casein	17.15541	29.06991
	Membrane	18.57691	35.11778
0.15%GMS	Total	24.16747	26.98145
	Whey	16.11927	26.46132
	Casein	28.13749	26.14109
	Membrane	20.67876	28.44868
0.15%GMS+0.02%Polysorbate-80	Total	21.97351	30.69625
	Whey	14.36124	26.46126
	Casein	25.69179	34.49924
	Membrane	14.78707	28.44868
0.15%GMS+0.04%Polysorbate-80	Total	18.60356	22.78302
	Whey	12.926961	20.05391
	Casein	21.52124	21.48503
	Membrane	20.04918	26.3331
0.15%GMS+0.06%Polysorbate-80	Total	18.74782	23.64832
	Whey	11.65252	25.19957
	Casein	22.27619	17.46759
	membrane	15.54835	30.85513

* Mix data from Bolliger et.al., 1998.

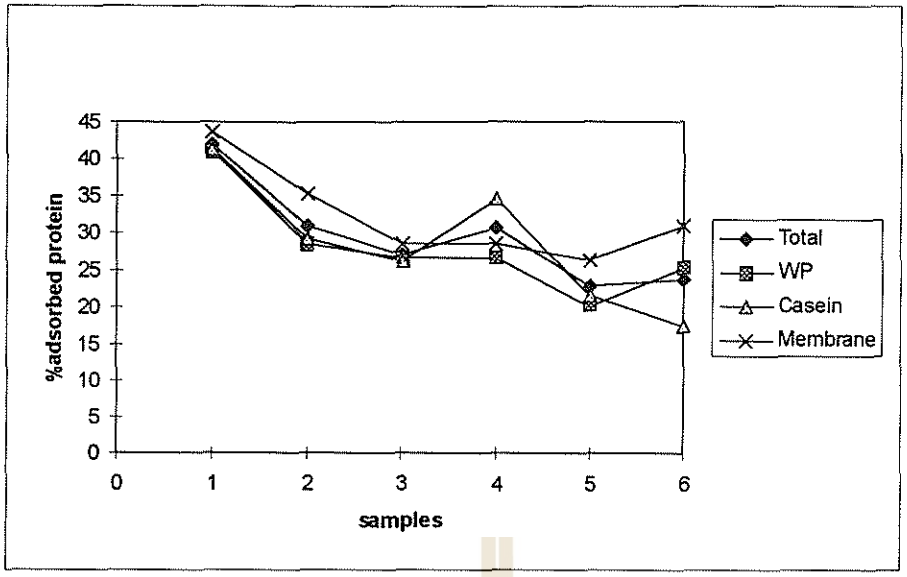


Figure 4. The amount of adsorbed protein in each fraction for frozen ice creams: 1= no emulsifier; 2= 0.075%GMS; 3= 0.15%GMS; 4= 0.15%GMS+ 0.02%P-80; 5= 0.15%GMS+0.04%P-80; 6= 0.15%GMS+0.06%P-80.

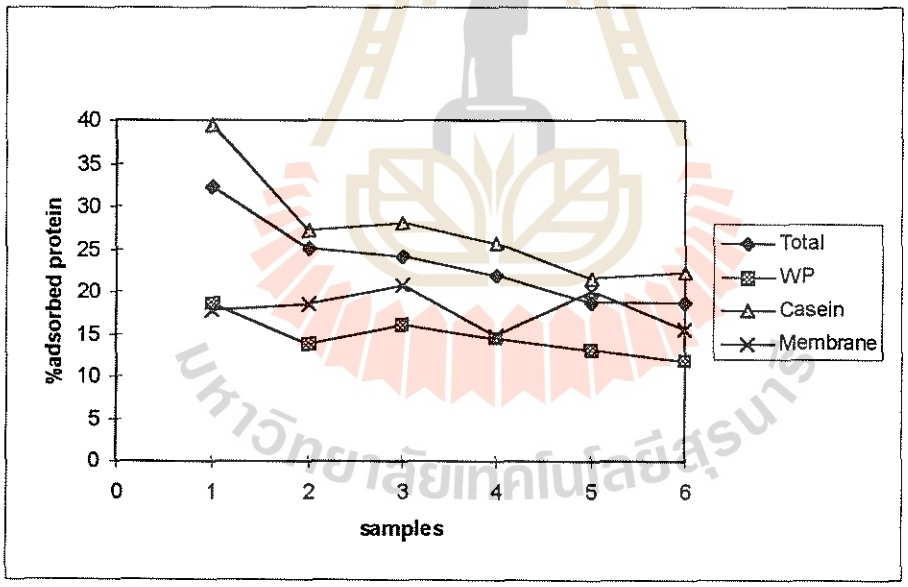


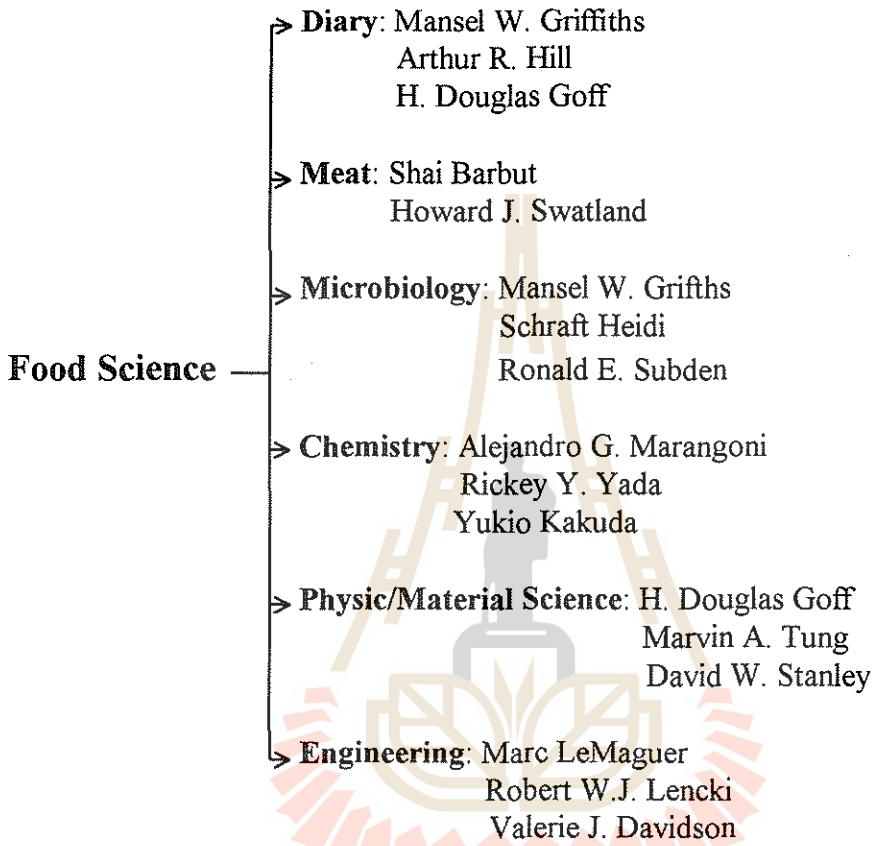
Figure 5. The amount of adsorbed protein in each fraction for ice cream mix: 1= no emulsifier; 2= 0.075%GMS; 3= 0.15%GMS; 4= 0.15%GMS+ 0.02%P-80; 5= 0.15%GMS+0.04%P-80; 6= 0.15%GMS+0.06%P-80.

Generality of Work

Working Area:

Laboratory at Food Science Department, University of Guelph, Guelph, Ontario N1G 2W1 Canada.

The Organization Chart of Food Science Department:



Learning Objectives:

1. To study and see the advance of technology in laboratory in other country
2. To have a chance to work with different people, and being interpersonal
3. To have more opportunities to practice English in communication
4. To become more confident since has to have to look after myself in foreign country
5. To have a chance to see new things as new experiences
6. To get some new idea, and new vision from seeing new things
7. To have an opportunity to meet some people from different cultures, and know more about their styles
8. To have responsibilities in doing works, and know how to response my own duty

Responsibilities and Kind of Work:

1.Laboratory research assistant:

In the laboratory I worked with some graduated students. My work was helping in them to do some experiment. As the sametime, I had an opportunity to learn techniques in doing experiments. The following are the activity I had done:

- Beibei's work is research about separation of casein proteins by ion exchange chromatography. I helped her to prepare some solution and she taught me how, and I learned a lot from her.
- Karla's work is research about in microstructure of ice cream. I helped her in preparing ice cream and sampling ice cream, and she taught about generally of DSC.
- Help Magali (the exchange student from France) in the experiment of modification of the properties of whey protein isolate emulsion by heating. She taught me in many techniques that related with my own project, such as electrophoresis and centrifugation.

2. Doing my own project:

I had done an experiment in " Effect of type and amount of emulsifier on protein adsorbed to fat globules in frozen ice cream". The experiment began with melting samples and then centrifugation, electrophoresis, scanning densitometry, and calculated the amount of adsorbed protein on fat globules, respectively. After I have gotten all data, I had to compare my data with Dr. Stephen 's data.

My co-op work period was on Sep. 15 - Dec. 15, 1998.

The beneficial that I have gotten from co-op works:

From doing these work and staying in Guelph (Canada), I have gotten many good experiences. First thing is I have a chance to see and work with people from different countries. They are very nice to me, and I worked with them happily. I worked and did experiment with many equipments which are very helpful and we can get the data very precisely. This is the kind of new and advance technology that I have seen and work with. It made me think, how better it will be if we have this equipment in our laboratories. And from the doing my own project, I have gotten more knowledge in the field that it related.

Next thing, I have to do many things by myself without some advice from my family or friends. It is kind of challenging, and I have more confidence as doing things by myself. I have seen many things new; cultures, technology, food, people that can not see in my country. That made my vision wider, and I know many things more. I have to speak English with people , consequently my English is getting better, even sometime it is hard to understand and communicate, but it is better than I never use it at all.

Other than that, I have had some good times with the family that I stayed with. There are fun, happiness, and warmness that this family has given me. I have done something fun with people from the same country (Thailand). These people made me not feel so lonely as being away from home.

I have gotten the worth experiences from coming and working in Canada and I will keep these good memories forever.

Recommendations:

1. For those students who are interested in international co-op program, and have a chance to come to foreign country, they should practice or improve their English skill more. Because of English is very important in communication and study. If we have good English skill, we can understanding and getting things easier.
2. Before the students come to foreign country, if they have a chance to know what project or planning project that they have to do. Then they should study on those thing more, to improve their knowledge about those field.