Table 3-5. Globule count, diameter range, and mean diamater (µm) ± standard deviation values for natural and reformulated creams as indicated by transmission electron microscopy.

Formulation	Separation Temperature(°C)	Globule Count	Globule Diameter Range (µm)	Mean Diameter (µm)
20% lmbo+80% skim	49	357	0.14-6.94	0.77±0.82
20% lmbo+80% skim	55	1148	0.09-1.25	0.49±0.24
20% mmbo+80% skim	55	481	0.10-6.30	0.69±0.53
20%lmbo + 70%bm + 10%ap	49	169	0.10-4.79	0.79±0.65
20%lmbo + 70%bm + 10%ap	55	162	0.09-4.22	0.62±0.67
20%mmbo + 70%bm + 10%ap	55	135	0.16-5.73	0.87±0.63
Natural Cream	49	194	0.09-4.22	0.57±0.54
Natural Cream	55	197	0.10-4.58	0.55±0.66

[1]Values are means and standard deviations for 1 replication.
[2]lmbo = low-melt butteroil; mmbo = medium-melt butteroil; bm = buttermilk; ap = aqueous phase

Table 3-6. Chemical composition[1] (% lipid, protein, cholesterol, and phospholipid) of natural and reformulated creams consisting of components obtained at two separation temperatures (49°C and 55°C) and butteroils having different melting point range characteristics (low and medium-melt fractions).

Formulation	Separation Temperature(°C)	Fat (%)[2]	Protein (mg/g)	Cholesterol (mg/g)	Phospholipid (mg/g)
20%lmbo + 80%skim	49	20.17	40.12	0.693	0.067
20%lmbo + 80%skim	55	20.17	40.29	0.679	0.063
20%mmbo + 80%skim	55	20.08	31.57	0.507	0.066
20%lmbo+70%bm+10%ap	49	20.67	34.62	0.750	0.539
20%lmbo+70%bm+10%ap	55	20.75	34.82	0.707	0.515
20%mmbo+70%bm+10%ap	55	21.25	27.83	0.564	0.522
Natural cream	49	20.75	27.77	0.610	0.486
Natural cream	55	21.92	29.88	0.614	0.492
Standard error		0.378	2.564	0.020	0.065
<u>CONTRASTS</u>					
Skim LM 49 + Skim LM 55 * Skim MM 55		0.8821	0.0156	* 0.0001	0.9927
BM LM 49 + BM LM 55 * BM MM 55		0.3428	0.0457	* 0.0001	0.9487
Skim * BM		0.0608	0.0345	* 0.0103	* 0.0001
Skim * Natural		0.0115	* 0.0027	0.4348	* 0.0001
BM * Natural		0.2980	0.1462	* 0.0039	0.5461
Nat 49 * Nat 55		0.0884	0.5691	0.9014	0.9452
Skim LM 49 * Skim LM 55 + MM 55		0.9409	0.2036	* 0.0009	0.9731
BM LM 49 * BM LM 55 + BM MM 55		0.5553	0.3122	* 0.0003	0.8016

[1]Values are means and standard errors for 3 replications.
[2]Babcock Method (Marshall, 1993)
[3]lmbo = low-melt butteroil; mmbo = medium-melt butter oil; bm = buttermilk; ap = aqueous phase
[4]LM = low-melt; MM = medium-melt; BM = creams formulated with buttermilk and butter-derived aqueous phase
* predetermined p-value of 0.01 used for determining statistical significance

Protein content of reformulated creams was different ($p \leq 0.01$) when considering components used in formulation. Skim component formulations had significantly higher ($p \leq 0.01$) amounts of protein than natural creams. This is in contrast to the observations of Elling et al. (1996) who reported no significant ($p > 0.05$) differences in protein content among creams. Elling et al. (1996) found that amount of protein (mg/g) occurring in control and reformulated creams ranged from 24.82 ± 2.63 to 27.90 ± 2.30, the former associated with creams formulated with butteroil and sweet buttermilk homogenizaed at 13.6/3.4 Mpa and the latter associated with creams formulated with skim milk and butteroil homoenized at 10.2/3.4 Mpa. Higher protein content occurring in reformulated creams comprised of skim component and butteroil can be attributed to higher amounts of protein associated with skim as a reformulating component. Whey and casein proteins are associated with all components. However, as a component skim does not have a high degree of milkfat globule membrane fragments as sweet buttermilk and butter-derived aqueous phase. There was probably more opportunity for protein interaction on lipid surfaces associated with creams formulated with skim and butteroil.

Separation temperature, melting range characteristics of butteroil, and formulation all significantly ($p \leq 0.01$) affected cholesterol content of creams. For reformulated creams, creams processed from components obtained by 49°C separation had significantly higher ($p \leq 0.01$) amounts of cholesterol than like creams manufactured from 55°C separation components. Also, reformulated creams consisting of medium-melt fraction butteroil had significantly ($p \leq 0.05$) lower amounts of cholesterol than reformulated creams comprised of low-melt fraction butteroil. Creams comprised of sweet buttermilk and butter-derived aqueous phase had significantly higher ($p \leq 0.01$) amounts of cholesterol than skim component and natural creams. This particular observation can be attributed to the fact that 75%, 10%, and 15% of total cholesterol is associated with core lipid, milkfat globule membrane, and skim phase membrane material (Mulder and Walstra, 1974). As components, both sweet buttermilk and butter-derived aqueous phase had higher ($p \leq 0.01$) percent lipid values than skim. Also, sweet buttermilk and butter-derived aqueous phase are more abundant in fragments of milkfat globule membrane constituents, indicating that higher amounts of cholesterol may occur in these particular components. Elling et al. (1996) found that creams formulated with ratios of skim, sweet buttermilk, and sweet buttermilk+ butter-derived aqueous phase and cholesterol-reduced butteroil had significantly lower ($p \leq 0.05$) amounts of cholesterol than control creams. Additionally, creams formulated with sweet buttermilk or sweet buttermilk and butter-derived aqueous phase had significantly higher ($p \leq 0.05$) amounts of cholesterol than creams formulated with skim component.

Phospholipid concentration of reformulated and natural creams was affected only by the components used in formulation of the creams (Table 3-6). Creams formulated with skim component had significantly lower ($p \leq 0.01$) phospholipid content than creams formulated with sweet buttermilk and butter-derived aqueous phase or natural creams. As indicated by chemical characterization of components, butter-derived aqueous phase was a significantly higher ($p \leq 0.01$) source of phospholipids. This finding resulted in creams formulated with sweet buttermilk and butter-derived aqueous phase having significantly higher ($p \leq 0.01$) amounts of phospholipids than creams formulated with skim component. Creams formulated with sweet buttermilk and butter-derived aqueous phase did not differ ($p > 0.01$) from natural creams. Elling et al. (1996) also found butter-derived aqueous phase to be significantly higher ($p \leq 0.05$) in phospholipid content than sweet buttermilk and skim components. In contrast, however, Elling et al. (1996) found that formulations comprised of sweet buttermilk and butter-derived aqueous phase had significantly higher ($p \leq 0.05$) amounts of phospholipids (approximately 1.0 mg phospholipid/g lipid) than natural creams, creams formulated with only buttermilk component, and skim component. Elling et al. (1995) may have observed higher amounts of phospholipid in creams comprised of swet buttermilk and butter-derived aqueous phase due to use of pilot plant butter-derived aqueous phase, which may not have been separated as efficiently as commercial butter-derived aqueous phase used in this investigation. Creams consisting of buttermilk and butteroil did not differ ($p > 0.05$) from natural creams. The formulation consisting of 80% skim component and 20% butteroil, however, was significantly lower ($p \leq 0.05$) in phospholipid content (0.15 mg phospholipid/g lipid) than all other formulations. Due to higher phospholipid contents, creams processed from sweet buttermilk and butter-derived aqueous phase proved to have better emulsion stability than creams formulated from skim milk.

Individual phospholipid analysis using thin layer chromatography demonstrated that creams formulated with sweet buttermilk and natural creams had similar, discrete bands of individual phospholipids (Figure 3-5). Creams consisting of skim component had less distinct bands of individual phospholipids. In considering all natural and reformulated creams, bands of sphingomyelin and phosphatidyl choline were the most prominent. These observations are supported by results from the individual phospholipids associated with components used for cream reformulation. Sphingomyelin, phosphatidyl choline, and phosphatidyl ethanolamine are the most abundant phospholipids associated with the phospholipid fraction of dairy products (Deeth, 1997).

Fatty acid analysis of components was beneficial in understanding fatty acid profiles of creams. However, free fatty acids contributed by fractionated butteroils in reformulated creams also must be considered (Table 3-7). Amounts of individual fatty acids were determined for natural and reformulated creams on one replication of the study (Table 3-6). For creams formulated with skim component and fractionated butteroils, the most noticeable difference was amount of palmitic acid. Cream consisting of skim component and medium-melt fraction butteroil had much higher amounts of palmitic acid and stearic acid, chief saturated fatty acids in milk. In most instances, creams formulated with skim component and low-melt fraction butteroil had slightly more short chain, saturated fatty acids such as butyric acid, caproic, and caprylic acid. Some variation occurred among skim component formulations in unsaturated fatty acid content. Creams formulated with skim component obtained at 55^{o}C separation and low-melt fraction butteroil had higher amounts of individual fatty acids whereas creams formulated with skim component obtained at 49^{o}C and low-melt fraction butteroil and skim component obtained at 55^{o}C separation and medium-melt fraction butteroil had similar amounts of individual fatty acids. For creams consisting of sweet buttermilk and butter-derived aqueous phase, those creams having emulsified medium-melt fraction butteroil had higher amounts of the longer chained saturated fatty acids palmitic and stearic acid. Although creams

Figure 3-5. Thin layer chromatographs of individual phospholipids (sphingomyelin, phosphatidyl choline, phosphatidyl serine, phosphatidyl inisitol, and phosphatidyl ethanolamine) for natural and reformulated creams processed from components obtained at two separation temperatures (49^{o}C and 55^{o}) and low-melt and medium-melt fraction butteroils (a, 49^{o}C skim, low-melt butteroil) (b, 55^{o}C skim, low-melt butteroil) (c, 55^{o}C skim, medium-melt butteroil) (d, 49^{o}C sweet buttermilk, commercial butter-derived aqueous phase, low-melt butteroil) (e, 55^{o}C sweet buttermilk, commercial butter-derived aqueous phase, low-melt butteroil) (f, 55^{o}C sweet buttermilk, commercial butter-derived aqueous phase, medium-melt butteroil) (g, 49^{o}C natural cream) (h, 55^{o}C natural cream)

Table 3-7. Fatty acid analysis of reformulated and natural creams processed from components obtained at two different separation temperatures (49°C and 55°C).

	Amount of Fatty Acid (μg/ml)										
Cream	C4:0	C6:0	C8:0	C10:0	C12:0	C:14:0	C16:0	C16:1	C18:0	C18:1	C18:2
49°C 20%lm+80%skim	15.71	11.68	26.78	11.68	10.45	15.31	23.29	2.29	7.31	25.91	2.75
55°C 20%lm+80%skim	13.91	12.25	21.14	13.02	7.95	18.66	35.86	6.32	9.08	30.89	4.00
55°C 20%mm+80%skim	8.63	10.32	21.42	10.08	7.79	18.82	50.80	2.38	17.61	27.96	3.61
49°C 20%lm+70%bm+10%ap	4.56	8.96	5.84	11.50	13.88	15.65	34.21	2.87	10.40	34.19	4.29
55°C 20%lm+70%bm+10%ap	9.45	9.92	9.36	12.31	11.24	15.31	29.28	2.92	8.87	29.84	3.83
55°C 20%mm+70%bm+10%ap	10.65	11.60	6.24	12.88	13.20	18.48	48.55	2.29	16.08	28.28	3.53
49°C Natural Cream	8.36	7.21	3.70	8.24	11.26	17.97	44.48	3.75	13.98	30.06	3.08
55°C Natural Cream	12.25	8.80	4.16	9.65	12.97	20.17	49.12	3.74	15.80	41.70	3.74

[1]Means from triplicate measurements from one replication
[2]lm = low-melt; mm = medium-melt; bm = buttermilk; ap = aqueous phase

formulated with sweet buttermilk, butter-derived aqueous phase, and low-melt fraction butteroil had higher amounts of palmitoleic, oleic, and linoleic acid, differences between creams formulated with sweet buttermilk, butter-derived aqueous phase, and medium-melt fraction butteroil were slight. Creams formulated with buttermilk, butter-derived aqueous phase, and medium-melt fraction did have higher amounts of short chain fatty acids such as butyric acid. Natural creams had high levels of palmitic and oleic acid, with creams formulated with components obtained at 55^{o}C having higher amounts than creams formulated with 49^{o}C separation components. Also, creams formulated with skim component and natural cream processed from 55^{o}C components had higher amounts of long chained saturated fatty acids compared to counterparts separated at 49^{o}C.

Characterization of Milkfat Globule Surface Material. Unprocessed cream samples have relatively higher amounts of intact native milkfat globule membrane components, particularly phospholipids and proteins. These particular components are highly surface active, acting as emulsifying agents at the oil-water interface. Creams which undergo essential processing steps such as homogenization and pasteurization to prolong stability and shelf-life have fragments of the milkfat globule membrane. The native milkfat globule membrane is fragmented during processing, resulting in increased attachment of skim milk proteins to lipid globules. Lipid globules of reformulated and control creams were principally emulsified by casein and whey proteins and some milkfat globule membrane fragments.

Two types of measurements proved to be very useful in analyzing milkfat surface material of reformulated and control creams. Since proteins and phospholipids are important in maintaining stability, measuring the quantity of both types of molecules in the milkfat surface material was necessary. Sodium dodecyl sulfate polyacrylamide gel electrophoresis was utilized to characterize the types of proteins associated with lipid globules occurring in natural and reformulated creams. The factors of formulation, separation temperature in obtaining components, and melting range profile of butteroil did not cause differences in the types of proteins associated with milkfat globule surface areas in creams (Figure 3-6). As expected, casein was the major protein associated with lipid globules in both reformulated and natural creams. Oortwijn and Walstra (1979) determined the quantity of proteins adsorbed on milkfat droplets in recombined cream consisting of milkfat in either skim milk, whey, or casein protein dispersions. In comparison to skim milk proteins and whey proteins, casein proteins were more adsorbed to fat globules (Oortwijn and Walstra, 1979). The protein load (mg/m^2) for milkfat in casein, skim milk, and whey were 20, 10, and 2.5 mg/m^2 (Oortwijn and Walstra, 1979). Bands of whey proteins β-lactoglobulin and α-lactalbumin were also present. Similarly, Elling et al. (1996) reported that casein was the major individual protein attached to lipid globule surfaces of creams formulated from cholesterol-reduced butteroil (20%), skim (80%), sweet buttermilk (80 or 70%), and butter-derived aqueous phase (10%), however whey proteins were not observed due to cream washing. Elling et al. (1996) also noted that casein was the predominant protein in natural creams. Tomas et al. (1994) made oil-in-water emulsions from milkfat and skim milk, varying in the fat (4-30 g/100g) and

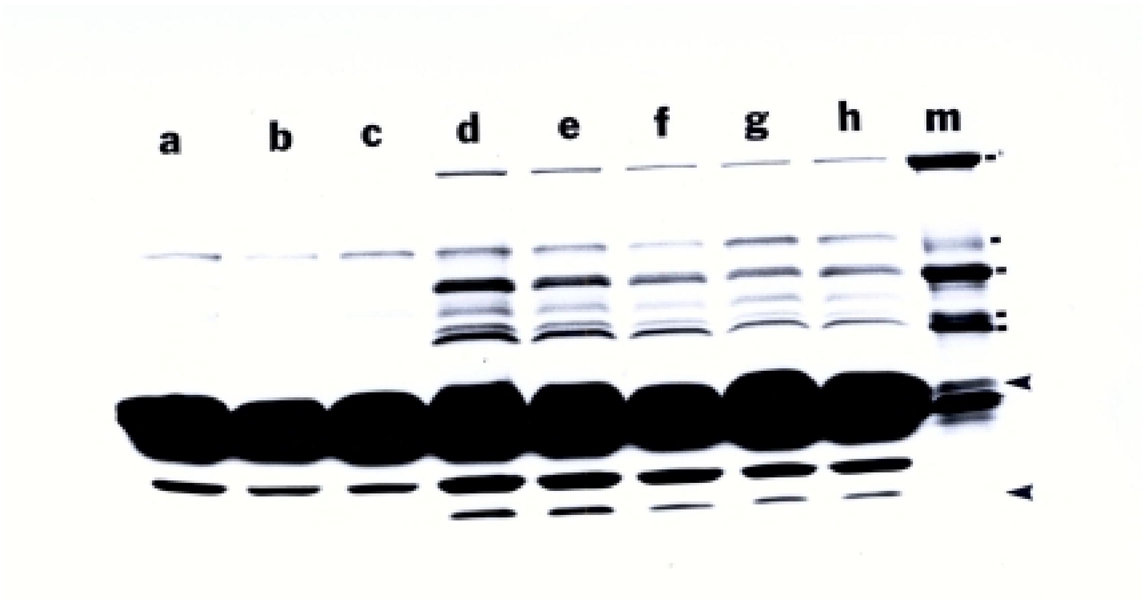

Figure 3-6. Polypeptide profiles of surface material (SM) isolated from lipid globules of natural and reformulated creams processed from components obtained at two different separation temperatures (49°C and 55°C) and low-melt and medium-melt fraction butteroils (a, 49°C skim component, low-melt butteroil) (b, 55°C skim component, low-melt butteroil) (c, 55°C skim component, medium-melt butteroil) (d, 49°C sweet buttermilk, commercial butter-derived aqueous phase, low-melt butteroil) (e, 55°C sweet buttermilk, commercial butter-derived aqueous phase, low-melt butteroil) (f, 55°C sweet buttermilk, commercial butter-derived aqueous phase, medium-melt butteroil) (g, 49°C natural cream) (h, 55°C natural cream) (m, purified milkfat globule membrane extract) (dashes from top to bottom: xanthine oxidase, CD36, butyrophilin, glycoprotein B) (arrowheads from top to bottom: casein and whey proteins β-lactoglobulin and α-lactalbumin, respectively)

protein (3.2-0.4 g/100g) contents. Proteins contributed from the skim phase of milk played a significant role in maintaining emulsion stability. Both casein and whey proteins were adsorbed, however, preferential adsorbance of casein over whey proteins occurred (Tomas et al., 1994). SDS-PAGE also indicated that proteins which were not adsorbed were predominantly whey proteins (Tomas et al., 1994). Native milkfat glouble membrane proteins such as butyrophilin, xanthine oxidase, and glycoprotein B were associated with the surface of lipid gloubles in much lower concentrations. As a standard, milkfat globule membrane extract had higher amounts of native milkfat globule membrane proteins with less amounts of casein and whey proteins. Using gel electrophoresis, Keenan et al. (1983) found that found that casein as well as membrane associated proteins such as xantine oxidase and buytrophilin were still associated with homogenized milk. This occurrence can be related to processing techniques such as homogenization which result in fragmentation of the original milkfat globule membrane. As a result, skim milk proteins become attached to the surface of lipid globules. In comparing formulations, creams formulated with sweet buttermilk and butter-derived aqueous phase components and natural creams had more distinct bands of native milkfat globule membrane proteins than skim milk formulations. Thus, sweet buttermilk and butter-derived aqueous phase are indicative of the amount of native milkfat globule membrane proteins that may have reassociated with lipids after reformulation and processing.

The amount of protein and phospholipid (mg/g lipid in cream) in a specific amount of lipid in cream as well as percent associated with lipid globules are reported (Table 3-8). Also, the amount of protein and phospholipid occurring in 10 mg of milkfat surface material also was determined (Appendix B, Table B-3). The composition of the surface material of surrounding lipid globules in reformulated creams was not affected ($p > 0.01$) formulation, melting range characteristics of butteroil, or separation temperature used to produce components. The amount of protein occurring in the milkfat surface material per gram of lipid did not differ significantly ($p > 0.05$) with formulation, however the percent of total protein associating with lipid globules differed significantly ($p \leq 0.01$) between creams formulated with skim component and natural creams. Natural creams had a significantly higher ($p \leq 0.01$) percent of proteins associated with lipid globules compared to creams formulated with skim component. Compared to creams formulated with skim components, significantly higher ($p \leq 0.01$) amounts of phospholipid were found on surface material collected from creams formulated with sweet buttermilk and butter-derived aqueous phase and natural creams than creams formulated with skim component. In most instances, comparing the composition of the lipid surface material obtained from the reformulated and natural creams, the formulations consisting of buttermilk and butter-derived aqueous phase were more comparable to natural creams than were creams formulated with skim component. Elling et al. (1996) found that creams homogenized at 13.6/3.4 MPa had more surface material and protein and phospholipid occurring in the surface material than creams homogenized at 10.2/3.4 MPa. Elling et al. (1996) noted significant ($p \leq 0.05$) differences in the amount (mg protein/g lipid in cream) of protein occurring in the surface material existed among formulations. The amount of phospholipid occurring in the surface material of skim

Table 3-8. Composition[1] of milkfat surface material (SM) isolated from lipid globules of natural and reformulated creams processed from components obtained at two separations (49°C and 55°C) and butteroils having different melting range characteristics (low and medium-melt fractions).

Formulation	Separation Temperature(°C)	SM/lipid in cream (mg/g)	Protein in SM/ lipid in cream (mg/g)	% of total protein associated with lipid globules	Phospholipid SM/lipid in (mg/g)	% of total phospholipid associated with lipid globules
20%lmbo + 80%skim	49	140.995	40.273	20.461	0.452	55.146
20%lmbo + 80%skim	55	134.785	42.171	21.338	0.428	63.827
20%mmbo + 80%skim	55	121.905	45.277	28.666	0.345	80.633
20%lmbo + 70%bm + 10%ap	49	97.684	41.650	25.509	1.045	45.443
20%lmbo + 70%bm + 10%ap	55	100.751	48.172	29.969	1.030	44.519
20%mmbo + 70%bm +10%ap	55	90.501	43.026	32.799	0.929	42.649
Natural cream	49	82.273	45.306	33.843	1.078	51.202
Natural cream	55	78.468	45.205	33.185	1.030	48.903
Standard Error		24.486	5.691	3.616	0.161	12.671
<u>CONTRASTS</u>						
Skim LM 49 + Skim LM 55 * Skim MM 55		0.6024	0.5700	0.0936	0.6372	0.1945
BM LM 49 + BM LM 55 * BM MM 55		0.7756	0.7908	0.2725	0.5872	0.8827
Skim * BM		0.0913	0.7185	0.0667	* 0.0005	0.0487
Skim * Natural		0.0350	0.6137	* 0.0092	* 0.0006	0.1761
BM * Natural		0.4874	0.8541	0.2359	0.7255	0.6210
Natural 49 * Natural 55		0.9141	0.9902	0.8996	0.8352	0.8997
Skim LM 49 * Skim LM 55 + Skim MM 55		0.6796	0.6282	0.3124	0.7437	0.2895
BM LM 49 * BM 55 + BM MM 55		0.9462	0.5800	0.2059	0.7431	0.9064

[1]Values are means and standard errors for 3 replications.
[2]lmbo = low-melt butteroil; mmbo = medium-melt butteroil; bm = buttermilk; ap = aqueous phase
[3]LM = low-melt; MM = medium-melt; BM = creams formulated with buttermilk and aqueous phase
*predetermined p-value of 0.01 used for determining significance

creams was significantly ($p < 0.05$) lower than that of its buttermilk and natural cream counterparts. When comparing the amount of phospholipid associated with the milkfat globule surface material, the skim component formulation differed significantly ($P \leq 0.05$) from all formulations consisting of buttermilk (Elling et al., 1996). The buttermilk formulated creams had more phospholipid contributing to the surface material. At an optimal homogenization pressure of 13.6/3.4, buttermilk and buttermilk+butter-derived aqueous phase had 0.58 ± 0.04, and 0.67 ± 0.05 mg phospholipid/g lipid in cream (Elling et al., 1996). Skim milk formulations had only 0.33+0.02 mg phospholipid/g lipid in cream (Elling et al., 1996).

Phosphodiesterase I is a marker enzyme for the milkfat globule membrane. Like other enzymes of the milkfat globule membrane, phosphodiesterase comes from the cytoplasm and membranes of secretory cells (Fox and McSweeney, 1998). These particular enzymes become part of the milkfat globule membrane because of globule excretion from cells. Phosphodiesterase I activity was measured (Table 3-9) as an indication of the amount of native milkfat globule membrane associating with lipid droplets. Phosphodiesterase I was significantly ($p \leq 0.05$) higher in skim milk formulation in comparison to buttermilk and natural formulations.

Conclusions. Creams (20% milkfat) formulated with low-melt and medium-melt fractionated butteroils, skim, sweet buttermilk, and butter-derived aqueous phase components and were characterized as oil-in-water emulsions. The components used to formulate creams had the greatest impact on the chemical characteristics of reformulated creams. Composition of components used in the reformulation process served as a predictor of chemical characteristics of reformulated creams. Butter-derived aqueous phase and sweet buttermilk components had significantly higher ($p \leq 0.01$) levels of fat, cholesterol, and phospholipids than skim milk, resulting in creams formulated with these two components having significantly higher level of cholesterol and phospholipids ($p \leq 0.01$).

Melting range characteristics of fractionated butteroils had the greatest effect on fatty acid profile of reformulated creams. In particular, creams formulated with medium-melt fraction butteroil had much higher amounts of the predominant longer chained saturated fatty acids palmitic and stearic acid. Incorporation of low-melt fractionated butteroils in place of medium-melt fractionated butteroils substantially lowered the amount of long chained saturated fatty acids within treatments and slightly increased unsaturated fatty acids such as oleic acid and linoleic acid. Thus, low-melt fractionated butteroils changed the fatty acid profile of reformulated creams in a positive direction in terms of functionality and nutritional benefits. Also, cholesterol content was lower ($p < 0.01$) in reformulated creams formulated with medium-melt fraction butteroil than like creams having low-melt fraction butteroil.

Table 3-9. Phosphodiesterase activity[1] of natural and reformulated consisting of components obtained at two different separation temperatures (49°C and 55°C) and butteroils having different melting point range characteristics (low-melt and medium-melt fraction)

Formulation	Separation Temperature(°C)	uM Phosphodiesterase I/ mg protein in cream/minute	uM PhosphodiesteraseI/ 10 mg MM
20%lmbo + 80%skim	49	34.627	6.531
20%lmbo + 80%skim	55	36.839	7.198
20%mmbo + 80%skim	55	26.927	6.948
20%lmbo + 70%bm + 10%ap	49	19.562	4.852
20%lmbo + 70%bm + 10%ap	55	18.801	5.066
20%mmbo + 70%bm+10%ap	55	9.569	3.360
Natural cream	49	9.401	3.950
Natural cream	55	8.394	3.273
Standard error		4.427	0.842

CONTRASTS		
Skim LM 49 + Skim LM 55 * Skim MM 55	0.1266	0.9361
BM LM 49 + BM LM 55 * BM MM 55	0.0980	0.1432
Skim * BM	* 0.0004	* 0.0030
Skim * Nat	* 0.0001	* 0.0008
BM * Nat	0.1016	0.3068
Nat 49 * Nat 55	0.8745	0.5785
Skim LM 49 * Skim LM 49 + Skim MM 55	0.6206	0.6071
BM LM 49 * BM LM 49 + BM MM 55	0.3382	0.5451

[1]Values are means and standard errors for 3 replications.
[2]lmbo = lmbo; mmbo = medium-melt butteroil; bm = buttermilk; ap = aqueous phase
[3] LM = low-melt; MM = medium-melt; BM = creams formulated with buttermilk and aqueous phase
*predetermined p-value of 0.01 used for determining significance

Overall, creams formulated with sweet buttermilk and butter-derived aqueous phase had more chemical similarities to natural creams than creams consisting of skim component. In the present investigation, reformulated creams formulated with low-melt fraction butteroil had higher concentrations of unsaturated fatty acids when compared to their medium-melt fraction butteroil counterparts. In most instances, milkfat consists of 65-70% saturated fatty acids (Rizvi, 1991). Thus, procedures such as milkfat fractionation can yield forms of milkfat which could possibly enhance the lipid profile of dairy products.

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