A Critical Evaluation of Thermal Fractionation of Butter Oil

F.M. Fouad, F.R. van de Voort, W.D. Marshall*, and P.G. Farrell[a]

Department of Food Science and Agricultural Chemistry and [a]Department of Chemistry, Macdonald College of McGill University, Box 187, St. Anne de Bellevue, Quebec, Canada H9X 1C0

Butter was fractionated on the basis of temperature (17–29°C) without agitation using slow cooling of melted anhydrous fat in conjunction with gentle vacuum filtration to produce four solid and four liquid fractions. Each of the fractions was analyzed for fatty acid composition, triglyceride profile, and characterized by gel permeation high performance liquid chromatography and differential scanning calorimetry thermograms. Fatty acid analysis indicated that the solid fractions had slightly higher amounts of palmitic and stearic acid and lower levels of oleic acid, while the remaining analyses did not indicate any substantial compositional differences between the fractions. Although the 29°C solid fraction (~ 10%) could be said to be somewhat unique, the natural variation in the normal seasonal composition of butterfat was almost equal to that obtained by fractionation. The experimental physicochemical data obtained for the fractions in this study extend and verify previous work on butteroil fractionation, and indicate that thermal fractionation has marginal merit. On the other hand, literature describing more positive thermal butteroil fractionation results obtained by the proprietary Tirtiaux process (Fleurus, Belgium), indicates that it may be a more expedient avenue to explore and let market forces determine whether fractionation has a future in Canada and North America.

KEY WORDS: Butter oil, differential scanning calorimetry, fatty acid composition, thermal fractionation, triglyceride profile.

Butter is an important traditional animal source of lipid which has had trouble maintaining market share due to its high price, strong vegetable oil competition and the health controversy surrounding its cholesterol, its saturated and *trans* unsaturated fatty acids' content. As a water in oil emulsion it has the disadvantage of having a high solid fat index (poor spreadability) which is compensated for to some extent by its positive flavor attributes. In general, protective legislation prevents the chemical modification of butter of its blending with vegetable oils to improve functionality (i.e., spreadability). Butterfat is composed of a complex mixture of triglycerides, some unique short chain fatty acids, but mostly longer chain, saturated fatty acids, including some in the *trans* forms produced by hydrogenation in the rumen. Although a species specific triglyceride compositional profile is often observed in natural fat systems, the possible mixture of individual triglycerides appear to be almost infinite and as a result are not simple to resolve. Beyond compositional variation, triglycerides also show temperature dependent polymorphic behavior, complicating their physical properties.

Considering the general legislative and economic limitations imposed on the methods of modifying butter or butteroil, one potential avenue which has been explored is the separation of butterfat by thermal fractionation to obtain more functionally useful forms. Even though butterfat fractionation has been investigated since the 1940's, it does not appear that any conclusive results about the benefits of fractionation have emerged from all of this work. Conflicting perceptions still exist in terms of the efficacy of the fractionation process, the optimal temperatures to be used, and whether the fractions differ sufficiently in composition or textural properties to be exploited commercially (1–5). The usefulness of physically fractionating milkfat can therefore still be considered an open question, with some researchers indicating that unique fractions are obtained (6), whereas others have indicated that there is very little to be gained by fractionation (7). On the other hand, commercial fractionation processes have been developed in Europe and are being used (8–9).

It is clear that the variables used in thermal fractionation (temperature, rate of cooling, agitation, filtration and pressure) influence the physical properties of the milkfat fractions obtained (8,10,11). The fractionation procedure does not appear to be a precise separation and as the solid fraction forms, it carries with it increasing amounts of the liquid fraction (11). Maximum fractionation efficiency has been reported to be around 28°C with subsequent fractions becoming increasingly similar to the original butterfat. A number of workers have found that the variations in the fatty acid composition of butterfat fractions were not much greater than those encountered in normal seasonal variations (12–14). In addition, both polymorphism and triglyceride composition have been cited as factors which influence the properties of the milkfat fractions obtained (10–11). Two more recent and detailed studies on butterfat fractionation have reached conflicting conclusions, with Makhlouf *et al.* (5) stating that the separation of milkfat triglycerides by molecular size is not feasible by melt crystallization, where Amer *et al.* (6) claimed that butteroil fractions obtained by melt crystallization yielded solid fractions which were significantly different in their chemical makeup and had noticeably different physical properties.

Based on the lack of a general consensus among researchers about the efficacy of fractionation, it was deemed useful to re-investigate the chemical and physicochemical properties of milkfat fractions obtained by crystallization and try to reach a more definitive conclusion based on new data using Quebec butter. This paper presents the results of an extensive fractionation study of milkfat in terms of fatty acid/triglyceride composition, triglyceride molecular weight distributions and differential scanning calorimetry (DSC) profiles in an attempt

*To whom correspondence should be addressed.

to resolve the issue as to whether there are actually any substantive differences between the solid fractions obtained by simple thermal fractionation.

Materials. Anhydrous butteroil was obtained from Agropur (Granby, Quebec, Canada), remelted at 60°C, stored for 24 hr over anhydrous sodium sulfate, filtered through Whatman No. 1 filter paper under vacuum and subsequently stored under nitrogen at −20°C to await characterization.

EXPERIMENTAL PROCEDURES

Thermal fractionation. Molten neat butteroil, warmed to 60°C, was fractionated without agitation into liquid and solid portions using the procedure and apparatus described by Amer *et al.* (6) at temperatures of 29, 25, 21 and 17°C. After reaching the desired temperatures, the molten butter was left to crystallize for a period of 4 hr while maintaining the selected temperature. The precipitated triglycerides were then filtered at the selected temperature using milk filters (Kendall, Boston, MA) which allowed complete separation of the crystals from the mother liquor within 5 to 15 min.

Analyses: Fatty acids. Fatty acid analysis was carried out by gas chromatography using a Varian Model 3700 gas chromatograph (GC) (Varian Associations, Palo Alto, CA) equipped with a flame ionization detector and an on-column injector, a Supelco (Supelco, Inc., Canada) fused capillary column (30 m × 0.32 mm) coated with SP-2340, and helium at 1.5 mL/min as the carrier gas. The GC was temperature programmed to start at 50°C (1 min), increasing to 160°C at a rate of 5°C/min while the detector temperature was maintained at 210°C. Methyl esters of the fatty acids of the fractions were prepared by a modification of the method described (15), always using freshly prepared solutions of sodium methoxide. The detector response to individual fatty acids was quantified by the method of external standards using commercially available mixtures of fatty acid methyl esters dissolved in n-hexane (Nu-Chek Prep, Inc., Elysian, MN). Using the constants derived for each fatty acid, the integrator response was calibrated to provide the results of each component on a percent by weight basis using a 0.2 μL injection.

Analyses: Triglycerides. Triglycerides were separated using 0.1 μm DB-5 stationary phase coated onto a 15 m × 0.32 mm i.d. fused silica capillary column (J & W Scientific Inc., Rancho Cordova, CA) and helium (1.5 mL/min) as the carrier gas. The temperature program required two stages, 50–240°C at a rate of 25°C/min followed by 240–350°C at a rate of 3°C/min; the injector temperature was programmed to increase from 70°C to 330°C at a rate of 100°C/min and the detector temperature was maintained at 350°C. The separation of triglycerides by this procedure was based principally on differences in carbon number and the identity of the components in the butterfat fractions were inferred from co-chromatography with components of a standard commercial mixture of triglycerides (Nu Check Prep) ranging from C_{18}–C_{54}. Fifteen μg of fractionated anhydrous butter was dissolved in 6 mL of n-hexane and 0.2 μL were injected onto the column.

Analyses: High performance liquid chromatography (HPLC). Gel permeation HPLC of the butter and its fractions was carried out using a Waters Associates (Milford, MA) system composed of a Model 510 pump, a U6K Universal injector, a R401 differential refractometer (8 × 8 attenuation) and three serially connected 7.8 mm i.d. × 30 cm Ultrastyragel columns having exclusion limits of 10^3, 500 and 100 Å, respectively. The permeation and void volumes of this combination of columns were determined to be 36 and 18 mL, respectively. Thirty to 50 mg of the selected sample was dissolved in 1 mL of THF, stabilized with butylated hydroxytoluene (250 ppm), injected into the system and eluted at a flow rate of 1 mL/min. Peak detection and integration was performed using a Spectra-Physics model SP-4270 integrator (Spectra-Physics, St. Albans, U.K.).

Analyses: DSC/melting points. A Mettler TA 3000 (Mettler Instruments Ltd., Switzerland) heat flow differential scanning calorimeter (DSC) calibrated against indium was used to record the crystallization and melting behavior of the isolated butterfat fractions. The DSC was programmed to heat the sample (20–30 mg) to 80°C for 10 min to destroy any previous crystalline structure, cooled at 10°C/min to −40°C to crystallize the material and subsequently reheated to 80°C at the same rate, while recording the phase changes occurring during the reheating cycle. The relative percentage of liquid fat as a function of temperature over 0–30°C was determined by integration of the DSC melting curve using the Mettler TC 10 data processing accessory. Melting points were also determined for each fraction using method Cc 1-25 (16).

RESULTS AND DISCUSSION

Fractionation. Fractionation was carried out without agitation to minimize excessive co-precipitation and/or occlusion of short chain and unsaturated fatty acids on the active surface of crystalline triglycerides and as a means of producing more clearly defined fractions. The crystals formed were larger and easier to filter than those formed with agitation, but resulted in a lower solids yield. The solids content of butterfat obtained by crystallization increased sigmoidally (Fig. 1, curve A) from a low of ~ 10% at 29°C to a high of 52% at 17°C, and clearly indicates that most of the solids changes take place over a relatively narrow temperature range between 21 and 25°C. In contrast, the yields obtained by Amer *et al.* (6) shown in curve B of Figure 1 were higher, the only difference being the use of agitation. Other workers reported solid contents of 9.8% at 32°C increasing to 37.8% at 25°C (17); 31.8% at 27°C increasing to 48.6% at 24°C (18); 46% at 26°C increasing to 60% at 25° (3) and 36.5% at 25.5°C (19). Clearly, the fractionation conditions (i.e., temperature, time, agitation) and raw material source/composition are major variables in the recoveries obtained.

Fatty acids. The fatty acid profiles of anhydrous butteroil and the fractions obtained therefrom are presented in Table 1. Between 92–96% of the total chromatographic peak areas of these fatty acid fractions were accounted for by the analytical procedure. By quantitatively relating the fatty acid composition of the

TABLE 1

Fatty Acid Profiles of Parent Butteroil and its Solid (S) and Liquid (L) Fractions

Fatty Acid	Butter	S-29	S-25	S-21	S-17	L-29	L-25	L-21	L-17
4:0	5.05[a,b]	2.06	3.84	3.84	3.87	5.32	6.25	7.93	6.98
6:0	3.07	0.90	2.14	2.05	2.19	2.30	3.52	3.93	3.93
8:0	1.38	0.67	1.16	1.00	1.17	1.25	1.43	2.11	1.57
10:0	3.24	2.31	2.57	2.82	2.95	3.11	3.29	3.60	3.35
12:0	3.47	3.35	3.35	3.48	3.50	3.58	3.54	3.48	3.36
14:0	11.13	12.81	12.50	12.21	12.23	1165	11.39	10.73	10.79
14:1	0.99	0.66	0.68	0.84	0.88	0.99	1.02	1.04	1.08
16:0	27.53	36.58	34.61	32.23	31.84	29.35	28.25	26.17	26.69
16:1	1.14	0.85	0.86	1.04	1.20	1.29	1.27	1.32	1.42
18:0	10.79	16.52	14.93	3.17	12.69	10.94	10.50	9.38	9.36
18:1t	1.55	1.53	1.48	1.51	1.52	1.50	1.50	1.55	1.55
18:1	20.86	14.55	15.02	18.66	18.70	21.43	20.46	21.08	22.58
18:2	1.70	1.16	1.13	1.47	1.49	1.70	1.85	1.89	1.94
20:0	0.14	0.27	0.23	0.18	0.18	0.16	0.15	0.11	0.11
18:3	0.54	0.37	0.37	0.43	0.45	0.53	0.55	0.55	0.59
Other	7.42	5.41	5.22	5.07	5.07	4.90	5.03	5.13	4.70

[a]Results are expressed as a percent by weight of the total fatty acid fraction and represent the average of two replicate GC analyses of each of three separate fractionation experiments (i.e., $n = 6$).

[b]The relative standard deviation associated with the reported average was in the range of ±2% of that value.

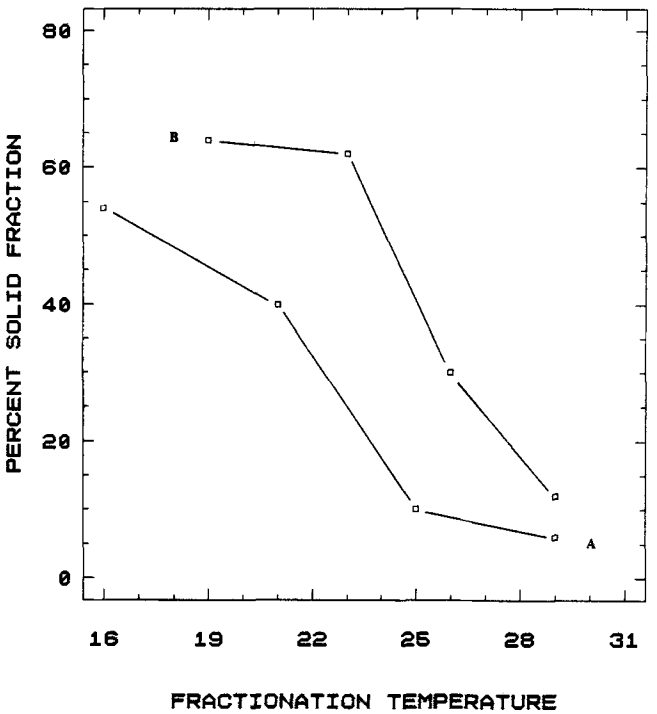

FIG. 1. A plot of % solids obtained by fractionation without agitation (A) and with agitation (B) vs. temperature. The data in (B) is from Amer *et al.* (6).

fractions to the original butteroil an impression can be obtained as to the changes taking place in the fatty acid composition as a function of fractionation temperature. In general, for the solid fractions, there is some loss of short fatty acids (C4-C8) and oleic acid with an increase in selected longer chain fatty acids (C16,C18). As the temperature of fractionation drops, the fatty acid composition shifts toward the original butterfat composition as noted by deMan (17). It is much more difficult to discern any obvious changes in the fatty acid profile of the liquid fractions *vis a vis* the parent butteroil, although it appears there is a minor increase in the short chain fatty acid components. These observations concur with the trend in the fatty acid analyses conducted on fractions obtained by others (3,5,6).

GC triglyceride analyses. The triglyceride distribution of the parent butteroil is presented in Table 2 along with the relative degree of change (%) observed in each fraction subsequently derived from it, with the butteroil data being similar to that obtained by deMan (11,17). In general there is a decrease in the low molecular weight components and an increase in the higher molecular weight components as the temperature at which the solid fraction was obtained increased (S17-S29), whereas the converse is observed for the liquid fractions. Relative to the original triglyceride component concentrations, the C32-C42 (medium molecular weight triglycerides) and C44-54 (high molecular weight triglycerides) show the greatest changes, the latter illustrated graphically in Figure 2. Once again the molecular composition of the fractions is most different for the S-29 and S-25 fractions; subsequent fractions approach the original butterfat triglyceride profile, much like the observations obtained from the fatty acid analyses.

Gel permeation HPLC. Gel permeation HPLC was carried out on the butteroil and its fractions to determine whether there were any clear cut differences between the samples based on the molecular volumes of their components. Basically, all the fractions were characterized by a similar elution pattern, having two peak envelopes, the first eluting at 21.6 min containing a mixture of higher molecular weight triglycerides and the second eluting about 1 min later, comprising lower molecular weight triglycerides. Table 3 presents the relative peak areas associated with selected fractions; they do not differ greatly from the results for the original butteroil. There is a decreasing trend in the peak area associated with the envelope eluted at 21.6 min and a corresponding increase in the peak area for the enve-

TABLE 2

Gas Chromatographic Analysis of the Triglyceride Profile of Parent Butteroil [Percent Composition by Acyl Carbon Number (ACN)] and Relative Changes in the Percent Composition Observed in the Solid (S) and Liquid (L) Butteroil Fractions[a]

ACN	Butteroil	S-29	S-25	S-21	S17	L-29	L-25	L-21	L-17
26	0.20	−45	−35	−15	−5	+40	+15	−5	+30
28	0.62	−39	−39	−13	−6	+24	+24	−5	+43
30	1.10	−60	−36	−16	−4	+23	+16	−2	+30
32	2.34	−52	−56	−17	−22	−1	+15	+10	+19
34	5.64	−43	−33	−19	−6	+13	+13	+1	+28
36	10.32	−40	−34	−13	−11	+13	+6	+5	+25
38	11.53	−35	−28	−7	−4	+18	+15	+9	+22
40	9.37	−30	−22	−10	−3	+19	+10	+5	+25
42	6.66	−11	−1	−2	+4	+13	+6	−10	+1
44	6.20	+14	+23	+6	+16 0	+1	−24	−17	
46	6.49	+48	+48	+20	+19	−8	−11	−29	−25
48	7.63	+55	+50	+42	+22	−5	−10	−28	−26
50	9.21	+51	+44	+21	+9	−6	−3	−23	−17
52	8.52	+24	+9	+1	−2	−7	−12	−12	−16
54	3.56	+11	−3	−3	−1	+2	+7	−3	−1
Other	10.61								

[a]Results are expressed as percent by weight of the total triglyceride fraction (parent butteroil) or as a percent change of the component in the respective fractions relative to the butteroil. Results are an average (n = 6) of two replicate determinations of each fraction and the standard deviation associated with the reported average is in the range of ±2% of the value indicated.

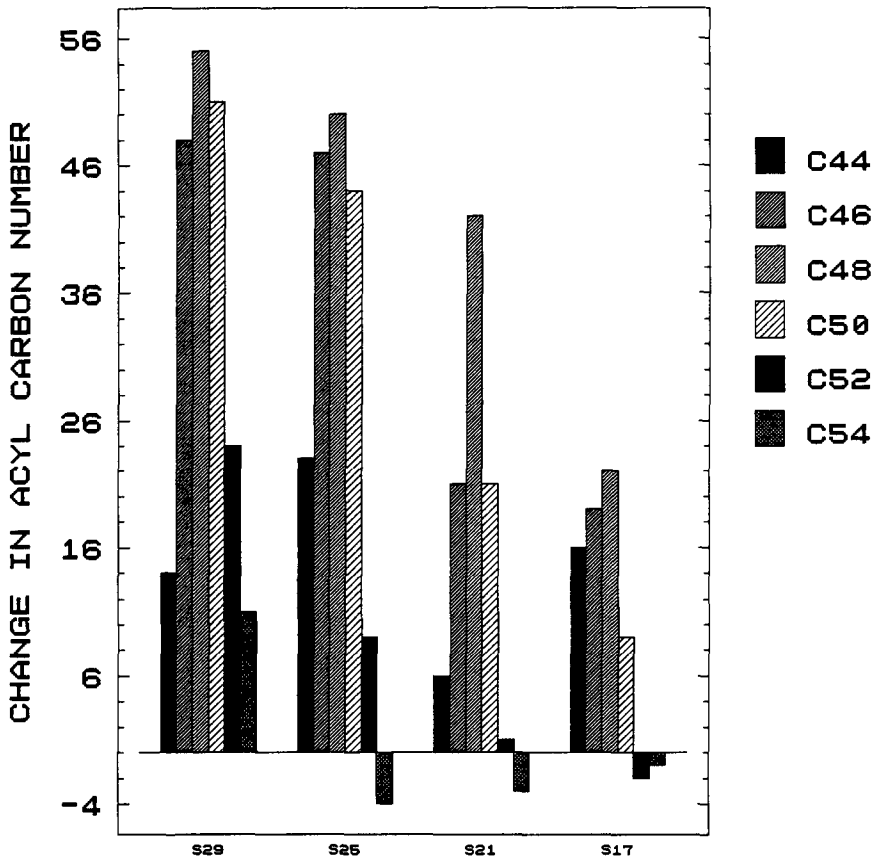

FIG. 2. Percent changes (relative to the parent butteroil) in the content of high molecular weight triglycerides (C44-54) in solid fractions isolated at 29, 25, 21 or 17°C.

lope eluted at 22.2 min as the temperature of fractionation was decreased. These data corroborate the compositional data, as determined by GC, and suggest that differences in physical properties of the separate fractions are the result of small differences in the proportions of component triglycerides.

DSC analysis. Figure 3 provides examples of a DSC scan of whole anhydrous butterfat and two selected solid

TABLE 3

Relative Peak Areas[a] of the Two Peak Envelopes in the HPLC Elution Profile of Parent Butteroil and Selected Fractionation Products

Sample	Peak area # 1 high molecular weight RT = 21.6 min	Peak area #2 low molecular weight RT = 22.2 min
Butteroil	51.0	48.5
S-29	59.8	37.3
S-25	58.1	40.3
S-21	56.8	42.8
S-17	50.6	48.2
L-17	43.2	56.1

[a]Average results of three fractionation trials, having a mean relative standard deviation of ±2% per analysis.

TABLE 4

Solids Content and Transition Temperatures for Butterfat and its Fractions Based on DSC Scans

Sample	% Solids recovered	Transition point temperature		
		T1	T2	T3
Butter	NA[a]	9.0	17.0	34.0
S-29	10.0	9.8	16.7	43.4
S-25	12.0	10.4	16.7	42.0
S-21	43.5	10.4	16.7	37.4
S-17	52.3	10.3	16.8	36.1
L-29	90.0	NP[b]	15.7	27.4
L-25	88.0	NP	14.5	26.4
L-21	57.5	NP	13.2	17.5
L-17	47.7	NP	NM	16.8

[a]NA, not applicable.
[b]NP, not present.

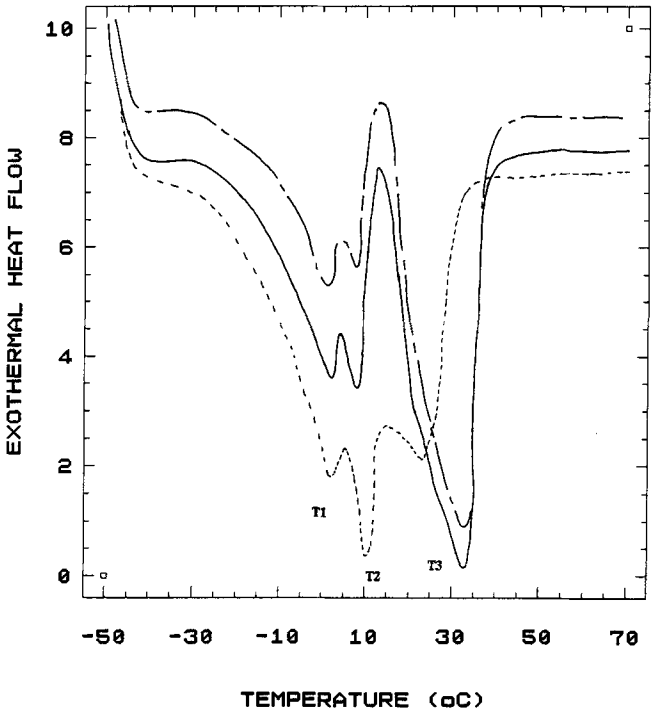

FIG. 3. DSC thermograms of butteroil and selected fractions (butteroil, ···; S-17, — · —; S-25, — - —; and —, S-29).

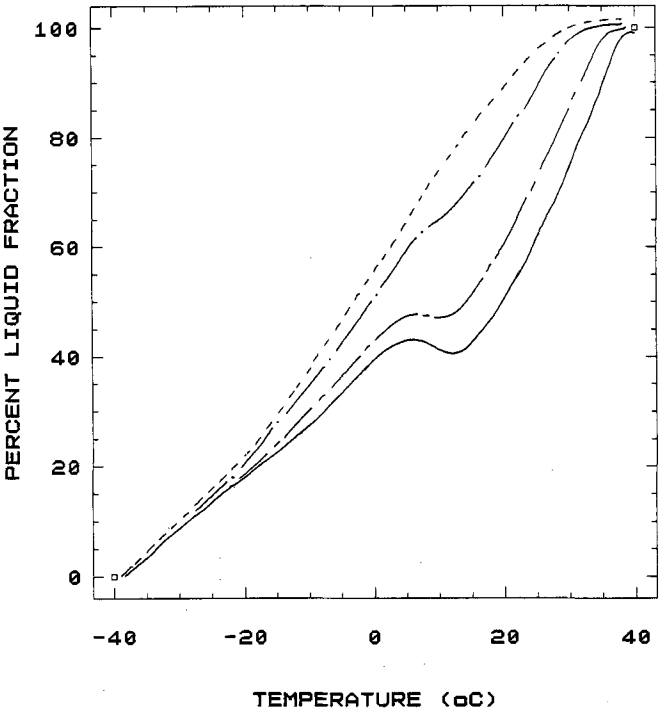

FIG. 4. Solid fat index of butteroil (···) and selected fractions (S-17, — · —; S-25, — - —; and —, S-29) obtained by the integration of their DSC thermograms.

fractions (S-29 and S-25). The peaks represent exothermic changes occurring as the crystalline material is rewarmed at a constant rate, implying phase transitions as various components melt or undergo polymorphic changes. In general, the butterfat and its solid fractions are characterized by three phase changes. Each of the fractions is characterized in terms of its major transition temperatures in Table 4. No major changes are apparent in the transition temperatures of the various fractions and only peak T3, the highest temperature phase transition, can be said to have changed to any appreciable extent.

A transformation of the DSC data to obtain a melting profile of the individual fractions (expressed in terms of percent liquid as a function of temperature) are compared with the original anhydrous butteroil in Figure 4. The 17 and 21°C (latter not shown) fractions overlapped and did not show any appreciable change relative to butteroil, whereas the 25 and 29°C fractions were characterized by an inflection in the melting curve. A similar plot for the liquid fractions is presented in Figure 5, which behave in a manner very similar to the butteroil, although there is a perceptible shift of the melting plots toward a higher percentage of liquid being present as the temperature of crystallization decreased. The changes observed in either the solid or liquid fractions appear to indicate that simple fractionation of butter has not changed the physical characteristics in a substantive manner and most of the changes observed may,

TABLE 5

Comparison Butterfat Fatty Acid Composition (%) on a Grouped Basis for Winter and Summer Butterfat and Selected Fractions, Grouped from Data Obtained by Amer *et al.* (6)

Fatty acid group	Butter oil, winter	Butter oil, summer	S29 Summer	S19 Summer	S29 Winter	S19 Winter
C_4–C_{10}	12.97	11.82	9.37	11.10	10.40	12.17
C_{12}–C_{15}	16.86	15.44	15.88	15.78	17.52	17.07
C_{16}–C_{20}	40.65	39.47	47.04	41.75	47.38	42.90
$C_{10:1}$+$C_{18:3}$	24.92	26.37	21.14	24.73	20.43	23.18
$C_{18:1t}$	1.55	3.35	3.13	3.06	1.46	1.55
Others	3.04	3.55	3.44	3.58	2.18	2.13

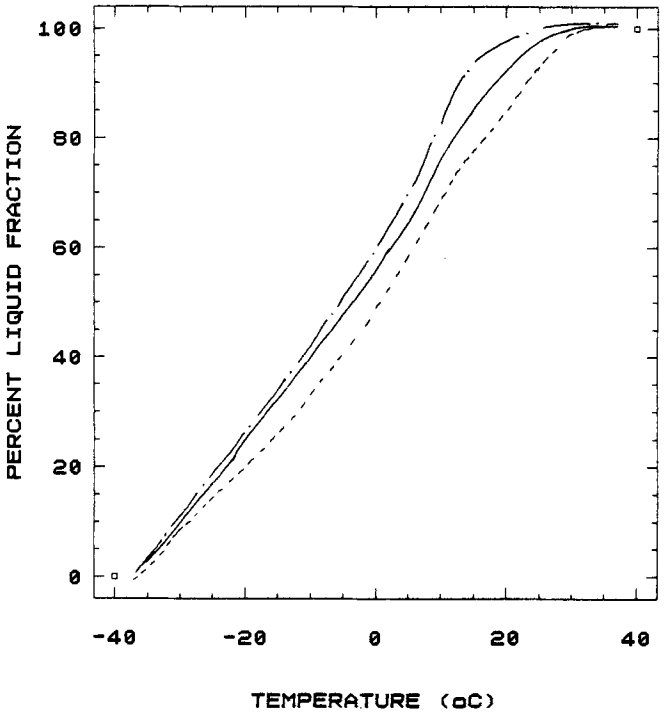

FIG. 5. Solid fat index of butteroil (·) and liquid fractions (L17, — · —; L29, —) obtained by the integration of their DSC thermograms.

in fact, be due to the polymorphic behavior. This hypothesis is supported to a large extent by the fact that there are only minor compositional changes observed in the fatty acid and triglyceride analyses, and the largely similar HPLC elution profiles. Nevertheless, deMan (11) expressed doubts that polymorphism could be the sole cause of the differences between the properties of fast and slow cooled butteroil.

Another way of looking at the changes resulting from fractionation is to compare the fatty acid composition of summer and winter butterfat to their corresponding extreme solid fractions (S-19 and S-29). Table 5 was developed using the data presented by Amer *et al.* (6); the changes occurring in terms of the fatty acid composition (arbitrarily grouped) appear to be minimal, with a maximum change observed in the C_{16}–C_{20} group. These changes have to be further tempered by the fact that the solid fractions only make up ca. 13% in the case of the S-29 and 54% in the case of S-19 components. A similar analysis of our data produced analogous results, although the total amounts of the individual fractions were lower. Overall, the variations in seasonal butterfat composition are only slightly less than that observed after fractionation and are almost within experimental error. These observations corroborate the results obtained by other researchers (12–14).

The suggested uses of fractionated butter include: (i) The addition of the low melting point fraction to milk powder to improve its reconstitutional properties (20) and to improve spreadability of butter (21), and (ii) to use the high melting point fraction for puff pastry (22) and as a coating (8). Although these appear to be desirable ends, the literature is unclear regarding the merits of butterfat fractionation and no consensus has been formed to date regarding the functionality of the fractions, partially because of conflicting reports by various researchers. Amer *et al.* (6) concluded that fractions had been obtained which differed markedly in their physical and chemical characteristics, based on data very similar to that obtained in this study, although he used agitation in his experimental protocol. Many of the conclusions were based on statistical differences, which may be valid in a statistical sense, but not be of practical relevance.

Butterfat and many other lipid systems are very complex from the viewpoint of molecular structure and composition, largely because so many combinations and permutations are possible given the large number of fatty acids which can be attached to the glycerol backbone. Even though each triglyceride in the mixture can be unique in structure, there is very little difference in terms of the overall physical properties between them. When one looks at a specific triglyceride in isolation, many unique physical properties can be discerned, including stereoisomerism, polymorphism and crystal packing of aliphatic chains (23). For example, studies carried out on defined mixtures of tristearin (SSS) and either of two forms of 2-stearodiplamitin (PSP/SPP) produced dramatically different crystallization behavior (24). Considering the major effects associated with the simple change of a single fatty acid on the glycerol molecule, these effects must be compounded in natural triglyceride mixtures such as butter which may contain more than 437 individual fatty acids (25) and it would be expected that any individual characteristics are lost to a complex continuum of physical properties. It is most likely that temperature fractionation is, in fact,

more a setting up of conditions which favor a particular form of crystalline association or packing rather than specifically separating out fractions based on molecular weight. The latter process could be expected in noninteracting, temperature-dependent systems, but is unlikely to occur in a complex triglyceride mixture (23).

Integrating the information from our experiments with the results of other Canadian researchers (5,6), both the fatty acid and triglyceride composition do not change appreciably as a function of fractionation temperature. The behavior of the fractions in terms of DSC scans and solid/liquid ratios also is not appreciably different. HPLC gel permeation analysis (using molecular size as a basis) indicates only minor differences between the fractions obtained over the 29–17°C range relative to the parent butteroil. Clearly butter can be fractionated according to temperature, however, one has to ask the question of what the benefits of such a process would be. The rationale usually given is that fractionation confers special properties on one of the fractions. The only fractions which could be said to be somewhat different based on our work would be S-29 and S-25, which generally contain slightly higher levels of longer chain saturated fatty acids and triglycerides but only comprise 10–12% of the total lipid. Of the uses proposed for butter fractions, the cocoa butter substitute may have viable economic potential, however, none of the fractions obtained show physical behavior similar to cocoa butter. Our fractionation process, which more appropriately could be termed a tempering process, provides conditions for the formation of a stable crystal form, which is then separated. As concluded by Makhlouf *et al.* (5), the separation of milk fat triglycerides by molecular size does not appear to be feasible by melt crystallization based on the lack of differences in the average molecular weight of the various fractions. Our results indicate that the fractions produced can barely be differentiated from the seasonal variation observed in the parent butterfat.

Although our evidence points to discounting fractionation, two commercial thermal fractionation processes are being marketed and used under the trade names Tirtiaux (8) and Francexpa (26) largely for pastry/bakery applications. Only detailed information is available for the Tirtiaux process (8), which is a proprietary two step continuous fractionation process using filtration to first produce a stearin and an olein fraction; the olein then being refractionated to produce a second stearin and olein fraction. Five hundred tons of butteroil are fractionated per day in Europe and Japan by the Tirtiaux process and the fractions are said to find applications in ghee production, reconstitution of hard butters destined for the tropics, coatings, puff pastries and other baking applications, and the preparation of refrigerator-spreadable butters. In addition, the flavor of butter is not affected by the process, the composition of the fractions are shown to differ markedly from the seasonal variation observed in butter composition and the latter is only considered a variable affecting the stearin yield rather than fraction composition. The key to the process is a patented means of temperature control whereby the rate of cooling controls the latent heat of crystallization and avoids supercooling (8). Beyond these factors, butterfat fractionation also may be driven and made viable by the special position butter holds in numerous countries, where it is protected legislatively.

Our first solid fraction (S-29) is similar in composition to the first stearin fraction obtained in the Tirtiaux process, and our stearin yields are much lower (13 vs. 28%), while the other fractions differ markedly. Our laboratory fractionation procedure is not as clear cut as the Tirtiaux process, indicating the technologically (i.e., scale and design factors, mixing, cooling rates, etc.), the commercial process is superior in its fractionation ability or that European butters have a distinct triglyceride profile, while still maintaining an overall similarity in gross fatty acid composition.

The experimental evidence for obtaining unique compositional and/or textural characteristics for butterfat fractions obtained by a one step, simple thermal fractionation process is weak, based on studying butter available in Quebec. Most of the literature involving laboratory scale fractionation also indicates relatively minor differences between fractions produced by controlled cooling and crystallization, although direct comparisons are difficult. The success attributed to commercial processes developed in Europe contradict our general findings and indicate that on an industrial scale, fractionation of butter is possible, feasible and that value added products can be produced. Based on our laboratory scale process, fractionation of Quebec butter does not appear to have merit. The only way to resolve the fractionation debate would be to fractionate our butter using the Tirtiaux or Fracexpa process to determine whether the resulting fractions are markedly different in their physical and functional properties. Whether the differences would be adequate to justify implementing such a process on a commercial scale in Canada would then be left to market forces.

ACKNOWLEDGMENTS

The authors thank the Natural Sciences and Engineering Research Council of Canada for financial support.

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[Received December 12, 1989; accepted September 3, 1990]