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Modification of Beef Tallow Stearin and Olein by Chemical and Enzymatic Interesterification with Soybean Oil

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Abstract: Beef tallow stearin and beef tallow olein were interesterified with soybean oil using sodium methoxide or immobilized lipases from Rhisomucor miehei (Lipozyme IM) and Candida antarctica (Novozym 435) as catalysts. It was found that after interesterification the contents of free fatty acids and of mono- and diacyloglycerols increased. The slip melting point and solid fat content of the triacylglycerol fraction isolated from interesterified samples containing stearin were lower compared with nonesterified blends. For interesterified mixtures containing olein and soybean oil opposite dependencies for slip melting point and solid fat content were observed. The total fatty acids composition of fats before and after interesterifications remained unchanged but their distributions between sn-1, 3 and sn-2 positions were modified depend on catalysts used. These distributions were random after chemical interesterification or close to random when Novozym 435 was used. When Lipozyme IM was used the fatty acid composition at sn-2 position remained practically unchanged compared with starting blend.

Key words: Interesterification, Lipases, Sodium metoxide, Soybean oil, Tallow olein, Tallow stearin

Introduction

Beef tallow is one of the most important by-products of meat industry. European annual production of tallow is about 1.42 million tones (Gunstone, 2000). Because of its high melting temperature and low level of unsaturated fatty acids (C18: 2, C18: 3) tallow practically cannot be directly used for edible purposes. For edible use it has to be fractionated and/or modified by interesterification with edible oils (Gunstone, 1998, Marangoni and Rousseau, 1995). The selection of vegetable oil depends on the purpose of tallow modification. When the fat produced is intended to use as a component of "low trans" margarine oils with relatively high contents of linoleic and linolenic acids soybean oil can be used. It also can be used for production of some plastic fats and mayonnaise oils. There are several papers on interesterification of beef tallow with vegetable oils (Lo and Handel, 1983, Forssell *et al.*, 1992, Foglia *et al.*, 1993, Ledochowska and Wilczynska, 1998, Rodriguez *et al.*, 2001, Gruczynska *et al.*, 2002 and Kowalski *et al.*, 2004 a, b, c). Substantially less information is available on the interesterification of tallow fractions with vegetable oils (Bhattacharyya *et al.*, 2000 and MacKenzie and Stevenson, 2000). This study deals with the modification of beef tallow by acetone fractionation followed by blending or interesterification of beef tallow fractions with soybean oil in different proportions. The objective of this study was to investigate selected chemical and physical properties of beef tallow stearin or olein and their mixtures with soybean oil modified by interesterifications. Both chemical and enzymatic interesterifications were studied, and the properties of final fats were compared with those of the starting blends.

Materials and Method

Materials: Soybean oil was commercial product purchased on local market. Its main fatty acids composition was as follows: C16:0 (11.0 %), C18:0 (4.0%), C18:1 cis9 (22.7%), C18:2 all cis (51.9%), C18:3 all cis (6.4%). Beef tallow was laboratory refined, bleached and deodorized under vacuum at 105 °C. Then it was fractionated from acetone. Only these tallow samples were used for fractionation that acid values were lower than 1.0 mg KOH/g. Beef tallow sample (100g) was dissolved in acetone (600g) and boiled under reflux for 1 hour. Then the solution was left for 15 hours at 20 °C. Precipitated white crystals of stearin (~20g, slip melting point 54 ± 1 °C) were filtered off and stored in vacuum dessicator to remove acetone. Fatty acids composition of stearin was: C14:0 (3.0%), C16:0 (34.3%), C:16:1 cis 9 (1.3%), C17:0 (2.5%), C18:0 (34.1%), C18:1 trans 9 (1.9%), C18:1 cis 9 (15.5%), C18:2 all cis (0.6%). From the filtrate acetone was evaporated at reduced pressure and as the remaining fat ~80g of olein (slip melting point 24 ± 1 °C) was obtained. Fatty acids composition of olein was: C14:0 (3.0%), C16:0 (26.4%), C16:1 cis 9 (2.5%), C17:0 (1.6%), C18:0 (19.4%), C18:1 trans 9 (2.3%), C18:1 cis 9 (35.0%), C18:2 all cis (1.8%).

Blends Preparation: Stearin (S) or olein (O) were mixed at 70 °C under nitrogen with soybean oil (SBO) in proportions ranging from 10 to 60 wt % of SBO. Ten blends, five containing soybean oil and stearin (10% SBO + 90% S, 25% SBO + 75% S, 40% SBO + 60% S, 50% SBO + 50% S, 60% SBO + 40% S) and five containing sunflower oil and olein (10% SBO + 90% O, 25% SBO + 75% O, 40% SBO + 60% O, 50% SBO + 50% O, 60% SBO + 40% O) were prepared. The selected properties of stearin and olein and of starting mixtures are given in Results and Discussion section.

Catalysts: Chemical interesterifications were catalyzed by powdered sodium metoxide (CH_3ONa, Merck, Germany) which was used as supplied. As catalysts for enzymatic interesterification two commercial preparations Lipozyme IM and Novozym 435 (Novozymes, Bagsvaerd, Denmark) were used. Lipozyme IM contains immobilised lipase from *Rhizomucor miehei,* and Novozym 435 from Candida antarctica. Lipozyme IM and Novozym 435 contained 4 % and 2 % of water, respectively.

Methods

Chemical Interesterification: Directly before interesterifications the fats were dried at 90 °C under reduced pressure. Flasks containing fat blends were flushed with nitrogen, stoppered and positioned in thermostated mineral oil shaker bath. After thermal equilibration of samples at 90 °C the catalyst (0.6 wt-% sodium metoxide) was added under nitrogen. The interesterification was carried out with continuous shaking for 2 hours. The reaction was stopped by addition of hot water containing 5% H_3PO_4. Interesterified fats were extracted with hexane, washed with water and dried. Hexane was evaporated under reduced pressure and remaining interesterified fats were analysed.

Enzymatic Interesterifications: After thermal equilibration of fat blends at desired temperature (80 °C for Novozym 435 or 60 °C for Lipozyme IM) 8 wt-% of enzymatic catalyst was added. Water content in biocatalyst was adjusted by water addition directly before reaction. The interesterifications were performed with continuous shaking. After a predetermined time (Novozym 4 h, Lipozyme 8 h) filtering off the biocatalyst stopped interesterification. As the filtering bed contained drying agent, water was also removed from fat.

Determination of Free Fatty Acids: Free fatty acids (FFA) were determined by titration of the fat sample dissolved in the mixture of ethanol:diethyl ether (1:1 vol/vol) with 0.1-M ethanolic potassium hydroxide solution. The mean molar masses of fatty acids from analysed samples were calculated based on the results of gas-liquid chromatography analyses.

Gas-Liquid Chromatography Analyses: The fatty acid compositions of the fats studied were determined by gas liquid chromatography (GLC) after conversion of the fats to fatty acid methyl esters (Polish Standard PN-ISO 5509). For GLC analyses a Hewlett Packard 5890 II chromatograph, equipped with flame-ionisation detector and BPX 70 capillary column (50 m x 0.25 mm), was used. The temperature program was 5 min at 140 °C, then the temperature was increased 1.5 °C/min to 210 °C and kept another 10 min at 210 °C. The injection and detector temperatures were 230 °C and 250 °C, respectively. Helium was used as the carrier gas.

Separation Fat Samples into Triacylglycerol and Non-Triacylglycerol Fractions: Fats before and after interesterification were separated into triacylglycerols (TAG) and non-TAG fraction, referred to as polar fraction (PF), by column chromatography on silica gel (SG 60, 70-230 mesh, Merck). The TAG were eluted with the mixture of petroleum ether : diethyl ether = 87:13 vol/vol and then polar fraction which contained FFA, monoacylglycerols (MAG), and diacylglycerols (DAG), was eluted with diethyl ether. The weight percent TAG and PF were determined after evaporation of eluting solvent (Polish Standard PN-ISO 8420, 1995).

Slip Melting Point: The slip melting point, (SMP, °C) a temperature at which the fat confined in open capillary immersed in water moves upward was determined in accordance with Polish Standard (PN ISO 638, 1991).

Solid Fat Content by NMR Analysis: The solid fat content (SFC,%) of TAG as a function of temperature (5–50 °C) was determined by a pulse nuclear magnetic resonance in a Brucker Minispec 120 NMR Analyser.

Samples for SFC determinations were prepared according to the Polish Standard (PN ISO 8292, 1991).

Positional Distribution of Fatty Acids Between sn-2 and sn-1, 3 Positions of TAG: The positional distribution of fatty acids between sn-2 and sn-1,3 positions of triacylglycerols were determined using the method developed by Brockerhoff (1965) and then modified by Drozdowski (1974). The method is based on the ability of pancreatic lipase, to selectively hydrolyze ester bonds in the sn-1,3 positions of TAG. The products of lipolysis were separated by thin layer chromatography (TLC) on plates covered with Kieselgel G (Merck,) with a developing system

petroleum ether: diethyl ether: acetic acid = 70: 30: 1, vol/vol/vol. The sn-2 MAG band was scraped off and its lipids were extracted into diethyl ether and subsequently used for fatty acids determinations (FA_{sn-2}) by GLC. The composition of fatty acids in the sn-1, 3 positions of TAG was computed from the equation:

$$\% \text{ FA sn-1,3} = (3 \% FA_{TAG\ total} - \% FA_{sn-2}) : 2$$

where ($FA_{TAG\ total}$) is the fatty acid composition of fat before enzymatic hydrolysis with pancreatic lipase.

Results and Discussion

The chemical interesterifications of SBO + S and SBO + O blends were performed at 90 °C for 2 h using 0.6 % of sodium metoxide. During interesterifications of fats apart from usually desired new triacylglycerols, free fatty acids, mono- and diacylglycerols also are formed. They were determined in the post-reaction mixtures and the results are listed in Table 1. For comparison the results for blends before interesterification are also given. As seen from the Table 1 after interesterifications there was an increase in FFA and MAG + DAG contents compared with initial blends. Consequently about 10% decrease in TAG concentrations for interesterified mixtures were observed. Similar trends have been observed in our earlier studies on interesterification of beef tallow blends with rapeseed oil (Gruczynska *et al.*, 2002 and Kowalski *et al.*, 2004a, b, c). Studying interesterification beef tallow + rapeseed oil blend containing 40 wt-% of tallow Ledochowska and Wilczynska (1998) have observed that after chemical interesterification (65 °C, 0.7wt-% CH_3ONa) the crude post-reaction products contained 0.5% FFA, 12.2% DAG and 0.5% MAG and 86.8% TAG. In our experiments we have obtained similar yields of TAG (88.0 ± 1.0 % and 87.8 ± 0.2 % for interesterified blends containing stearin and olein, respectively) although the FFA contents in crude interesterified fats were also higher. The slip melting points of the TAGs isolated from post-reactions mixtures were measured and the results are also listed in Table 1. As seen from Table 1 the SMP values for TAGs of interesterified blends containing stearin are lower (49.9 – 40.9 °C) than for starting blends (51.2 – 45.1 °C). On the contrary for TAGs of interesterified blends containing olein the increases of the SMP (29.0 – 22.9 °C) were observed. The dependencies of solid fat content against temperature for TAG fractions were determined by pulse-nmr and the results for systems containing 50 wt-% of SBO are illustrated in Figs. 1 and 2. As seen from the plots the SFC values for TAG isolated from chemically interesterified blends containing stearin are lower than for starting blend. For other compositions of blends their SFC patterns were similar and there were only quantitative differences. An opposite relationships were obtained for blends consisted of olein and soybean oil. For such blends the increase of SFC values were observed after interesterification. As expected, the positional distribution of fatty acids between the sn-2 and sn-1,3 positions in TAG of chemically interesterified blends was near random and different from nonesterified blends. The data showed in Tables 2 and3 for equal-weight blends containing stearin or olein and SBO before and after interesterification serve as the examples.

For enzymatic interesterification, the blends studied and the time and temperature of reaction and catalyst dose were established in our earlier experiments, and these parameters were kept constant as specified in Materials and methods section. Only the water contents in catalysts were fixed at two levels (2 and 10 wt-% for Lipozyme IM and 4 and 10 wt- % for Novozym 435).

The crude post-reaction mixtures were characterized by determinations of FFA, MAG + DAG and TAG percentages and they are listed in Tables 4 and 5. Comparing the results for initial (Table 1) and enzymatically interesterified (Tables 4 and 5) blends, a sharp increase in the FFA and MAG + DAG concentrations is observed, especially at 10% water content in biocatalyst used. These increases are in agreement with the findings reported in literature (Foglia *et al.*, 1993, Ledochowska and Wilczynska, 1998 and Kowalski *et al.*, 2004 b,c). Consequently the concentration of TAG fractions in interesterified fats decreased compared with starting blends. The TAG fractions were isolated from crude interesterified fats and their slip melting points were measured. The results are also listed in Tables 4 and 5. As seen from Table 1 (initial blends) and Tables 4 and 5 the slip melting points of TAG from enzymatically interesterified blends containing stearin are lower than for starting blends. The reduction in SMP was proportional to the water content in enzyme catalysts. Lipozyme IM has appeared to be more effective than Nowozym 435 in SMP reduction. The TAGs from enzymatically interesterified blends containing olein displayed higher SMP values compared with suitable initial blends. The increases in SMP were proportional to the water content in catalyst preparations and Novozym 435 has appeared to be more effective than Lipozyme IM. The reduction of SMP of blends containing stearin and increase of SMP of interesterified olein and their blends with soybean oil is caused by an alteration of the TAGs structure. Due to the exchange of fatty acids within and between TAG new triacylglycerols are formed and new interrelations among them can appear. The distributions of fatty acids between the sn-2 and sn-1,3 positions of TAG after enzymatic interesterifications of equal-weight blends of soybean oil with stearin and olein were determined. The results are listed in Tables 6 and 7. When Novozym 435 was used as catalyst the fatty acid distributions after interesterification suggest that some positional randomization has occurred. But these distributions were still far from statistical

Table 1: Free fatty acids (FFA), mono- and diacylglycerols (MAG + DAG), triacylglicerols (TAG) contents and slip melting points (SMP) of TAGs for stearin (S) and olein (O) and their mixtures with soybean oil (SBO) before and after chemical interesterification.

Fat sample	Before interesterification				After chemical interesterification			
	FFA	MAG + DAG	TAG	SMP of TAG	FFA	MAG + DAG	TAG	SMP of TAG
	[%]	[%]	[%]	[°C]	[%]	[%]	[%]	[°C]
Stearin (S)	1.1	0.9	98.0	54.3	1.5	6.8	91.7	53.8
10% SBO + 90% S	0.5	1.6	97.9	51.2	1.7	9.3	89.0	49.9
25% SBO + 75% S	0.4	1.5	98.1	49.6	1.8	10.2	88.0	47.2
40% SBO + 60% S	0.3	1.6	98.1	48.2	1.7	11.3	87.0	44.3
50% SBO + 50% S	0.3	1.3	98.4	46.7	1.6	9.3	89.1	42.7
60% SBO + 40% S	0.2	1.3	98.5	45.1	1.8	10.5	87.7	40.9
Olein (O)	1.0	2.1	96.9	22.8	1.5	7.2	90.3	30.6
10% SBO + 90% O	1.0	2.1	96.9	21.8	2.4	9.8	87.6	29.0
25% SBO + 75% O	0.9	2.1	97.0	20.5	2.5	9.7	87.8	28.4
40% SBO + 60% O	0.7	2.1	97.2	17.8	2.6	9.5	87.9	26.8
50% SBO + 50% O	0.6	2.1	97.3	14.6	2.6	9.8	87.6	26.1
60% SBO + 40% O	0.5	2.1	97.4	10.1	2.5	9.6	87.9	22.9

Table 2: Fatty acid composition (TAG total) and distribution between the (sn-2) and (sn-1,3)[a] positions for triacylglycerols obtained from the mixture of soybean oil (50%) and stearin (50%) before and after chemical interesterification.

Fatty acid	TAG total [%]	Before interesterification		Chemically interesterified	
		% in sn-2	% of a given fatty acid in in sn-2	% in sn-2	% of a given fatty acid in in sn-2
14:0	1.9	3.1	54.4	2.0	35.1
16:0	22.7	15.4	22.6	22.4	32.9
16:1 (9 c)	0.7	0.6	28.6	0.7	33.3
17:0	1.3	1.1	28.2	1.3	33.3
18:0	19.1	15.1	26.4	18.9	34.2
18:1 (9 t)	0.9	0.2	14.3	0.8	28.3
18:1 (9 c)	19.1	22.8	39.8	19.6	34.2
18:2 (9, 12 c)	26.3	34.1	43.2	27.5	34.9
18:3 (9,12,15c)	3.3	3.0	30.3	3.3	33.3

[a] sn-1,3 = [3 TAG total – (sn-2)] : 2

Table 3: Fatty acid composition (TAG total) and distribution between the (sn-2) and (sn-1, 3)[a] positions for triacylglycerols obtained from the mixture of soybean oil (50%) and olein (50%) before and after chemical interesterification.

Fatty acid	TAG total [%]	Before interesterification		Chemically interesterified	
		% in sn-2	% of a given fatty acid in sn-2	% in sn-2	% of a given fatty acid in sn-2
14:0	1.6	1.9	39.7	1.7	35.4
16:0	18.7	10.9	22.6	17.5	31.2
16:1 (9 c)	1.3	1.3	33.3	1.3	33.3
17:0	0.9	0.4	14.8	0.8	29.6
18:0	11.7	7.6	21.7	11.3	32.2
18:1 (9 t)	1.1	0.5	15.1	1.0	30.3
18:1 (9 c)	28.9	34.0	39.2	30.0	34.6
18:2 (9, 12 c)	26.9	34.7	43.0	28.8	35.7
18:3(9,12,15 c)	3.6	3.9	36.1	3.6	33.3

[a] sn-1,3 = [3 TAG total – (sn-2)] : 2

Table 4: Free fatty acids (FFA), mono- and diacylglycerols (MAG + DAG), triacylglicerols (TAG) contents and slip melting points (SMP) of TAGs isolated from stearin (S) and olein (O) and from their mixtures with soybean oil (SBO) after enzymatic interesterification catalyzed by Novozym 435.

Fat sample	After interesterification catalyzed by Novozym 435 containing 2% of water				After interesterification catalyzed by Novozym 435 containing 10% of water			
	FFA [%]	MAG + DAG [%]	TAG [%]	SMP of TAG [°C]	FFA [%]	MAG + DAG [%]	TAG [%]	SMP of TAG [°C]
Stearin (S)	2.0	13.0	85.0	53.1	11.2	18.0	70.8	49.3
10% SBO + 90% S	1.8	7.1	91.1	51.5	10.0	21.8	68.2	46.9
25% SBO + 75% S	1.6	7.2	91.2	47.8	10.1	19.8	70.1	42.3
40% SBO + 60% S	1.9	6.0	92.1	43.0	10.3	20.5	68.5	39.1
50% SBO + 50% S	2.0	5.1	92.9	42.1	10.3	20.6	69.2	36.8
60% SBO + 40% S	1.7	5.3	93.0	37.8	10.0	20.4	69.6	34.0
Olein (O)	3.1	5.8	91.1	41.7	9.0	18.8	72.2	40.1
10% SBO + 90% O	2.5	5.4	92.1	38.1	9.1	17.3	73.6	37.0
25% SBO + 75% O	2.4	6.1	91.5	37.4	9.2	17.4	73.4	36.0
40% SBO + 60% O	2.8	5.3	91.9	35.7	9.0	18.0	73.0	34.6
50% SBO + 50% O	2.6	7.0	90.4	32.0	9.1	17.4	73.5	32.9
60% SBO + 40% O	2.6	6.8	90.6	28.9	9.0	17.5	73.5	29.7

Table 5: Free fatty acids FFA, mono- and diacylglycerols (MAG + DAG), triacylglycerols (TAG) contents and slip melting points (SMP) of TAGs isolated from stearin (S) and olein (O) and from their mixtures with soybean oil (SBO) after enzymatic interesterification catalyzed by Lipozyme IM.

Fat sample	After interesterification catalyzed by Lipozyme IM containing 4% of water				After interesterification catalyzed by Lipozyme IM containing 10% of water			
	FFA TAG [%]	MAG + DAG SMP of TAG [%]	TAG [%]	[°C]	SMP of TAG [%]	[%]	FFA [%]	MAG + DAG [°C]
Stearin (S)	2.7	15.3	82.0	51.0	14.1	9.8	76.1	44.9
10% SBO + 90% S	4.4	9.7	85.9	49.3	11.6	15.9	72.5	42.3
25% SBO + 75% S	4.4	9.6	86.0	45.8	13.0	15.2	71.8	40.1
40% SBO + 60% S	3.6	9.4	87.0	42.3	13.2	15.9	70.9	37.5
50% SBO + 50% S	3.6	8.5	87.9	41.0	13.0	13.7	73.3	31.9
60% SBO + 40% S	4.0	8.5	87.5	37.1	11.6	14.5	73.9	25.4
Olein (O)	4.5	9.7	85.8	36.5	10.6	14.1	75.3	36.3
10% SBO + 90% O	4.0	7.1	88.9	33.2	8.7	17.0	74.3	32.8
25% SBO + 75% O	4.2	7.1	88.7	27.6	9.7	16.5	73.8	31.4
40% SBO + 60% O	3.2	7.5	89.3	23.3	9.9	17.1	73.0	30.9
50% SBO + 50% O	3.5	7.0	89.5	19.0	9.8	16.6	73.6	28.8
60% SBO + 40% O	3.3	8.4	88.3	16.4	9.8	16.5	73.7	27.6

(33.3%), even from the data obtained for chemical interesterification (Tables 2 and3).

A different situation was observed for TAGs obtained from interesterifications catalyzed by Lipozyme IM. Due to positional (sn-1,3) specificity of the lipase the interesterification occurred mainly in external positions of TAGs. The data of fatty acid distributions for esterified and nonesterified blends showed their similarity. As the enzyme operated on the external ester linkages the percentages of particular fatty acids in the sn-2 positions of interesterified TAGs in comparison with their counterparts for initial blends remain nearly unchanged. The small changes in sn-2 percentages can be caused by possible acyl migration in TAG molecules during prolonged time of interesterification, as reported by Xu *et al.* (1998).

The altered triacylglycerol distributions of fatty acids of enzymatically interesterified soybean and stearin or olein blends were reflected in the solid fat content over the temperature range of 5 – 50 °C. Significant reductions in the solid fat content were detected for TAG fraction isolated from interesterified blends containing stearin and soybean oil. The semi-solid at room temperature blends containing soybean oil and olein after interesterifications displayed at temperatures 20 – 40 °C increases in solid fat contents of their TAG fractions. At 5 - 10°C reductions in SFC values were observed compared with starting mixture. Typical dependencies for SFC versus temperature for selected blends

Table 6: Fatty acids composition (TAG total) and distribution between the (sn-2) and (sn-1,3)[a] positions for triacylglycerols obtained from the mixture of soybean oil (50%) and stearin (50%) after enzymatic interesterification.

Fatty acid	TAG total [%]	Interesterified / Novozym 435		Interesterified / Lipozyme IM	
		% in sn-2	% of a given fatty acid in sn-2	% in sn-2	% of a given fatty acid in sn-2
14:0	1.9	2.1	36.8	3.3	57.9
16:0	22.7	21.5	31.6	15.1	22.2
16:1 (9 c)	0.7	0.7	33.3	0.5	23.8
17:0	1.3	1.3	33.3	1.0	25.6
18:0	19.1	18.9	33.0	15.4	26.9
18:1 (9 t)	0.9	0.7	25.0	0.2	14.3
18:1 (9 c)	19.1	20.0	34.9	23.1	40.3
18:2 (9, 12 c)	26.3	27.9	35.4	33.9	43.0
18:3 (9,12,15c)	3.3	3.3	33.3	2.9	29.3

[a] sn-1,3 = [3 TAG total – (sn-2)] : 2

Table 7: Fatty acids composition (TAG total) and distribution between the (sn-2) and (sn-1, 3)[a] positions for triacylglycerols obtained from the mixture of soybean oil (50%) and olein (50%) after enzymatic interesterification.

Fatty acid	TAG total [%]	Interesterified / Novozym 435		Interesterified / Lipozyme IM	
		% in sn-2	% of a given fatty acid in sn-2	% in sn-2	% of a given fatty acid in sn-2
14:0	1.6	1.8	37.5	2.1	43.8
16:0	18.7	16.5	29.4	11.2	20.0
16:1 (9 c)	1.3	1.3	33.3	1.5	38.5
17:0	0.9	0.7	25.9	0.5	18.5
18:0	11.7	10.7	30.5	7.3	20.8
18:1 (9 t)	1.1	0.9	27.3	0.7	21.2
18:1 (9 c)	28.9	30.4	35.1	33.7	38.9
18:2 (9, 12 c)	26.9	29.2	36.2	34.9	43.2
18:3 (9,12,15c)	3.6	3.6	33.3	4.1	38.0

[a] sn-1,3 = [3 TAG total - (sn-2)] : 2

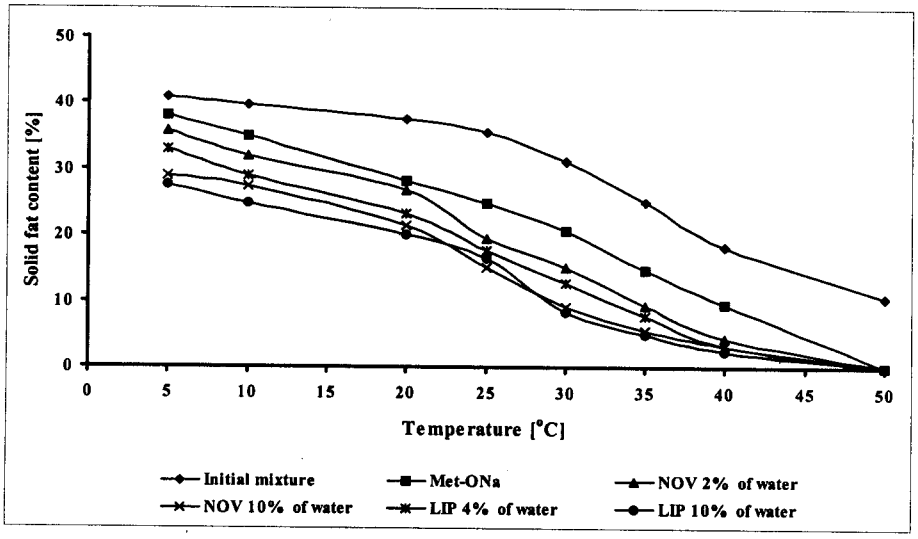

Fig. 1: The solid fat content (SFC) versus temperature for the initial mixture consisted of 50% soybean oil and 50 % stearin and for TAGs isolated from fats after interesterifications catalyzed by sodium metoxide (Met-ONa),Novozyme 435 (NOV) and Lipozyme IM (LIP).

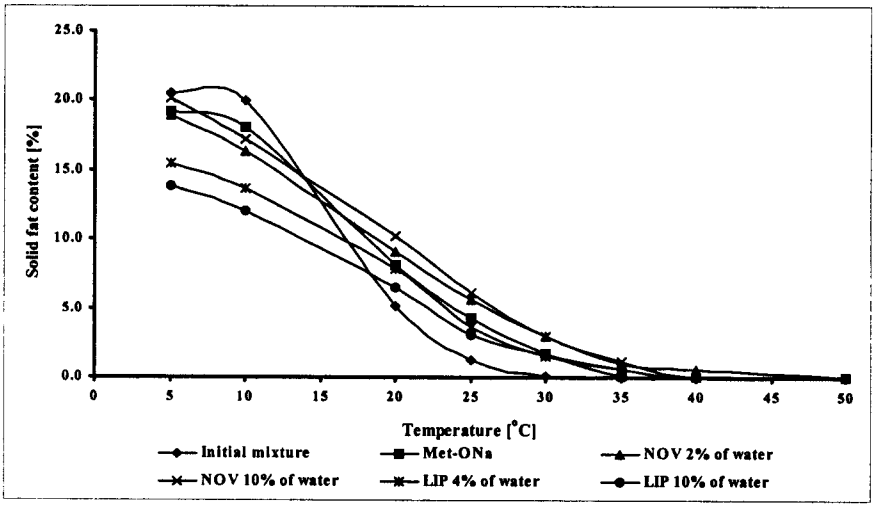

Fig. 2: The solid fat content (SFC) versus temperature for the initial mixture consisted of 50% soybean oil and 50 % olein and for TAGs isolated from fats after interesterifications catalyzed by sodium metoxide (Met-ONa), Novozyme 435 (NOV) and Lipozyme IM (LIP).

containing 50 % of beef tallow fractions and 50 % of soybean oil are illustrated in Fig.s 1 and 2.
Beef tallow stearin and olein contained 1.9% and 2.4% of C18:1trans isomer, respectively. Blending with soybean oil reduced its concentration. After interesterification the content of trans C18:1 isomer retained on the same level as for initial blends, independent on the catalyst used. The results obtained in this work showed that interesterifications of blends containing soybean oil and stearin or olein produce new fats that when purified are suitable for use in various applications, thus widening the utilization of beef tallow. The components of blends are available, and there is a need to utilize of beef tallow so interesterification of its fraction can be introduced into practice.

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