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Impact of technology and storage on fatty acids profile in dairy products

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Abstract

In the present study fatty acid (FA) composition in four main groups of dairy products was determined to investigate their development during processing and storage. Fresh cheese, sour cream, butter, and ultra-high temperature (UHT) milk representing differences in technological approach were chosen for the study. Fatty acids methyl esters (FAME) were quantified using a gas chromatograph (GC) equipped with a mass spectrometer (MS) and a capillary column SP-2560. The concentrations and profile of FA in final products were primarily dependent on the FA content of raw milk for UHT milk and fresh cheese production or in the raw cream for sour cream and butter. The shelf life had a significant impact ($P<0.05$) only in UHT milk and butter, whereby unsaturated fatty acids (UFA) and polyunsaturated fatty acids (PUFA) decreased significantly in UHT milk, while PUFA decreased significantly in butter.

Key words: **milk, fatty acids, dairy products, processing, storage**

Introduction

The range of dairy products is constantly expanding and the internal markets are overloaded, so manufacturers are looking for new markets for their products. As a result, the problem of product compliance with the increasing quality requirements for imported products is highlighted. This is especially true for the composition/ratio of milk fat in dairy products. Some non-EU countries, which are an important export market for EU dairy producers, formally regulate the limits of individual FA's in various imported dairy produce with non-compliance resulting in returned shipments. Non-compliance of dairy products in the FA profile with the standards of the export country may be influenced by quite a number of already known intrinsic factors such as stage of lactation, pregnancy (Samková et al., 2012), breed or genotype (Hanuš et al., 2016), or extrinsic factors like nutrition, season (Ozcan et al., 2015), dairy production system (Morales et al., 2015), feeding ration (Ferlay et al., 2006). All of previously listed factors can vary greatly among the countries, therefore, the same product produced in a different country can vary in composition. Furthermore, the impact of dairy processing technological stages such as heat treatment, homogenization, fermentation, churning, and storage on FA profile should be also considered. The research done in this area is either scarce or scattered. The influence

of high temperatures on milk has been studied, but the results vary widely among the studies. Some of them present an increase of SCFA, MCFA, and decrease of LCFA after pasteurization and boiling (Khan et al., 2017), others point at a decrease of SCFA (Pestana et al., 2015) or of all FA concentration during the UHT treatment (Ajmal et al., 2018). The results from previous studies on the milk and cream fermentation also vary (Gerchev and Mihaylova, 2012; Gassem et al., 2016; Jia et al., 2016) and were influenced by the chosen bacterial culture and the origin of the raw material.

The dynamics of dairy FA during the technological process are still unclear due to intermediate stages of each technological process being bypassed in all previous studies. No studies were done so far to estimate the FA profile in samples taken directly from the dairy production line. In none of them dairy by-products such as whey and buttermilk were analysed along with the final products (cheese and butter, respectively) as well as the end of shelf life impact of FA profile. For dairy processors exporting dairy products to countries where FA levels are regulated, to track any loss of FA or change in their quantity and ratio during the production is particularly relevant. Therefore, the aim of this study was to analyse the extent of FA transfer from milk fat to the fat of dairy product through the main processing stages and examine the effect of storage on FA content in selected dairy products – UHT milk, sour cream, fresh cheese, and butter.

Materials and methods

Samples and reagents

To analyse the impact of technological process on the FA profile several dairy products such as ultra-high temperature (UHT) milk (fat content 2.5 g 100 g^{-1}), fresh cheese (fat content 9 g 100 g^{-1}), sour cream (fat content 25 g 100 g^{-1}) and butter (fat content 82 g 100 g^{-1}), representing differences in technological approach were chosen for the study.

All dairy products for this experiment were produced and collected at one of the largest dairy processing companies in Lithuania during the summer (June - August) in 2018. Each sample was taken and analyzed in triplicate. The sampling scheme is given in Table 1.

The products were manufactured according to standard methods (Walstra, 1999). Production flow charts are presented in Figure 1.

TABLE 1. Sampling points at the main stages of the technological process and at the end of shelf life

Product	Sampling points					Conditions of storage	Evaluated effect of processing
UHT milk	raw milk	separated cream	standardized and pasteurized milk	UHT milk	end of shelf-life	180 days in ambient temperature	separation; pasteurization; UHT treatment
Sour cream	raw cream	standardized and pasteurized cream	sour cream	-	end of shelf-life	25 days in 5 °C	pasteurization; fermentation
Butter	raw cream	standardized and pasteurized cream	butter	buttermilk	end of shelf-life	90 days in 5 °C	pasteurization; churning; by-product
Fresh cheese	raw milk	standardized and pasteurized milk	fresh cheese	whey	end of shelf-life	25 days in 5 °C	pasteurization; fermentation; by-product

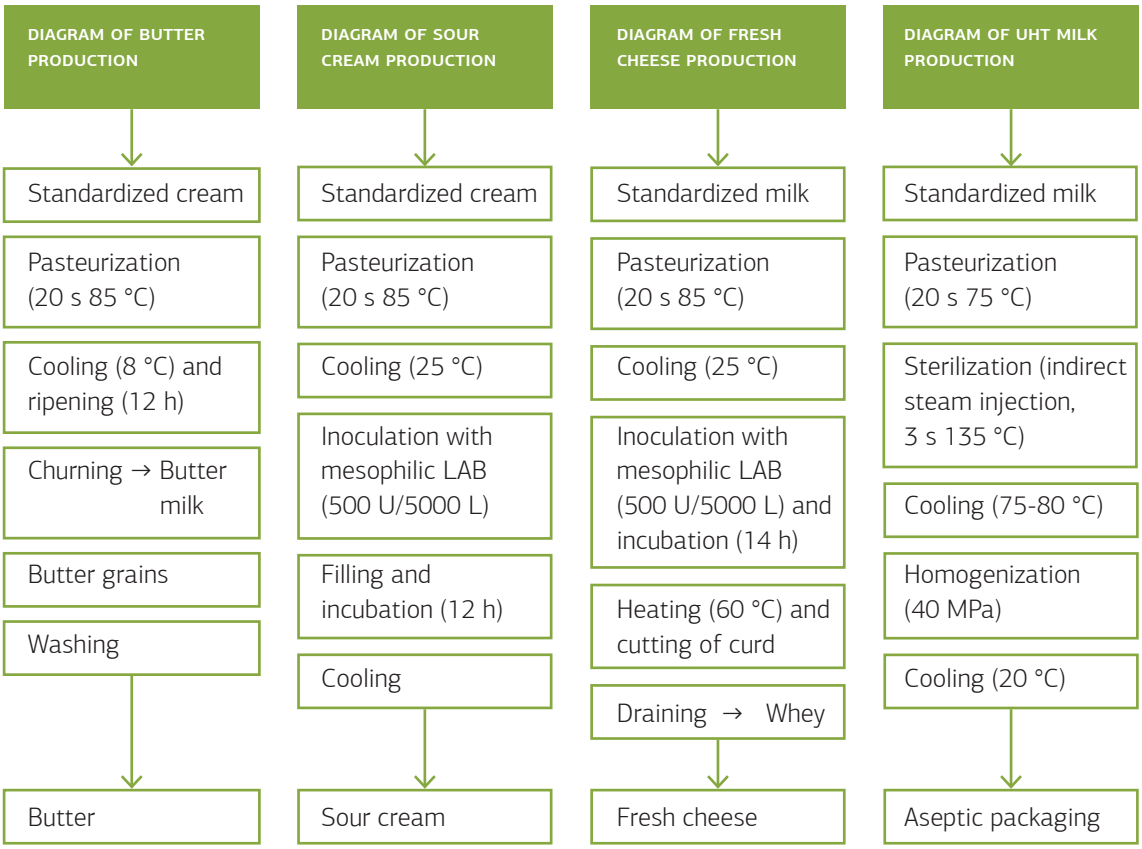

FIGURE 1. Production flow charts.

All chemical reagents and FAME standards for GC analysis were purchased from Sigma-Aldrich (Merck, KGaA, Darmstadt, Germany).

Lipid extraction

The lipid separation from liquid samples was done by double centrifugation. Depending on the fat content of the sample, 20 mL of cream/soured cream, 40 mL of raw milk, 80 mL of standardized/UHT milk, and 320 mL of whey/buttermilk sample were poured into 50 mL conical tubes and centrifuged for 30 min at 12.000 rpm at 4 °C (Thermo Scientific, Heraeus Multifuge X1R Centrifuge). The settled fat layer at the top of the tube was collected and transferred into 1.5 mL tubes (Eppendorf) for further fat separation (20 min 13.000 rpm, 20 min, 20 °C) by microcentrifuge (Eppendorf Centrifuge 5418). The concentrated fat was collected and directed for FAME preparation (Feng et al., 2004).

The lipids from curd were extracted using hexane: 10 g of sample was dispersed in 15 mL hexane using a homogenizer (IKA T25 digital ULTRA TURAX) for 3 min, shaken mechanically and then centrifuged at 5000 rpm for 20 min. The upper solvent was removed and the sediment extracted again twice. The solvents with dissolved fats were combined and evaporated with a rotary evaporator (IKA, RV 10 basic) under vacuum (GOST 32915 2014). After evaporation fat was collected and directed for FAME preparation.

Preparation of fatty acid methyl esters

The FA were converted into fatty acid methyl esters (FAME). 60 mg of concentrated fat was mixed with 4 mL of hexane and 200 µL of 2 mol L^{-1} KOH in methanol, then intensively vortexed for 1 min and after 10 min of resting, the top layer was collected and filtered into chromatography vial (Ficarra et al., 2010).

Gas chromatography (GC) analysis

FAME were quantified using a GC Clarus 680 (Perkin Elmer) equipped with a mass spectrome-

ter (MS) and a capillary column SP-2560, 100 m x 0.25 mm id x 0.20 µm. Conditions for chromatographic analysis were as following: the injector and detector temperatures were maintained at 230 °C. Injection volume was 1 µL, a split ratio of 1:19. Oven temperature was held at 100 °C for 4 min, increased to 240 °C (4 °C min^{-1}) and held for 30 min (total analysis time 70 min). Carrier gas (He) flow rate was 1 mL min^{-1}. FA peaks were identified using Supelco® 37 Component FAME Mix. Each FA were expressed in g 100 g^{-1} of total FAME content. FA was divided into four main groups depending on the number of carbon atoms: short-chain fatty acids (SCFA; C4-C6), medium-chain fatty acids (MCFA; C8-C15) and long-chain fatty acids (LCFA; C16 and more; Yilmaz-Ersan, 2013); and in four main groups depending on the presence and the number of double or triple bonds: saturated fatty acids (SFA), unsaturated fatty acids (UFA), monounsaturated fatty acids (MUFA) and polyunsaturated fatty acids (PUFA).

Statistical analysis

Statistical analysis was performed by SPSS statistical package (Chicago, SPSS Inc., SPSS 17). The data were analyzed using Descriptive Statistics (Explore) and Analysis of Variance (ANOVA) methods. The significance of interactions among the groups assessed was determined by the Tukey HSD test. The differences were considered significant at $P<0.05$.

Results and discussion

Fresh cheese

To make fresh cheese raw milk was standardized, pasteurized, cooled and inoculated with mesophilic LAB (*Lactococcus lactis* subsp. *cremoris,* subsp. *lactis,* subsp. *lactis biovar diacetylactis* and *Leuconostoc* subsp.). Curd body was heated to 60 °C and sliced/mixed to separate the whey after 14 h fermentation. Processing of raw milk into fresh cheese and storage at 5 °C for 25 days, did not have a significant effect on the content of FA (Fig. 1).

The FA profile in whey remained similar to that of raw milk and fresh cheese. Nudda et al. (2005) did not find significant differences in FA profile between raw sheep milk and fresh cheese/ricotta fats either. The author state that concentrations of FA in fresh cheeses fat were primarily dependent on the FA content of the raw milk that is following findings of this study. High cooking temperature (up to 60 °C) traditionally applied in Lithuanian fresh cheese (quark) production does not leave many chances for mesophilic starter strains to survive. Prandini et al. (2009) stated the same findings - neither the LAB added to the milk, nor processing technology and ripening did influence the SFA, MUFA, PUFA and CLA content in dairy products during the production of Grana Padano cheese. Surprisingly, in the production of ripened cheese with lipolytic starter strains and molds technologically cultivated, lower pH, lower water activity and presence of the other FA are discussed as possible factors inhibiting the lipase activity (Bisig et al., 2007).

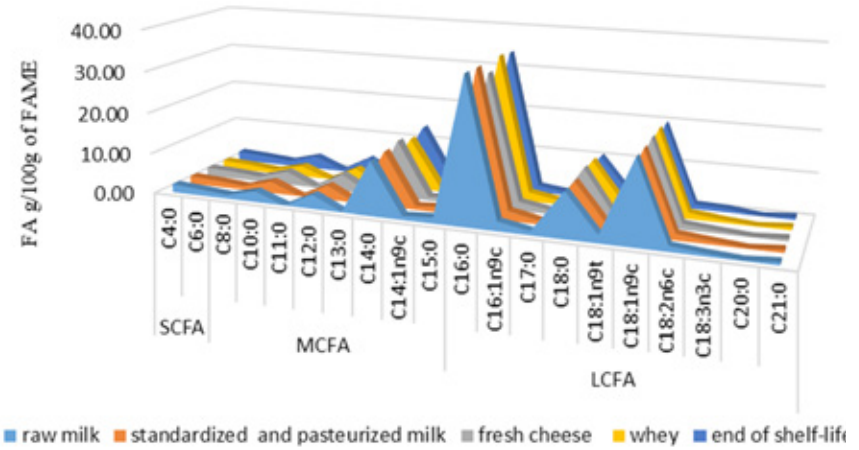

FIGURE 2. The profile and distribution of FA of different fresh cheese production stages

Sour cream

Raw cream was standardized, homogenized, pasteurized and inoculated with a mesophilic starter culture (*Lactobacillus lactis* subsp. *cremoris*, subsp. *lactis*, subsp. *lactis biovar diacetylactis* and *Leuconostoc* subsp.) during sour cream production. The fermentation lasted until the acidity of the cream reached pH 4.5-4.6. The profile of individual FA did not change during sour cream processing and storage at 5 °C for 25 days (Fig.2).

This comes in agreement with other findings - no pasteurization effect on milk fat profile (Pestana et al., 2015; Santos, 2012), no homogenization effect on cream (Pirisi et al., 2007) or milk (Michalski and Januel, 2006) FA profiles were found.

Meanwhile, data from previous studies on milk and cream fermentation are rather controversial. Usually, changes in FA content during milk fermentation and storage are related to the bacterial enzyme lipase that catalyzes the triglycerols to release free fatty acids (FFA) and glycerol (Santos, 2012). However, not all LAB strains have lipolytic activity (Dinçer and Kıvanç, 2018). Bettache and Fatma (2012) found that only two from 76 LAB isolates (from 4 genera *Lactobacillus, Lactococcus, Leuconostoc*, and *Enterococcus*) were lipolytic: *Lactobacillus delbrueckii* subsp. *delbrueckii* and *Lactobacillus delbrueckii* subsp. *bulgaricus*. A previous survey with milk fermentation using thermophilic LAB (*Lactobacillus bulgaricus*, *Lactobacillus lactis*, and *Streptococcus thermophilus*) have been reported an increase of MCFA and LCFA (except C16:1, C20:0) in fermented camel milk (Gassem et al., 2016). Buffalo milk fermentation with *Lactobacillus acidophilus* and *Lactobacillus lactis* showed an increase in SCFA and MCFA (except C14:0) (Yadav et al., 2007). Sheep milk fermentation with thermophilic LAB (*Lactobacillus delbrueckii* subsp. *bulgaricus* and *Streptococcus thermophilus*) did not reveal a change in the FA profile (Gerchev and Mihaylova, 2019). Yilmaz-Ersan (2013) observed that cream fermentation with probiotic mesophilic bacteria *Bifidobacterium lactis* was associated with increases of LCFA and cream fermentation with *Lactobacillus acidophilus* showed an increase of MCFA. Apparently the storage time in combination with thermophilic LAB could increase the content of SFA in yogurt, however showing no impact on sheep yogurt SFA content (Serafeimidou et al., 2013).

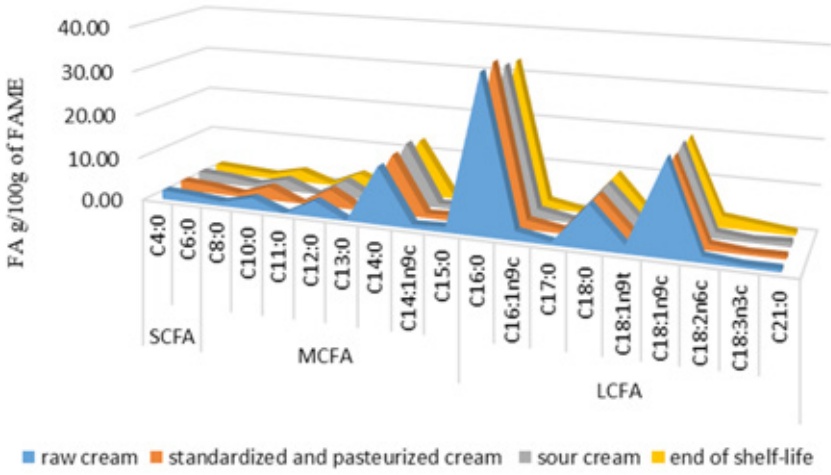

FIGURE 3. The profile and distribution of FA of different sour cream production stages

The reported results are pointing at the importance of LAB strains used for fermentation, and probiotic strains, in particular, contributing to significant changes in FA distribution.

UHT milk

The UHT milk was chosen for this study to assess the high-temperature effect on FA profile. At UHT treatment stage, the standardized milk is first preheated to a noncritical temperature (70-80 °C), and then quickly heated to the temperature required by the process. In heat treatment processes, various time/temperature combinations can be applied, depending on the product properties and

shelf-life requirements and this why time/temperature varies among factories and countries. Typically, temperature-time conditions for UHT treatment of milk are 130-150 °C for 1-3 sec (Manners and Craven, 2003). In our case, standardized and pasteurized milk was indirectly heated by steam for 3 sec at 135 °C.

The percentage of individual FA and their groups at the main technological stages of UHT milk processing are shown in Table 2.

TABLE 2. The profile and distribution of individual FA and their groups at the main technological stages during UHT milk processing

FA (g 100g^{-1} of FAME)	Raw milk		Separated cream		Standardized and pasteurized milk		UHT milk		End of shelf life	
	Mean	±SEM	Mean	±SEM	Mean	±SEM	Mean	±SEM	Mean	±SEM
C4:0	1.52	0.15	1.89	0.15	1.80	0.19	2.41	0.37	1.95	0.19
C6:0	1.29	0.02	1.57	0.01	1.34	0.18	1.54	0.13	1.71	0.20
∑SCFA	2.81	0.13	3.47	0.16	3.14	0.37	3.95	0.51	3.66	0.39
C8:0	0.98	0.04	1.24	0.15	0.86	0.10	0.92	0.01	1.18	0.20
C10:0	2.77	0.09	2.76	0.13	2.62	0.08	2.82	0.20	3.25	0.31
C11:0	nd	-	nd	-	nd	-	nd	-	0.11	0.05
C12:0	3.06	0.06	3.76	0.31	3.31	0.03	3.65	0.44	4.03	0.47
C13:0	nd	-	nd	-	nd	-	nd	-	0.08	0.03
C14:0	10.95	0.58	12.89	0.61	12.52	0.80	12.09	0.90	13.75	0.42
C14:1n9c	1.16	0.04	1.19	0.15	1.03	0.14	1.03	0.06	1.11	0.07
C15:0	1.75	0.18	1.39	0.00	1.47	0.09	1.57	0.11	1.48	0.05
∑MCFA	20.67	0.56	23.22	1.34	21.79	1.02	22.08	1.72	24.98	1.42
C16:0	32.99	0.36	33.63	0.35	35.06	0.90	34.23	0.03	34.72	0.08
C16:1n9c	1.59	0.32	2.60	0.03	2.48	0.14	2.10	0.39	2.10	0.27
C17:0	1.06	0.01	1.05	0.19	1.12	0.04	0.85	0.01	0.99	0.07
C18:0	10.97	0.57	11.20	0.65	11.54	0.77	10.84	0.12	10.02	0.39
C18:1n9t	2.36	0.40	2.13	0.12	2.14	0.31	2.28	0.09	1.73	0.11
C18:1n9c	21.54	0.92	19.27	1.60	19.36	1.05	19.59	1.03	17.18	0.01
C18:2n6c	1.96	0.17	1.54	0.02	1.58	0.16	1.96	0.42	1.42	0.20
C18:3n3c	1.75^{a}	0.31	0.87^{a}	0.07	0.80^{a}	0.01	0.87^{a}	0.02	0.70^{b}	0.03
C21:0	2.30	0.27	1.02	0.04	0.99	0.20	1.24	0.19	2.48	1.79
∑LCFA	76.52	0.42	73.31	1.50	75.07	1.39	73.96	1.22	71.36	1.80
∑SFA	69.65^{a}	1.03	72.41^{a}	1.19	72.62^{a}	1.23	72.17^{a}	1.11	75.76^{b}	0.44
∑UFA	30.35^{a}	1.03	27.59^{a}	1.20	27.38^{a}	1.23	27.83^{a}	1.11	24.24^{b}	0.46
∑MUFA	26.64	1.30	25.19	1.29	25.00	1.07	25.00	0.68	22.12	1.23
∑PUFA	3.71^{a}	0.37	2.41^{a}	0.19	2.38^{a}	0.15	2.83^{a}	0.43	2.12^{b}	0.13

Means denoted in rows by different letters indicate statistically significant differences ($P<0.05$); SCFA - short chain fatty acids; MCFA - medium chain fatty acids; LCFA - long chain fatty acids; SFA - saturated fatty acids, UFA - unsaturated fatty acids; MUFA - monounsaturated fatty acids; PUFA - polyunsaturated fatty acids

Data of this study showed a slight change in the amount of certain FA but no individual FA losses were detected during the production of UHT milk. The amounts of SCFA and MCFA (except C8:0, C14:1n9c, C15:0) showed a tendency to increase, while LCFA (except C16:0, C16:1n9c, C18:2n6c) slightly decreased after the high-temperature treatment. However, the significance of these changes has not been statistically confirmed. Meanwhile, Khan et al. (2017) estimated a significant increase of SCFA and MCFA, and decrease of LCFA after pasteurization and boiling (1 min) in cow and buffalo milk. Unlike us, some authors referred to the significant decrease of SCFA, MCFA, and LCFA (Ajmal et al., 2018) due to UHT treatment but it's not clear what temperature modes were used in this study. Pestana et al. (2015) stated that raw, pasteurized (75 °C for 15 sec) and UHT (140 °C for 3 sec) milk had very similar fatty acid profiles. A significant decrease was found only for C4:0, C6:0, C8:0 and C:20 which indicated pasteurization and sterilization of milk had a little effect on FA profile (Pestana et al., 2015). Our results revealed no significant effect of temperature treatment on FA profile of UHT milk or other dairy product (fresh cheese, sour cream) analysed in this study. Concentrations of FA in UHT milk fat were primarily dependent on FA content of raw milk.

The storage period in ambient temperature for 180 days had a significant impact on FA content in UHT milk: UFA, PUFA and C18:3n3c significantly decreased in UHT milk fat while SFA showed the opposite tendency ($P<0.05$) at the end shelf-life. Ajmal et al. (2018) revealed a negative effect of 90 days storage on UHT milk FA profile: SFA and UFA decreased at the end of storage. According to the authors, heat, moisture, metal ions and bacterial lipases that survive the orthodox UHT treatment cleave the bonds between the fatty acids and glycerol, leading to the formation of free fatty acids in milk.

Butter

The European-style unsalted 82 % fat butter was chosen for our study. Processing of raw sweet (uncultured) cream into butter did not have a significant effect on the content of FA.

Despite the fat loss (0.5 %) with buttermilk during butter processing, the FA ratio in buttermilk remained similar to that of raw cream and butter. However, the storage at 5°C for 90 days significantly decreased PUFA and C18:2n6c content (Table 3).

TABLE 3. The profile and distribution of individual FA and their groups at the main technological stages during butter processing.

FA (g/100g of FAME)	raw cream		standardized and pasteurized cream		butter milk		butter		end of shelf-life	
	Mean	±SEM	Mean	±SEM	Mean	±SEM	Mean	±SEM	Mean	±SEM
C4:0	1.95	0.01	3.21	1.24	1.72	0.05	1.68	0.05	1.71	0.44
C6:0	0.96	0.63	1.31	0.26	1.30	0.12	1.39	0.07	1.94	0.70
∑SCFA	2.91	0.74	4.52	1.00	3.02	0.11	3.08	0.11	3.64	0.47
C8:0	1.21	0.11	0.83	0.27	0.80	0.21	0.86	0.12	1.54	0.38
C10:0	2.75	0.15	2.38	0.35	2.38	0.40	2.35	0.26	3.04	0.24
C11:0	0.36	0.07	0.16	0.07	0.10	0.08	0.15	0.07	0.17	0.09
C12:0	3.69	0.27	2.65	0.82	3.24	0.31	3.30	0.21	3.82	0.26
C13:0	0.65	0.36	0.10	0.05	0.15	0.07	0.12	0.05	0.11	0.04
C14:0	13.19	0.70	12.47	0.69	13.21	0.14	12.54	0.56	13.43	0.55
C14:1n9c	1.48	0.15	1.09	0.20	1.20	0.08	1.05	0.12	1.18	0.11
C15:0	1.71	0.32	1.39	0.07	1.43	0.04	1.35	0.10	1.42	0.09
∑MCFA	25.67	0.61	21.08	2.14	22.51	0.93	21.72	1.43	24.73	1.32
C16:0	32.80	0.26	34.30	0.81	35.20	0.27	36.23	0.53	33.22	1.06

FA (g/100g of FAME)	raw cream		standardized and pasteurized cream		butter milk		butter		end of shelf-life	
	Mean	±SEM	Mean	±SEM	Mean	±SEM	Mean	±SEM	Mean	±SEM
C16:1n9c	1.97	0.14	1.91	0.19	2.15	0.10	2.01	0.10	1.98	0.16
C17:0	0.46	0.39	1.02	0.11	1.01	0.09	0.88	0.02	0.93	0.05
C18:0	9.76	0.32	10.73	0.71	10.02	0.32	10.73	0.76	10.78	0.44
C18:1n9t	0.66	0.31	1.58	0.15	1.62	0.26	1.34	0.06	1.49	0.05
C18:1n9c	21.75	1.13	21.76	1.33	20.65	0.47	20.87	1.08	20.13	1.75
C18:2n6c	2.54[a]	0.28	1.90[a]	0.18	1.87[a]	0.21	1.68[a]	0.23	1.58[b]	0.09
C18:3n3c	0.73	0.18	0.59	0.13	0.71	0.13	0.66	0.03	0.75	0.05
C20:0	0.11	0.01	0.16	0.05	0.13	0.06	0.20	0.07	0.17	0.06
C21:0	0.63	0.20	0.45	0.15	1.11	0.34	0.60	0.04	0.58	0.01
∑LCFA	71.42	1.36	74.40	2.01	74.47	1.01	75.20	1.55	71.63	1.30
∑SFA	70.86	0.73	71.17	1.47	71.82	0.54	72.38	1.07	72.88	1.71
∑UFA	29.14	0.71	28.83	1.45	28.18	0.64	27.62	1.06	27.12	1.68
∑MUFA	25.87	0.65	26.34	1.46	25.61	0.68	25.28	1.11	24.78	1.81
∑PUFA	3.27[a]	0.38	2.49[a]	0.26	2.57[a]	0.20	2.35[a]	0.36	2.34[b]	0.02

Means denoted in rows by different letters indicate statistically significant differences (P<0.05); SCFA - short chain fatty acids; MCFA - medium chain fatty acids; LCFA - long chain fatty acids; SFA - saturated fatty acids, UFA - unsaturated fatty acids; MUFA - monounsaturated fatty acids; PUFA - polyunsaturated fatty acids

Findings presented by Bisig et al. (2007) are similar to the data obtained in this study: butter-making process had no significant influence on the conjugated linoleic acid (CLA) and FA content of cream processed into butter. Similarly to our findings, Silva-Kazama et al. (2010) confirmed the effect of butter storage and pointed out that the relative percentage of SFA and MCFA increased due to the oxidation (decrease) of UFA. Usually, the lipid oxidation involves UFA, especially PUFA, because the hydrogen atoms on the methylene groups in UFA are much easier to disassociate than in SFA (O'Connor and O'Brien, 2006). Lipolysis is limited since the membrane protects milk fat. Churning was the main stage in the butter-making process that destroyed fat globules membranes. Antioxidants naturally present in raw buttercream (enzymes, vitamin C and lactoferrin) are either destroyed by pasteurization or separated since antioxidative caseins are removed with buttermilk (Lindmark-Månsson and Akesson, 2000). According to this, butter seems to be the most favorable environment for lipolysis, but in our study, a significant decrease was observed only for PUFA.

In this study, the storage had an impact only on butter and UHT milk fats. The main differences between products in this study were the storage period (relatively short 25 day period for sour cream and fresh cheese and, 90 and 180 day period for butter and UHT milk, respectively) and the technological aspect (fermentation for sour cream and fresh cheese and ultra-high temperature and churning for UHT milk and butter, respectively). Lipolysis in raw milk is largely due to the indigenous enzyme lipoprotein lipase (LPL). Since all products have passed the pasteurization, the LPL, which is sensitive to higher temperatures, was inactivated. Some spores of gram-positive psychrotrophic bacteria and especially enzymes of psychrotrophic bacteria can survive raw milk pasteurization and UHT treatment and can be related to flavors defects pronounced in cream, butter, cheese and UHT milk (Samaržija et al., 2012). The optimal growth temperature for these cold-tolerant strains is 15 - 20°C, but they can also grow and multiply at low temperatures through as well (Moyer and Morita, 2007). We can speculate that FA changes in UHT milk and butter during storage were influenced by psychrotrophic bacterial lipases. Meanwhile, these microorganisms and their lipases could not function in the fermented products due to the acidic environment.

Conclusions

This study showed that various technological treatments such as pasteurization at various temperatures, fermentation, and the churning process had no significant influence on FA composition and percentage at various stages of UHT milk, sour cream, fresh cheese, and butter production. No loss of individual FA was observed in any of the final products during the technological process. The observed variability in FA content of processed dairy products has been attributed to the variability in the FA content of raw milk.

Having that in mind, the raw milk has to be carefully selected by the producer to ensure the compliance of FA content to standard requirements before and during launching them to the export markets. As an outcome of this study, a prototype software was created and installed at the Lithuanian accredited central milk-testing laboratory to equip dairy producers with the raw milk screening tool according to the standard FA composition of their choice.

The shelf-life period had an impact only on UHT milk and butter fats. Antioxidative additives and proper shelf life duration/ conditions combination might help to protect fats of these products from oxidation thus resulting in no or lesser FA profile changes.

Utjecaj tehnološkog postupka i skladištenja na profil masnih kiselina u mliječnim proizvodima

Sažetak

U ovom je radu u četiri glavne vrste mliječnih proizvoda utvrđivan sastav masnih kiselina (FA), kao i njihov udio tijekom prerade i čuvanja. Kako bi se utvrdio utjecaj tehnološkog postupka, za istraživanje su odabrani svježi sir, kiselo vrhnje, maslac i trajno mlijeko obrađeno režimom UHT toplinske obrade. Metilni esteri masnih kiselina (FAME) određeni su pomoću plinskog kromatografa (GC) opremljenog masenim detektorom (MS) i kapilarnom kolonom SP-2560. Koncentracije i profil FA u krajnjim proizvodima su prije svega ovisili o koncentraciji FA u sirovom mlijeku prije UHT obrade mlijeka ili proizvodnje svježeg sira, odnosno o udjelima FA u svježem siru i sirovom vrhnju. Rok trajanja imao je značajan utjecaj ($P<0,05$) samo u UHT obrađenom mlijeku i u maslacu gdje je utvrđen pad koncentracije nezasićenih (UFA - samo mlijeko) i višestrukonezasićenih (PUFA - mlijeko i maslac) masnih kiselina.

Ključne riječi: **mlijeko, masne kiseline, mliječni proizvodi, prerada, skladištenje**

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