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CHANGES IN FATTY ACID COMPOSITION OF DIFFERENT MILK PRODUCTS CAUSED BY DIFFERENT TECHNOLOGY

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SUMMARY

The fatty acid composition of cow's milk with fat contents of 3.6%, Dalia cheese with fat contents of 44%, butter with fat contents of 80% and margarine with fat contents of 24% was determined after a heat treatment performed on cooking plate and microwave treatment, respectively of different durations. The biggest difference was obtained for oleic acid and elaidic acid since, with the exception of the margarine, in each case proportion of the cis-configurated oleic acid decreased while that of the trans-configurated elaidic acid increased. For all of the other fatty acids in the foodstuffs examined no such differences were obtained regarding change in fatty acid composition whose differences could influence healthy nutrition to considerable extent. Therefore we can take it as a fact that neither heat treatment performed on a traditional cooking plate nor microwave treatment affects considerably the composition of food fats.

Key-words: milk, cheese, butter, margarine, fatty acid composition, cis-trans isomers, microwave

INTRODUCTION

Role of fats and that of fatty acids, they are composed of, in the human nutrition is well-known. Fats contained in foodstuffs provide substantial amount of energy for the human organism, and the essential and semi-essential fatty acids are – as the human organism cannot produce them – indispensible to the human organism. Recently, there have been many discussions about trans fatty acids. Some experts considered their harmful effects to be proven, while others could not report on such negative effects. Some thought that trans fatty acids increased fragility of red blood cells, changed the aggregation of thrombocytes (Ascherio, 1994; Ascherio et al., 1999; Ascherio, 2002), and showed their negative effects on the metabolism of linolenic acid and arachidonic acid (Larque et al., 2000). It was established that they caused lack of essential fatty acids (Kummerow et al., 2004), inhibited synthesis of prostaglandin (Kushi and Giovanucci, 2002) and increased the risk of certain cancers. Lately it has been reported that incorporation of trans fatty acids into the phospholipids of the membranes affected its properties and mainly the activity of enzymes attached to the membrane. In fact, recently a positive relation has been established between allergic diseases and trans fatty acid consumption (Kritchevsky, 1997; Stender and Dyerberg, 2004).

Cis–trans transformations can take place due to several technological interventions, as well. The most important such operation is partial hydrogenation as a result of which a part of cis-configurated bonds transforms into trans configuration. By appropriate choosing of technological parameters it can be achieved that this transformation is possibly the slightest and that the products contain trans isomers in minimal quantity. Heating of fats can also cause isomerization, cooking in oils can result in appearance of multiple unsaturated trans fatty acids, and heat treatment of fats can produce trans fatty acids and even also a cyclic fatty acid derivatives (Hansen and Leth, 2000).

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It was reported that fatty acids can convert as a result of microwave treatment, as well. For soya bean, after being microwave-treated for 12 min transformation and decomposition of great volume of fatty acids was experienced. Compared changes in fatty acid composition during food making procedures with the effect of microwave treatment some experts have come to the conclusion that considerable changes could be expected during such treatment and they suggested choosing other kind of procedure instead of microwave treatment for warming up foods (Sachiko and Hiromi, 2002).
Because of the above, mentioned during present research we aimed at analysing changes of fatty acid composition of milk and foodstuffs with high fat contents (cheese, butter, margarine) as the effect of traditional heat treatment and microwave treatment. We paid special attention to the cis-configurated oleic acid and trans-configurated elaidic acid formed from the former by isomerization.

MATERIAL AND METHODS

Samples examined

Milk sample with fat contents of 3.6% was obtained from a seven year old Simenthal cow, fed mainly hay and minimal feed supplementation, and it was producing in the 2. month of lactation. Sample was taken from the mixed milk of the completely milked-out udder. Other components of the milk corresponded to the values characteristic for normal cow's milk in every respect.
In case of the cheese examined was a commercially obtainable cheese with the trade name of Dalia, being semi-hard, coagulated with rennet, pressed, formed in brine of 10%, then matured over 2 weeks at 13–14 °C. Its dry matter content was 55% and fat content referred to dry matter content was 44%. The other cheese used in our experiment was commercially obtainable under the trade name of Telemea, a type of feta cheese, fermented with *Lactobacillus acidophilus,* coagulated with enzymatic rennet, pressed, sliced and matured over 2 days. Dry matter content of this cheese was 55% and its fat content referred to dry matter was 44%.
The butter we used was a commercially obtainable butter of trade name Alpenbutter. The margarine examined was of a Holland-24 type, commercially obtainable margarine.

Heat treatment and microwave treatment

Heat treatment was carried out on a laboratory hot plate, for 2 and 8 min, respectively, after the boiling point was reached. For microwave treatment we applied a treatment over 1, 2, 4, and 8 min using a normal Electrolux EMN 2015 microwave oven at electrical power of 450 W. Subsequent to the heat treatment the samples were cooled down immediately and stored at –25 °C until prepared for analysis.

Determination of fatty acid composition

Sample preparation

A sample quantity containing approx. 0.5–1.0 g fat was destructed with 8–20 cm^3 of hydrochloric acid (37%) for 1 hour on hot water bath. After having cooled down, 7 cm^3 of ethanol was added. Lipids were extracted with 15 cm^3 diethylether and 15 cm^3 benzine (b.p.<60 °C), and the organic layers were combined. From a portion of this solution, containing approx. 150–200 mg fat, the solvents were removed under reduced pressure (a complete evaporation not necessary). To the residue 4 cm^3 of 0.5 M sodium hydroxide methanol solution was added and boiled until all the fat drops disappeared (approx. 5 min), then 4 cm^3 of 14% boron trifluoride methanol solution was added, boiled for 3 min, finally 4 cm^3 of hexane, dried on water-free sodium sulphate, was added and boiled for 1 min, and the mixture was allowed to cool down. Saturated aqueous sodium chloride solution was added and after having separated the organic layer was collected into a 4 cm^3 vial containing water-free sodium sulphate and was directly examined by gas chromatography.

Conditions of the gas chromatographic analysis

Instrument: Varian 3380 CP gas chromatograph. Column: 100 m·0.25 mm id, CP-Sil 88 (FAME) phase. Detector: FID 270 °C. Injector: splitter, 270 °C. Carrier gas: H_2, 235 kPa. Temperature program: 140 °C for 10 min; at 10 °C/min up to 235 °C; isotherm for 26 min. Injected volume: 1 μl.

RESULTS AND CONCLUSION

Change of fatty acid composition of milk as the effect of traditional heat treatment and microwave heat treatment

Change in fatty acid composition of raw milk for the control sample and for the samples heat treated for 2 and 8 min, on cooking plate and in microwave oven, respectively, is shown in Table 1.

Table 1. Change in fatty acid composition* as the effect of heat treatment performed on cooking plate and of microwave treatment, respectively

Fatty acid	Control	Microwave treatment		Cooking plate	
		2 min	8 min	2 min	8 min
Miristic acid, C14:0	11.45	11.62	11.35	11.05	10.94
Palmitic acid, C16:0	42.23	42.17	43.21	42.95	42.27
Stearic acid, C18:0	10.07	11.58	11.80	11.27	11.42
Linoleic acid, C18:2	1.38	1.32	1.31	1.36	1.30
Linolenic acid, C18:3	1.17	1.19	1.15	1.09	1.12

*In relative weight% of fatty acid methyl esters. Only fatty acids with concentrations higher than 9–10%, as well as linoleic acid and linolenic acid are shown. Oleic acid and elaidic acid are shown in Table 3

As it can be seen from the data of Table 1, the raw milk contains somewhat more fatty acid than the microwave-treated milk. No significant differences, however, could be found between the microwave treatments. Similarly, no significant differences could be found in palmitic acid and stearic acid contents. Fatty acids are mounting major part of the total fatty acid content. In the raw milk the milk fat contained 16.26% oleic acid and 1.53% elaidic acid; the cis configuration was 91.36% and the trans configuration was 8.64% of the total C18:1 fatty acids. After cooking for 2 min the proportion of the cis-configuration was reduced by 2%, and after cooking for 8 min it was reduced by 4%; the proportion of the trans configuration was increased as result of cooking (for 2–8 min) by around 15–20%. Similar changes could be observed due to microwave treatment: after a treatment of 2 min the proportion of the cis configuration was reduced by 2%, and after 8 min by nearly 10%, whereas the proportion of the trans configuration was increased by 10–15% after a treatment of 2 min, and by 40–50% after a treatment of 8 min. Hence, the conclusion can be drawn that heat treatment carried out for 2 and 8 min at 100 ºC, and microwave treatment performed for 2 and 8 min at 450 W reduce proportion of the cis-configurated oleic acid and increase proportion of the trans-configurated elaidic acid to a significant extent.

In case of the cheeses Dalia and Telemea, changes occured due to microwave treatment are summarized in Table 2, changes of oleic acid and elaidic acid contents of examined dairy products as an effect of traditional and microwave heating are summarized in Table 3.

Table 2. Changes of fatty acid composition* of cheeses Dalia and Telemea due to microwave treatment

Fatty acid	Dalia			Telemea		
	Control	2 min	8 min	Control	2 min	8 min
Miristic acid, C14:0	9.83	9.39	9.27	10.23	10.87	10.11
Palmitic acid, C16:0	29.24	28.99	30.33	30.79	31.77	32.14
Stearic acid, C18:0	14.41	14.66	15.45	13.13	13.42	13.85
Linoleic acid, C18:2	1.80	1.79	1.72	1.89	1.85	1.83
Linolenic acid, C18:3	1.50	1.42	1.40	1.08	1.06	1.04

*In relative weight % of the fatty acid methyl esters

For the cheese of Dalia-type with 44% fat content in the control sample not microwave-treated proportion of oleic acid was 83.84%, that of elaidic acid was 16.16% to the whole C18:1 fatty acids. As a result of microwave treatment of 2 min proportion of cis configuration was decreased by 1.5%, after treatment of 8 min it was decreased by 2%. During 2 min proportion of the trans configuration was increased by 8% and after 8 min by 9–10%. For all of the other fatty acids no significant changes were experienced owing to the microwave treatment, and composition of treated samples were

practically identical with that of the control sample. In case of the examined two cheese samples fatty acids behaved completely the same way towards microwave treatment.

Table 3. Changes of oleic acid and elaidic acid contents* of various dairy products due to conventional and microwave heat treatment, respectively

Sample examined		C18:1 fatty acid ratio	
		Oleic acid	Elaidic acid
Milk control		91.36	8.64
heat treatment	2 min	89.64	10.36
	8 min	87.18	12.82
microwave treatment	2 min	90.08	9.92
	8 min	84.11	15.89
Dalia control		83.84	16.16
microwave treatment	2 min	82.46	17.54
	8 min	82.21	17.79
Telemea control		84.73	15.27
microwave treatment	2 min	82.19	17.81
	8 min	81.47	18.53
Butter control		93.63	6.37
heat treatment	2 min	90.86	9.14
	8 min	90.49	9.51
microwave treatment	2 min	91.23	8.77
	8 min	90.63	9.37
Margarine control		14.36	85.64
heat treatment	2 min	14.23	85.77
	8 min	14.40	85.60
microwave treatment	2 min	14.29	85.71
	8 min	14.73	85.27

*Percentage of C18:1 fatty acids (total C18:1 fatty acid contents=100%).

Oleic acid content of the butter with fat content of 80% was 23.37%, elaidic acid content 3.62%, in percentage of total fatty acids. Within C18:1 fatty acids in untreated butter oleic acid was 86.58%, elaidic acid 13.42%. These proportions changed slightly for samples treated both on cooking plate at 215 °C and in microwave oven at 450 W. Increasing from 2 min to 8 min the duration of the treatment with a cooking plate of 215 °C proportion of oleic acid was decreased by 1%, and similar results are obtained when time of microwave treatment was increased from 2 to 8 min. Looking at the proportions for both treatment durations and both heat treatment methods decrease of oleic acid corresponds within the limits of error to the increase of elaidic acid. From our experiments we can draw the conclusion that, with increasing duration of the heating, in case of both experiment performed with cooking plate and that performed with microwave oven the quantity of cis-configurated oleic acid reduces whereas that of trans-configurated elaidic acid increases.

In case of margarine with 25% fat content the heat treatment and microwave treatment, respectively, do not affect concentration of cis and trans fatty acids. This contradicts our previous examinations, our experiences until now, and the literature as well. Since the cis configuration is substantially less stable than the trans, so after a heat treatment in principle quantity of fatty acids with cis configuration should be decreased and that of fatty acids with trans configuration should be increased. By the way, as a result of heat treatment, concentration of unsaturated fatty acids reduced due to various oxidative reactions and chain-crackings at the double bonds.

Summarized the effect of heat treatment and microwave treatment it can be said that, with the exception of oleic acid and elaidic acid, in case of various samples examined by us the differences in fatty acid composition are so slight that they do not indicate any harmful effect on either heat treatment or microwave treatment. For these fatty acids there is no difference in the effect of the duration of heat treatment and microwave treatment, either. No difference could be seen between the treatments with duration of 2 min and 8 min, respectively. The fact is that, for the examined

foodstuffs, time and energy combination used does not result in considerable deviation in the fatty acid composition. Thus, there is no need to be afraid that during microwave treatment any artificial product harmful to human beings would form or that biological value and utilization in the human organism of fat of foodstuff treated this way would reduce to significant extent.
In case of oleic acid and elaidic acid it was established that, by both heat treatment performed on a cooking plate and microwave treatment the proportion of the cis-configurated oleic acid decreased and that of the trans-configurated elaidic acid increased. This decrease and increase, respectively, do not reach, however, such an extent, which could affect the healthy nutrition.

REFERENCES

1. Ascherio, A., Katan, M.B., Stampfer, M. (1999): Trans fatty acids and coronary heart disease. N. Engl. J. Med., 340. 1994-1998.
2. Ascherio, A. (2002): Epidemiologic studies on dietary fats and coronary heart disease. Am. J. Med. 113. 9S-12S.
3. Ascherio, A., Hennekens, C., Buring. J., Master, C., Stamper, M., Willett, W. (1994): Trans fatty acids intake and risk of myocardial infraction. Circulation, 89. 94-101.
4. Hansen, K., Leth, T. (2000): Surveillance of margarines (Overvågning af margarine). Ministeriet for Fødevarer, Landbrug og Fiskeri, Fødevaredirektoratet, København.
5. Kritchevsky, D. (1997): Trans fatty acids and cardiovascular risk. Prostaglandins, Leukotrienes and Essential Fatty Acids, 57. 4-5. 399-402.
6. Kummerow, F.A., Zhou, Q., Mahfouz, M.M., Smiricky, M.R., Grieshop, C.M., Schaeffer, D.J. (2004): Trans fatty acids in hydrogenated fat inhibited the synthesis of the polyunsaturated fatty acids in the phospholipid of arterial cells. Life Sci., 74. 2707-2723.
7. Kushi, L., Giovannucci, E. (2002): Dietary fat and cancer. Am. J. Med., 113. (9B) 63S-70S.
8. Larque, E., Perez-Llamas, F., Puerta, V., Giron, M.D., Suarez, M.D., Zamora, S., Gil, A. (2000): Dietary trans fatty acids affect docosahexaenoic acid concentration in plasma and liver but not brain of pregnant and fetal rats. Pediatr. Res., 47. 278-283.
9. Sachiko, T., Hiromi, Y. (2002): Microwave heating influences on fatty distributions of triacylglycerols and phospholipids in hypocotyls of soybeans. Food Chemistry, 66.
10. Stender, S., Dyerberg, J. (2004): Influence of trans fatty acids on health. Ann. Nutr. Metab., 48. 61-66.

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