



Composition of the mother's milk II. Fat contents, fatty acid composition. A review

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Abstract. The authors have analysed fat contents and fatty acid composition of the mother's colostrum and mother's milk in comparison with the newest publications. They have established that the average fat contents of the mother's milk were 3.6–4.0%, and increased during lactation. Among the different ethnic groups there was found no significant difference in the fat contents of the mother's milk, although fat contents of the remainder and milk of corpulent mothers were found high (4–8%).

Saturated fatty acids contribute in 45–55% to the energy value of mother's milk; their amount is 38–41% in the milk fat, which does not change during lactation. With increasing butter consumption palmitic acid and stearic acid contents of the mother's milk increase, and also fatty acid composition of other nutriment is considerably affects the saturated fatty acid contents. Out of the monounsaturated fatty acids oleic acid represents 3–42%, whereas elaidic acid represents 11–12% of milk

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fat. Multiple unsaturated fatty acid contents of mother's milk are substantially affected by the food composition, and also the significant differences between the ethnic groups can be attributed to differences in the nutrition. During the lactation the amount of the n-3 fatty acids reduces while that of the n-6 fatty acids increase. The geographical and nutritional differences have effect especially on the concentration of long-chain multiple unsaturated fatty acids. Out of the essential fatty acids linolenic acid contents of the mother's milk are between 12–13%, in extreme cases can even reach 20.3%, whereas concentration of the other essential fatty acids is around 0.1–1.5%. No difference was found between the well and badly fed mothers, and the differences between the ethnic groups can also be attributed to the nutritional conditions. During the lactation concentration of both linoleic acid and linolenic acid increases, whereas concentration of arachidonic acid and docosahexaenoic acid decreases. Trans fatty acids form 0.2–17% of milk fat on average. Some believe that consumption of hydrogenated vegetable oils (margarines) does not have any effect on the concentration of trans fatty acids, while others think that it does. Similarly, conjugated linoleic acid contents of milk fat are influenced by the nutriment, and are considerably increased by consumption of alpine butter.

1 Fat content

Yamawaki et al. [54] examined fat content of milk of mothers from different areas of Japan. The milk samples were collected in summer between July and September, and in winter between December and March, respectively, from around 4000 women on different dates of lactation (day 1 to day 365). From each mother around 50 cm³ milk was collected in the part of the day between two nursings, the samples were stored in a deep-freeze until the analysis. The fat content increased during the lactation; it was significantly higher between days 11–89 of the lactation (3.75–3.90%) than between days 1–10 of the lactation (2.68–2.77%). Along with the sampling, data were collected on smoking habits, vitamin supplementation, birth-weight of the newborn and on whether the sample was taken from the left or right breast. The samples were arranged into four groups based on the obtained information: Group A (3170 sample): mothers aged below 40 years, non-smokers, who took vitamin supplementation, and with babies with birth-weight of 2.5 kg or more. Group B (630 sample): age of women and birth-weight of the babies were the same like in group A, but the mothers smoked regularly, took vitamin supplementation, and received also other drug treatment during lactation. Group C (30 sample): the only difference from group A was that the mothers were older than

40 years. Group D (200 sample): except birth-weight of the babies (less than 2.5 kg) this group was identical with group A. Between the formed groups no significant difference was found regarding fat content of the milk.

Rocquelin et al. [41, 42] measured fat content of milk of Congolese mothers in month 5 the lactation to be 2.87%. Fat content of the milk was in a negative relationship with the body mass index. In summary, it was established that the fat content of the milk of the Congolese women depends on the nutrition of the mother.

Saarela et al. [43] examined fat content of the milk during the first six months of the lactation. It was established that the fat content of the aftermilk (5.86%) could be more than double of that of the foremilk, since fat content of the milk increases considerably during the breast-feeding. Total energy content was by 105–126 kJ/100 cm³ higher in the ripe milk than in the foremilk. It was established that fat and energy content of the mother's milk did not change significantly between the first week and month 6 of the lactation.

Clark et al. [8] examined the total lipid content of milk taken from 10 mothers in week 2, 6, 12, and 16 of the lactation and experienced that it increased significantly from 3.9% measured in week 2 to 5.2% measured in week 16. Glew et al. [16] measured fat content of milk of North-Nigerian fulani nomadic tribes to be 3.05%, that of townmothers to be 3.63%, the difference was not significant between the two groups, however.

According to Bertschi et al. [3] fat content of milk of German mothers consuming butter of different amounts varied between 3.3–3.4%. Marín et al. [30] examined fat content of milk of overweight, normal weight and fat mothers living in La Plata in Argentina and established that fat content of milk of overweight mothers was significantly higher compared to the normal weight and fat mothers (98.1 g/dm³; 69.2 g/dm³; 71.5 g/dm³).

Finley et al. [13] found no difference in milk fat content of vegetarian, semi-vegetarian and non-vegetarian mothers between the three groups. In case of mothers who consumed less than 35 g animal fat a day, fatty acid composition of the milk fat depended significantly on the animal fat intake. For mothers, who consumed more than 35 g animal fat a day, fat content of the mother's milk was in a close positive relationship with the C10:0, C12:0 and C18:3 fatty acids, and in a negative relationship with the palmitic and stearic acid content. Based on the results it was concluded that both for palmitic and stearic acid there was a maximal amount that could be taken by the organism from the blood into the milk gland.

Picciano [38] examining the milk fat content of the mother's milk established that this was the most varied component of the milk, influenced by many

factors. Nourishment of the baby also affects it, as fat content of the mother's milk increases considerably during the breast-feeding. It is influenced by the food of the mother, if it is of low fat content, the endogenous synthesis of the middle-chain fatty acids (C6–C10) increases. Nourishment level of the mother, overweight during the pregnancy can have a connection with the increased milk fat content. Lipids are the most important energy-supplying compounds of the milk, being present in 97–98% as triglycerides in the mother's milk.

Minda et al. [33] collected milk samples from 18 mothers living in Pécs, who gave birth to healthy baby, on the days 1, 2, 3, 4, 5, 6, 7 and then day 14 and 28 after the childbirth. The milk samples were taken between 8 and 10 a.m., and delivered stored at 4–8 °C into the laboratory. The mothers were 29.4 ± 4 years old, and bore in the week 39.1 ± 1.6 of the pregnancy. Surveying the nutrition of the mothers, three of them were completely vegetarian (did not consume even fish), four of them consumed at least once, and 11 mothers consumed in one to three cases fish a week. Fat content of the milk samples varied between 4–8 g/100 cm³ determined gravimetrically.

Al-Tamer and Mahmood [1] examined composition of milk of mothers with premature and with normal-time childbirth in Iraq. Colostrum and blood samples were taken from mothers bearing in week 39.2 and 32.7, aged 20–40 years. It was established that fat content in the colostrum of mothers with premature childbirth was significantly lower than in the normal colostrum.

Koletzko et al. [24] recommend milk of healthy and well-fed mothers for the nourishment of babies in the first six months of their life. It was established that the fat content of the mother's milk is the main source of energy, contributing in 40–55% to the total energy input. The lipids can be found in the fat micelles with a diameter of 3–5 µm, and containing mainly triglycerides inside. Main components of the fat micelle membrane are the phospholipids and the cholesterol. Lipids of the mother's milk contain the fat-soluble vitamins and the polyunsaturated fatty acids (PUFA) including linoleic acid (LA, 18:2n6) and α-linolenic acid (ALA, 18:3n3). Various PUFAs are proved to have specific biological functions. Linoleic acid e.g. is a component of the skin ceramides that have an important role in formation of the epidermic water barrier. LA and ALA are the precursors of the PUFAs with 20 and 22 carbon atoms. N-6 and n-3 fatty acids take place in such enzyme reactions in which long-chain unsaturated fatty acids (LC-PUFA) are formed, like di-homo-γ-linolenic acid and docosahexaenoic acid (DHA). The LC-PUFAs are important in the formation of the membrane structure, and accumulate perinathalic in tissues rich in membranes like nervous tissue and retina.

2 Lipids in mother's milk

According to Koletzko et al. [24] the mother's milk contains approx. 3.8–3.9% fat, but this value varies between wide limits. The fat in the milk can be found in fat micelles that are formed in the alveolar cells of the milk gland. The fat micelle has a hydrophobic nucleus that is rich in triglycerides and also contains cholesterol ester and vitamin A esters. The surface of the fat micelles contains amphipathic phospholipids as well as proteins, cholesterol and the enzymes. Due to its amphipathic surface the fat micelle is stable in the aqueous medium, and can form the oil in the water emulsion. Major part of the membrane is the apical plasma and membrane of the Golgi apparatus, which distend along with the fat from the cells of the milk gland. The fat micelles have a diameter of 1–10 μm , thus total surface of the micelles in 100 cm^3 milk is 4.5 m^2 . To the surface of the fat micelles various lipases are bonded, which contribute to the efficient digestion of the triglycerides. With increasing fat content of the milk during the first four weeks of the lactation also the size of the fat micelles is increasing, resulting in the decrease of the phospholipids and the cholesterol in the membrane. The alveolar cells of the milk gland form the milk fat that can be stimulated by suckling or dosage of prolactin forming in the hypophysis. Major part of the milk fat comes from the foods consumed by the mother, the rest derives from the reserves of the mother's body. A part of the milk fat is synthesized locally in the milk gland from glucose, resulting in mainly C10–C14 fatty acids. The amount of the synthesized middle-chain fatty acids increases in the milk fat when the mother's food is of low fat and high carbohydrate content. There is no significant difference in the lipid composition between mothers with premature and normal time childbirth.

3 Fatty acid composition

3.1 Saturated fatty acids

Shores et al. [48] examined the relationships between copper and middle-chain saturated fatty acids in the milk of 33 Fulani women. Age, height, body mass and number of children of the mothers were recorded. After sample collection the samples were stored at -20°C until the analyses. A copper content of 399 $\mu\text{g}/\text{dm}^3$ was obtained, capric acid content was measured to be 0.28, lauric acid content to be 9.10 and miristic acid content to be 12.5% in the relative weight% of the total fatty acids. The three middle-chain fatty acids represented altogether 21.5% of the total fatty acids. Significant relationship

was found between the copper content and the three fatty acids, as well as the amount of the total middle-chain fatty acids. According to the authors the relationship between copper and the middle-chain fatty acids can be explained by the fact that either in the milk gland a copper-containing enzyme is necessary for the synthesis of the C10–C14 fatty acids or the middle-chain fatty acids are capable of bonding copper in a special way.

Minda et al. [33] by the examination of saturated fatty acid composition of milk of mothers living in Pécs established that out of the saturated fatty acids palmitic acid reduced during the lactation (25.73–22.33%), whereas the amount of miristic acid and stearic acid showed no substantial change in the first three months of the lactation (C14:0 5.16–6.25%; C18:0 6.96–7.04%).

Marangoni et al. [29] examined fatty acid composition of milk of ten Italian mothers from milk samples taken on the first day of the lactation, then in the month 1, 3, 6, 9 and 12 of the lactation. In the course of the lactation in the total amount of the saturated fatty acids no significant change could be found, their amount varied between 38–41%.

Sala-Vila et al. [44] examined saturated fatty acid composition of the colostrum (day 1–5), transitional milk (day 6–15) and ripe milk (day 15–30) of 66 mothers of Granada bearing at normal time. The milk samples were collected between the second and fourth week of the lactation using hand milk pump. After the collection the samples were immediately frozen down to -80°C , and stored until the analyses. Determining fatty acid content of the phospholipids it was established that palmitic acid (23.38–24.32%) increased significantly from the colostrum to the ripe milk, while the colostrum contained more stearic acid (24.00–23.49%) than the ripe milk. The amount of the saturated fatty acids (C8:0–C24:0) was measured to be significantly higher in the transitional (56.18%) and the ripe milk (56.89%) than in the colostrum (57.96%).

According to López-López et al. [27] in the human colostrum palmitic acid (19.64–19.9%) and stearic acid (5.24–5.30%) are present in big amount. More than 1% was measured for the lauric acid and miristic acid, whereas the rest of the saturated fatty acids was present in a concentration of below 1% in the milk fat of the mother's milk.

Fidler et al. [11] examined fatty acid composition of the colostrum of mothers living in Slovenia, in town and in country environment. Colostrum samples were taken from 41 Slovenian mothers, out of which 27 lived in town and 14 in the country, 3 days after the childbirth. Determining the fatty acid composition by capillary gas chromatography it was experienced that there was no significant difference in the fatty acid composition of the colostrum's

fat between the townmothers and the mothers from the country. Average saturated fatty acid content of the mothers milk was 37.68%.

Bahrami and Rahimi [2] examined the saturated fatty acid composition of milk of 52 healthy, breast-feeding, West-Iranian mothers aged between 19–39 years, who gave birth to their baby in week 37–45. The milk samples were immediately frozen down to -40°C , and kept at this temperature until the analysis. The fatty acid composition was determined after derivatization using high-performance liquid chromatography. It was established that out of the saturated fatty acids the middle-chain fatty acids (C6:0–C18:0) represented the main fraction with 37.3%. Schmeits et al. [45] measured the amount of C10:0–C14:0 fatty acids in the milk of 48 mothers living in the countryside territory of Nepal to be 25%.

According to Xiang et al. [52] saturated fatty acid concentration of milk of 41 mothers living in country environment of North China ranged between 34.66–36.59%. Precht and Molkentin [40] established that saturated fatty acid content of milk of 40 German mothers was as follows: C12:0 3.12%, C14:0 6.43%, C16:0 25.28% and C18:0 7.41%. Bitman et al. [4] analyzing the fatty acid composition of the mother's milk established that the amount of the middle-chain fatty acids (C12:0, C14:0, C16:0) in the colostrum of mothers with very premature and premature (23%) childbirth was considerably lower than in the normal colostrum (35%). Glew et al. [16] analyzing the amount of C6:0–C14:0 middle-chain fatty acids established that this was practically the same for both the townmothers (25.2%) and the country mothers (26.6%).

Fidler and Koletzko [10] summarized the results of 15 studies dealing with fatty acid composition of colostrum of mothers from the world's 16 regions. Out of the studies 11 derived from Europe, one from Central America, one from the Caribic, one from Australia and one from Asia. It was established that the amount of the saturated fatty acids was similar in the South-European countries (Spain, France, Slovenia). Colostrum of mothers living in St. Lucia contained more saturated fatty acids due to the foods of high carbohydrate and low fat content. In the colostrum of Australian mothers the amount of the saturated fatty acids was 43.8%.

Bertschi et al. [3] examined the effect of Alpenbutter consumption of German mothers on the fatty acid composition of the fatty acid composition. The butter originated from Graubünden (Switzerland), from 2100 m altitude; the 2 kg packings were stored at -20°C until they were utilized. The milk samples were taken on day 1, 5, 10, 15 and 20 of the experiment between 8–11 a.m. and the fatty acid composition of the milk was determined by gas chromatography. It was established that due to the alpenbutter supplementation the

proportion of the palmitic acid and stearic acid increased in the milk, as well as total amount of the saturated fatty acids.

Silva et al. [49] determining saturated fatty acid composition of ripe milk of Brazil mothers collected 80 milk samples from 18 healthy donors between week 4–13 of the lactation, who were breast-feeding their baby until week 37–42 after the childbirth. Sampling was done by hand; 10 cm³ of milk was taken each time that was immediately frozen down to –20 °C and stored until the analyses. Each mother was questioned based on a questionnaire about her nutritional habits, especially regarding the saturated and unsaturated fats, trans fatty acids and carbohydrate consumption (beef, pork, chicken, fish, cakes, rice, flour, margarine, butter, vegetable fats, animal fats, milk, dairy products, vegetables, fruits). On the basis of the questionnaire it was experienced that during the sampling the mothers consumed weekly in most cases rice, cakes, vegetable fats, chicken, fruits and vegetables (7 to 8 times a week), and only in a very few cases fish, butter and animal fat (2 to 3 times a week). The analysis of the fat was carried out in the form of fatty acid methyl esters using a gas chromatograph with a flame ionization detector. Size of the column was 50 m, 0.25 mm, helium as carrier gas with a flow rate of 1 cm³/min. It was established that out of the saturated fatty acids palmitic acid was present in the highest concentration (17.3%) representing 43.5% of the total saturated fatty acids, followed by miristic acid (7.02%), lauric acid (6.88%) and stearic acid (5.43%). It was concluded that the fatty acid composition of the food affects considerably the fatty acid composition of the mother's milk.

Hayat et al. [20] examined saturated fatty acid composition of milk of 19 healthy Kuwaiti mothers aged between 20–30 years, and parallelly with this based upon a questionnaire the foodstuffs consumed by the individual mothers was surveyed, that proved to be very rich in fats and proteins. The samples were taken using automatic pumps between week 6 and 14 after the childbirth, in the morning. Subsequent to the sampling the samples were placed immediately into ice and examined shortly after the delivery. Fatty acids present in the samples were converted into methyl ester, the examinations were performed by gas chromatography using flame ionization detector and capillary column (50 m long and 0.25 mm internal diameter). According to the examinations composition of the milk was considerably influenced by food consumption of the mothers. It was established that 42.6% of the total fatty acid content was represented by the saturated fatty acids, out of them in biggest amount occurred palmitic acid (50.8%), stearic acid (6.5%), miristic acid (6.4%), and lauric acid (6.0%).

Marín et al. [30] examining saturated fatty acid composition of milk of

mothers living in La Plata in Argentina analyzed the relationship between the fatty acid composition and the composition of the foods consumed by the mother. The milk samples were collected between month 1–3 of the lactation manually in the third minute of the breast-feeding. The samples were immediately frozen down to -70°C and stored until the analyses. The mothers were 16–39 years old. The entire fat amount was extracted using the Folch method and converted into fatty acid methyl esters. The methyl esters were analyzed by gas-liquid chromatography. Capillary column of 30 m length and with 0.25 mm internal diameter, 0.25 μm film thickness and a flame ionization detector was used. In the course of the examinations no difference was found in the amount of the individual saturated fatty acids between the obese and fat mothers despite that the concentration of the C10–C14 fatty acids was the lowest in the case of obese mothers. Within the saturated fatty acids in all three groups palmitic acid was present in the highest concentration (20.58–21.19%). Within the total fatty acid content the amount of the saturated fatty acids was 42.85%. No considerable difference was established in the saturated fatty acid content of the milk of the Argentinian, the Japanese and the Chinese mothers.

Rocquelin et al. [41, 42] examined saturated fatty acid composition of milk of Congolese mothers, with special respect to the nourishment level of the mother and to the satisfaction of the fatty acid requirements of the newborn. In the milk of Congolese women being in the fifth month of the lactation the amount of C8:0–C14:0 fatty acids (25.97%) was relatively high. The fatty acid composition was brought into connection with the consumption of foods with high carbohydrate content, that promote the biosynthesis of the C8:0–C14:0 fatty acids. In summary it was established that the fat content of the milk of Congolese women and the fatty acid composition of the fat depended considerably on the nutrition of the mother.

Xiang et al. [53] examining saturated fatty acid content of milk of Chinese and Swedish mothers analyzed the effect of food on the composition of milk. The Chinese mothers consumed mainly rice, steamed bean, noodles, Chinese cabbage and pork. Food of Swedish mothers consisted of bread, potato, paste, milk, sour milk and cheese. The Chinese consumed more carbohydrates (17% of the energy), less protein (4% of the energy) and fat (12% of the energy) than the Swedish. Fat content of the foods of the Chinese derived from soya oil and pork, whereas that of the Swedish mainly from cheese. It was established that due to the above nutrition the total saturated fatty acid content of the milk of Chinese mothers, with the exception of the arachidic acid (C20:0) and behenic acid (C22:0) was significantly lower (13.39 g/day) than in case of the Swedish

mothers (41.3 g/day). Within this, in the C12:0–C18:0 range the fatty acid content was significantly in case of the Chinese than in case of the Swedish; in the C20:0–C24:0 range an opposite result was obtained, however.

Serra et al. [46] determined fatty acid composition of milk of 20 Italian mothers nourishing according to appetite. The milk samples were taken on day 1, 4, 7, 14 21 and 28 after the childbirth. In the ripe milk the amount of the saturated fatty acids was 45.50%. It was established that fatty acid composition of milk fat of Italian mothers was similar to that of mothers living in the South European countries, which is presumably due to the similar nutrition habits. Laryea et al. [25] examining the fatty acid composition of milk fat of well-nourished Sudanese mother established that the amount of the saturated fatty acids represented 46% of the total fatty acid content.

According to Koletzko et al. [24] major part of the lipids of the mother's milk is composed of the saturated fatty acids. In the vegetable oils the saturated fatty acids take their place more or less randomly in the triglyceride molecule, in the mother's milk, however, the saturated palmitic acid is bonded in the sn-2 position. As the lipolytic enzymes cleave the bonds in the sn-1 and sn-3 positions more effectively, palmitic acid present in the mother's milk can be found mainly in monoglyceride form, whose absorption is greater than that of the free palmitic acid. Due to its the higher polarity, the absorption of the monoglyceride is easier. Most of the palmitic acid absorbs in sn-2 position, keeping its structure after the absorption even in the small intestines. Clinical experiments with baby food preparations confirmed that the palmitic acid absorbs better from the sn-2 position, than it is randomly linked to the glycerine.

According to Picciano [38] saturated fatty acid composition (C12:0–C18:0) of the mother's milk is affected by many factors. These fatty acids contribute in 45–55% to the energy content of the mother's milk.

3.2 Unsaturated fatty acids

Monounsaturated fatty acids Jahreis et al. [22] analyzed the composition of cow's, goat's, sheep's, sow's, mare's and mother's milk. Comparing the monounsaturated fatty acid content measured for the individual species it was established that in case of non-ruminants its concentration was the highest in the sow's milk ($51.8 \pm 5.8\%$), followed by the human milk ($33.2 \pm 2.9\%$) and the mare's milk ($20.7 \pm 1.2\%$). In the case of the ruminants no considerable difference was found within the individual species regarding the monounsaturated fatty acids with concentration ranging between 21.8–23.2%.

According to Xiang et al. [52] monounsaturated fatty acid content of milk of 41 mothers living in country environment of North China in the range C14:1–C24:1 is between 38.0–39.32%. Silva et al. [49] determining the unsaturated fatty acid content of ripe milk of Brazil mothers established that they represented 59.5% of the total fatty acids, out of which 27.6% was the monounsaturated fatty acids. Hayat et al. [20] measured the monounsaturated fatty acid composition of milk of 19 healthy Kuwaiti mothers, aged between 20–30 years, within the total fatty acid content to be 37.3%.

Sala-Vila et al. [44] examined fatty acid composition of the colostrum (day 1–5), transitional milk (day 6–15) and ripe milk (day 15–30) of 66 mothers of Granada bearing at normal time. Determining the fatty acid content of the phospholipids it was established that the amount of the monounsaturated C18:1n9 fatty acids increased significantly from the colostrum to the ripe milk (13.39–14.00%). In the transitional and the ripe milk the amount of the monounsaturated fatty acids was significantly lower (16.60%) than in the colostrum (17.91%), however.

According to López-López et al. [27] in the human colostrum in the highest amount the C18 oleic acid isomers containing one unsaturated bond were present (41.58–42.04%). An amount above 1% was measured also in the case of the palmitoleic acid. Fidler et al. [11] examined fatty acid composition of the colostrum of Slovenian mothers living in town and in country environment. The only difference was in the oleic acid content, which was 36.85% for the mothers living in the country, whereas 34.94% for the townmothers. Total amount of the monounsaturated fatty acids was 40.49%.

Serra et al. [47] determined fatty acid composition of milk of 20 Italian mothers nourishing according to appetite. It was established that with the advance of the lactation the amount of the monounsaturated fatty acids decreased significantly, which was 42.69% in the ripe milk. According to Laryea et al. [25] monounsaturated fatty acid content of milk of well-nourished Sudanese mothers represented 33% of the total fatty acids.

Bahrami and Rahimi [2] examining the fatty acid composition of the milk of 52 healthy West-Iranian mothers established that the monounsaturated oleic acid represented 30.9% while elaidic acid 11.3% of the milk's total fatty acids. According to the examinations of Minda et al. [33] the monounsaturated fatty acid content of the milk of mothers living in Pécs showed some decrease between day 1 and day 28 after the childbirth (36.79–35.75%). Marangoni et al. [28] measured monounsaturated fatty acid content of ten Italian mothers to be between 45–41%.

Marín et al. [30] measured the monounsaturated fatty acid content of milk of

mothers living in La Plata in Argentina to be 34.8%, within which proportion of the 20:1n9 was significantly higher in case of the fat mothers (0.19%) than in the case of normal mothers (0.08%). Total amount of the monounsaturated fatty acids in case of the fat mothers was significantly less compared to the normal and overnourished mothers (33.7%, 36.97%, 33.9%).

Scopesi et al. [46] studied the effect of monounsaturated fatty acid content of the food on the fatty acid composition of the mother's milk in the first month of the lactation in case of 34 breast-feeding mothers. The food's composition was determined six times on the day before the sampling. Milk sample taken on the first day after the childbirth was considered as colostrum, sample taken on days 4–6 as transitional milk, while sample taken on the days 14, 21 and 28 as ripe milk. It was established that the monounsaturated fatty acid content of the mother's food had a significant effect on the composition of the transitional milk.

Xiang et al. [53] examining monounsaturated fatty acid content of milk of Chinese and Swedish mothers analyzed the effect of food on the composition of milk. The Chinese mothers consumed mainly rice, steamed bean, noodles, Chinese cabbage and pork. Food of Swedish mothers consisted of bread, potato, paste, milk, sour milk and cheese. In case of the Chinese mothers the concentration of the total monounsaturated fatty acids was 39.32%, whereas in the milk of the Swedish mothers was 45.15%. Within this in the C14:1–C18:1 range a lower value was obtained for the Chinese mothers, while in the C20:1–C24:1 range the result was opposite.

Polyunsaturated fatty acids Jahreis et al. [22] analyzed the composition of cow's, goat's, sheep's, sow's, mare's and mother's milk. Comparing the polyunsaturated fatty acid content measured for the individual species it was established that its concentration was the highest in the mare's milk ($36.8 \pm 3.2\%$), followed by the sow's milk and the human milk (12.5–12.4%). In the case of the ruminants no considerable difference was found within the individual species regarding the polyunsaturated fatty acids with (2.42–4.05%).

Laryea et al. [25] examining the polyunsaturated fatty acid content of milk fat of well-nourished Sudanese mothers established that they represented 21% of the total fatty acids. Xiang et al. [52] determined long-chain polyunsaturated fatty acid composition of milk of 41 mothers living in country environment of North China and measured to be between 25.38–26.00%.

Serra et al. [47] determining the polyunsaturated fatty acid composition of milk of 20 Italian mothers nourishing according to appetite established that with the advance of the lactation out of the long-chain unsaturated fatty

acids the amount of the $\omega 6$ and $\omega 3$ fatty acids decreased significantly. In the ripe milk the amount of the total unsaturated fatty acids was 54.5%, out of which the polyunsaturated fatty acids represented 11.82%, and within the polyunsaturated fatty acids the long-chain fatty acids represented 1.27%.

Bitman et al. [4] examined the C18:3, C20:3 and C20:4 fatty acids of the mother's milk in case of mothers with very premature (5.6%), premature childbirth (6.2%) and mothers bearing at normal time (1.8%). Colostrum of mothers bearing at normal time contained significantly less out of these fatty acids compared to mothers with premature childbirth.

Fidler et al. [11] examining the fatty acid composition of the colostrum of mothers living in town and country environment in Slovenia did not find significant difference in the amount of the polyunsaturated fatty acids (21.82%). Ratio of the polyunsaturated and saturated fatty acids was 0.58, whereas the n-6/n-3 ratio was 8.0.

Silva et al. [49] examining the polyunsaturated fatty acid composition of the ripe milk of Brazil mothers established that they represented 23.4% of the total fatty acids. The amount of the n-6 long-chain polyunsaturated fatty acids was 1.56%, the C18:2n6/C18:3n3 ratio was 15.35.

Marín et al. [30] examined the long-chain polyunsaturated fatty acid composition of milk of mothers living in La Plata in Argentina and analyzed the relationship between the fatty acid composition and the composition of the foods consumed by the mother. It was established that in case of fat mothers the amount of the polyunsaturated fatty acids increased significantly and also the C18:2n6/total n-6 ratio was significantly higher compared to the ones with normal body weight (0.96%; 0.89%). No significant difference was found between the groups regarding the n-3 fatty acids, but the ratio between the n-6 and n-3 fatty acids was significantly higher for the obese mothers. Comparing the polyunsaturated fatty acid content of the milk of the Argentin, American, Japanese and Chinese mothers it was experienced that the milk of the Argentin mothers contained more C18:2n6 and C18:3n3 fatty acids than that of the rest of the mothers.

Olafsdottir et al. [36] examined the ratio of the polyunsaturated fatty acids in the milk of mothers living in Iceland, who consumed traditionally fish and fish liver oil. From 77 mothers milk samples were taken at 24 hour intervals and analyzing by gas chromatography the fatty acid composition it was established that in the milk of mothers who consumed fish liver oil the polyunsaturated fatty acids were present in a significantly higher concentration. The milk fat contained more docosahexaenoic acid (0.54%) than the milk of the control group (0.30%), similarly, also the amount of eicosapentaenoic (0.16%)

and docosahexaenoic acid (0.22%) was significantly higher than in the control group, where the concentration of these two fatty acids were 0.07 and 0.17%. It was also established that the proportion of eicosapentaenoic acid, docosapentaenoic acid and docosahexaenoic acid reach higher value without the amount of other important fatty acids having been decreased. It appears that the fish liver oil is a very important source of fat in respect of nutrition of both the mother and the newborn.

Scopesi et al. [46] studied the effect of polyunsaturated fatty acid content of the food on the fatty acid composition of the mother's milk in the first month of the lactation in case of 34 breast-feeding mothers. The food's composition was determined six times on the day before the sampling. Milk sample taken on the first day after the childbirth was considered as colostrum, sample taken on days 4–6 as transitional milk, while sample taken on the days 14, 21 and 28 as ripe milk. It was established that the polyunsaturated fatty acid content of the mother's food affected only the composition of the ripe milk.

Xiang et al. [53] examining long-chain polyunsaturated fatty acid content of milk of Chinese and Swedish mothers analyzed the effect of food on the composition of milk. The Chinese mothers consumed mainly rice, steamed bean, noodles, Chinese cabbage and pork. Food of Swedish mothers consisted of bread, potato, paste, milk, sour milk and cheese. Total amount of the polyunsaturated fatty acids was higher in case of the Chinese mothers (15.92 g/day) compared to that of the Swedish ones (11.71 g/day). Within this proportion of adrechinic acid (C22:4n6), as well as of the total n-6 and n-3 polyunsaturated fatty acids were significantly higher for the Chinese than for the Swedish. Eicosadienoic acid and clupanodonic acid were, however, significantly higher in case of the Swedish. It was established that due to the nutrition milk of Chinese mothers contained significantly more polyunsaturated fatty acids (26.02%) than that of the Swedish ones (14.14%). With the exception of γ -linolenic acid and docosapentaenoic acid the n-6 polyunsaturated fatty acids were present in the milk of the Chinese mothers in a significantly higher concentration. With the exception of the eicosatrienoic acid the n-3 polyunsaturated fatty acids occurred in the milk of the Chinese mothers in a significantly lower concentration.

Hayat et al. [20] examining polyunsaturated fatty acid composition of milk of 19 healthy Kuwaiti mothers aged between 20–30 years established that the amount of the long-chain polyunsaturated fatty acids depends on the composition of the food. In the milk of mothers who consumed bigger amount of fish the fatty acids C22:6n3 and C20:5n3 were present in a significantly higher amount. It was established that 62.7% of the total fatty acid content was

represented by the polyunsaturated fatty acids.

Wijga et al. [51] examined the relationship between the composition of the mother's milk and allergic diseases in case of allergic and non-allergic women. It was established that in case of the children of allergic mothers the amount of n-3 long-chain polyunsaturated fatty acids and the n-3/n-6 ration could be brought into connection with the developed asthma and eczema, no data were found, however, relating to whether fatty acid composition of the milk fat could make one susceptible to these diseases.

Lauritzen et al. [26] compared milk fat composition of non-atopic and atopic Danish mothers. It was established that milk fat of atopic mothers contained in significantly bigger amount C22:5n6 and in lower concentration C20:5n3 fatty acid, at the same time no difference was found between the two groups regarding the rest of the polyunsaturated fatty acids of the mother's milk, relationship was found, however, between the polyunsaturated fatty acid composition of the milk and similar parameters of the food.

Sousa et al. [50] examined fatty acid composition of colostrum, transitional milk and ripe milk of 9 Chilean mothers who bore in week 31 and week 34 of the pregnancy, in the first month after the childbirth. The first milk sample was taken on day 2 and day 3 after the childbirth, the second one between day 15 and day 18. The mothers derived from south-eastern part of Santiago, belonged mainly to low social class, and were in a bad social position. Energy content of their foods came in 20% from fat, in 68% from carbohydrates and in 12% from protein, and also the fatty acid composition of the foods consumed by the mothers was similar. Out of the polyunsaturated fatty acids the n-6's represented 88%, the n-3's 12%, the n-6/n-3 ratio was 7.5:1. Docosahexaenoic acid and eicosapentaenoic acid content of the mother's milk was higher than that of mothers living in the Western industrialized countries.

Patin et al. [37] examined the effect of the sardine consumption on the n-3 fatty acid content of the ripe mother's milk. It is well-known that sardine contains many n-3 polyunsaturated fatty acids. At the beginning of the experiment milk samples were taken from 31 breast-feeding mothers on day 15 and day 30, and the fatty acid composition was determined by gas chromatography. The mothers were divided into two groups regarding sardine consumption. The first group contained mothers who consumed sardine within 3 days prior to the sampling, while to the second group belonged mothers who consumed sardine four days before the sampling. It was established that the n-3 fatty acids of the mother's milk increased considerably at all the three sampling time in the case of the first group, the growth for the second group was only a small one, however. Comparing the n-3 fatty acids of the samples taken at the same

point of time of the two groups, in case of eicosapentaenoic acid for the sample taken on day 30 of the lactation (Group 1: 0.17; Group 2: 0.06%); whereas in case of docosapentaenoic acid at the beginning of the experiment (Group 1: 0.16; Group 2: 0.25%) could be found a significant difference. The amount of the n-3 and n-6 fatty acids showed a significant positive relationship on day 15 and day 30. It was established that fish consumption of the breast-feeding mothers (minimally 100 g sardinia 2–3 times a week) can considerably increase the amount of the n-3 fatty acids in the mother's milk.

According to Picciano [38] the short pregnancy can increase the amount of the long-chain polyunsaturated fatty acids. It is also influenced by the mother's food, as if it is of low fat content, endogenous synthesis of the middle-chain fatty acids (C6–C10) increases, and also the nourishment level of the mother influences it.

Sala-Vila et al. [44] examined polyunsaturated fatty acid composition of the colostrum (day 1–5), transitional milk (day 6–15) and ripe milk (day 15–30) of 66 mothers of Granada bearing at normal time. Determining polyunsaturated fatty acid content of the phospholipids it was established that the amount of the C20:5n3 (0.34–0.81) and C22:2n6 (0.44–0.55) fatty acids increased significantly from the colostrum to the ripe milk. At the same time the colostrum contained more C20:3n-6 (0.62–0.60%), C22:4n6 (0.27–0.06%) and C22:5n3 (0.83–0.65%) fatty acids than the ripe milk. In summary, the amount of the total n-3 polyunsaturated fatty acids decreased from the colostrum to the ripe milk (2.69–2.45%), while the amount of the n-6 fatty acids increased (5.10–5.26%) in this period. It was established that the milk of the mothers of Granada did not differ from the average fatty acid composition of milk of mothers examined in other parts of the world.

Al-Tamer and Mahmood [1] examined composition of milk of mothers with premature and with normal-time childbirth in Iraq. Colostrum and blood samples were taken from mothers bearing in weeks 39.2 and 32.7, whose age varied between 20–40 years. In the milk of mothers bearing at full time the amount of the C20:5n3 and C22:6n3 fatty acids was significantly higher, and some increase could be experienced in the n-3/n-6 ratio. It was established that the C22:6n3 and the n-3/n-6 ratio was lower in the colostrum of the mothers with premature birth than in the normal colostrum. The colostrum's fatty acid composition is considerably influenced by the serum's lipid composition. The difference in the middle-chain fatty acids in the serum and the colostrum explains that these are formed in the milk gland.

Serra et al. [47] determining the fatty acid composition of milk of 20 Italian mothers nourishing according to appetite established that with the advance

of the lactation the amount of the monounsaturated fatty acids decreased significantly, which was in the ripe milk 42.69%.

According to Minda et al. [33] polyunsaturated n-6 fatty acid content of milk of mothers living in Pécs decreased significantly, while major part of the n-3 fatty acids did not show any substantial change during the lactation.

Marangoni et al. [29] could not find a significant difference in the polyunsaturated fatty acid amount (16–16%) of milk of Italian mothers in months 1, 3, 6 and 12 of the lactation.

According to Koletzko et al. [24] the different LC-PUFAs occur in considerable amount in the mother's milk (LC-PUFA = long-chain polyunsaturated fatty acid). Analyzing the fatty acid composition of the ripe milk from industrial countries total n-6 LC-PUFA ranged between 0.83–1.40%, while the total n-3 LC-PUFA between 0.27–0.48% as percentage of the total fatty acids. The fatty acid composition in the studies are extremely similar to each other, irrespective of whether milk of mothers living in Europe or in Africa was examined. The LC-PUFA content appears to be almost entirely independent of life circumstances and the nutrition, irrespective of that they differ considerably between the individual groups. Main PUFAs of the mother's milk are the C20:4n6, C20:3n6 and C20:2n6 all belonging to the n-6 group, as well as docosahexaenoic acid (C22:6n3) and docosapentaenoic acid (C22:5n3) that belong to the n-3 group. The LC-PUFA content decreases in the first month of the lactation which does not mean, however, that the newborns get less such kind of fatty acid as the total fatty acid content considerably increases during the lactation and the amount of the total PUFA (polyunsaturated fatty acid) excreted with the milk remains relatively constant. It is thought that the high LC-PUFA content of the colostrum can be useful for the newborn as the consumed milk amount is little, the PUFA requirement of the newborns on the other hand because of the rapid growth, is high. Amount of some n-6 PUFA like C20:3n6 and C22:5n6 decreases during the lactation. This can be explained by the fact that the milk production during the lactation empties the LC-PUFA reserves of the body, which can serve as source of the milk fat. Comparing the milk composition of mothers bearing early and at normal time it was reported that the colostrum of mothers bearing early contained more LC-PUFA than that of the ones bearing at time. The LC-PUFA decreased in the first month of lactation in the milk of both the mothers bearing early and at time. Feeding with mother's milk has a great advantage for the babies both born prematurely and at time as its high LC-PUFA content satisfies the requirements of the newborn in the first weeks of its life. After the first month of the lactation no further decrease in the LC-PUFA was observed in

the milk of mothers bearing early, but for those who bore at time the decrease continued.

Fidler and Koletzko [10] summarized the results of 15 studies dealing with fatty acid composition of colostrum of mothers from the world's 16 regions. Out of the studies 11 derived from Europe, one from Central America, one from the Caribic, one from Australia and one from Asia. It was established that the amount of the polyunsaturated fatty acids was similar in the South-European countries (Spain, France, Slovenia). Colostrum of mothers living in St. Lucia due to the foods of high carbohydrate and low fat content contained less oleic acid, the rich fish consumption increased the proportion of the n-3 long-chain polyunsaturated fatty acids. In the colostrum of the Australian mothers is the lowest the amount of the polyunsaturated fatty acids, while eicosapentaenoic acid and total n-3 long-chain polyunsaturated fatty acid content of their milk (0.6%, 0.4%, 1.4%) is higher than in case of the European mothers. It was established that the fatty acid composition of the mother's colostrum was affected considerably by the geographical and nutritional differences.

3.3 Essential fatty acids

According to examinations of Marangoni et al. [29] out of the essential fatty acids of milk of Italian mothers in month 1, 3, 6, 9 and 12 of the lactation only the concentration of arachidonic acid show a bigger decrease (1.0–0.5%); the amount of linoleic acid (11.9–12.9%), α -linolenic acid (0.6–0.9%) and docosahexaenoic acid (0.5–0.3%) did not change in the course of the lactation.

According to Glew et al. [16] the differences in two essential fatty acid content (linoleic acid and α -linolenic acid) found in the milk of the Fulani nomadic tribes and townmothers were not significant. Average amount of α -linolenic acid (0.77–0.80%) did not differ in the two populations; the amount of linoleic acid varied between 6.97–7.83% both for the Fulani and townmothers, and was lower than in case of the non-African populations or than in case of the ones living in South part of Niger. The amount of arachidonic acid was significantly higher for the countrymothers (0.62%) than for the townmothers (0.48%).

Silva et al. [49] examining essential fatty acid composition of ripe milk of Brazil mothers established that the major part of the polyunsaturated fatty acids is composed of the essential linoleic acid and α -linolenic acid in a concentration of 20.3% and 1.43%. Concentration of arachidonic acid is 0.53%, that of docosahexaenoic acid is 0.14%, which perfectly corresponds to the needs of the newborn. It was established that milk fat of mothers living in the region

of Vicosa of Brazil contained high amount of linoleic acid and α -linolenic acid in connection with the high, polyunsaturated fatty acid containing oil content of the food. It is also established that the fatty acid composition of the food considerably influences fatty acid composition of the mother's milk.

Hayat et al. [20] examined essential fatty acid composition of milk of 19 healthy Kuwaiti mothers, aged between 20–30 years. According to their investigations composition of milk is considerably influenced by the mothers' food consumption. It was established that the concentration of linoleic acid and linolenic acid depends significantly on the food's composition. Comparing linoleic acid content of milk of mothers with different nationality it was experienced that the milk of the Spanish mothers contained 12.02%, that of German mothers 10.8% and that of Australian mothers 11.0% linoleic acid. Concentration of the α -linolenic acid (n-3) ranged in case of the Arab mothers between 0.3–2.4%, whereas for the German mothers between 0.8–1.2%. It was concluded that the milk composition of adequately nourished mothers satisfied well the requirements of the newborn.

Knox et al. [23] analyzing the fatty acid composition of milk of 89 Nigerian (Kanuri) mothers wanted to know what relationship between the nutritional level and the amount of the essential fatty acids present in the milk there is. The milk samples were taken in week 1–64 of the lactation using sampling by hand, then cooled down to -20°C , and delivered at 2–4 weeks into the laboratory for analysis. For determination of the fatty acid composition for the transesterification a chloroform-methanol 2:1 mixture and boron trifluoride in methanol were used, then the analysis was carried out using a gas chromatograph with a flame ionization detector. By arranging the mothers into groups based on the body mass index it was established that in the well-nourished group the ratio of the n-3 and n-6 fatty acids with the exception of the linolenic acid and docosahexaenoic acid did not differ significantly from that of the less well-nourished groups. It was also established that in case of underfed mothers a different mechanism helped the transport of the essential fatty acids into the milk fat than in case of the well-nourished mothers.

Rocquelin et al. [41] examined essential fatty acid composition of milk of Congolese mothers, with special respect to the nourishment level of the mother and to the satisfaction of the essential fatty acid requirements of the newborn. In the milk of Congolese women being in the fifth month of the lactation the amount of the polyunsaturated fatty acids was relatively high, especially that of the n-3 fatty acids (2.39%) consisted mainly of C18:3 and C22:6 fatty acids. The fatty acid composition was brought into connection with the consumption of foods with high carbohydrate content, of fresh-water and salt-water

fishes, vegetable oils, vegetables and high fat content fruits (nuts, avocado), which foods are traditional in Congo. In summary it was established that the fat content of the milk of the Congolese women and the fatty acid composition of the fat depends considerably on the nutrition of the mother, and that the 5-months-old Congolese babies presumably did not receive the n-6 and n-3 essential fatty acids in the amount satisfying their requirements with the mother's milk.

Marín et al. [30] measured linoleic acid content of milk of overweight, fat and normal weight mothers living in La Plata in Argentina to be 6.61; 19.12 and 22.71%. Comparing the polyunsaturated fatty acid content of milk of Argentin, American, Japanese and Chinese mothers it was experienced that the milk of Argentin mothers contained more C18:2n6 and C18:3n3 fatty acids than that of the ones living at other places.

Schmeits et al. [45] determined the fatty acid composition of the milk of 48 mothers living in the countryside territory of Nepal 2–4 weeks after the childbirth. It was established that the linoleic acid concentration of the mother's milk was very low (7.91%), while that of the α -linolenic acid was relatively high (1.93%), arachidonic acid was measured to be 0.35%, docosahexaenoic acid to be 0.21% in the percentage of the total fatty acids. 6.8% of the phospholipids was represented by the two essential fatty acids, and 23% belonged to the C10:0–C14:0 ranged. Arachidonic acid is present in 0.57%, whereas docosahexaenoic acid in 0.78% in the phospholipids. It was concluded that the low linoleic acid content of the milk of Nepalese mothers was in connection with the low linoleic content of the food.

Boylan et al. [5] examined milk composition of mothers with low income in Texas state of the USA in an environment where the fish consumption was very rare. The milk samples were taken from 22 mothers, the same way, between day 8 and day 11 of the lactation, and all the foodstuffs the mothers consumed 24 hours before the sampling were recorded. 19 mothers had never eaten fish in oil, the rest consumed once a year. Another characteristic feature of the nutrition was that the mothers consumed few fruits and vegetables, and also their milk consumption was very low. By the examination of the fatty acid composition of the mother's milk it was established that the docosahexaenoic acid content of the milk fat was extremely low, 0.08% compared to 0.2–0.4% found in the literature. Linoleic acid, α -linolenic acid and other fatty acid content was similar to the literature values. It was established that for mother of Texas who consumed little vegetables, fruits, milk and fish, the docosahexanoic acid content of the milk fat was low.

Glew et al. [17] examining the essential fatty acid composition of milk of

Nepalese mothers looked for a relationship between the essential fatty acid composition of the serum phospholipids and the melting point. From 36 mothers aged between 15–32 years milk and serum samples were taken and the fatty acid composition of the phospholipid fraction was determined. α -linolenic acid content of the milk's lipids was measured to be 1.84%, arachidonic acid content to be 0.43%, docosahexaenoic acid content to be 0.23%, linoleic acid content to be 9.05%. In case of the serum phospholipids and the milk fat a positive relationship was established between the arachidonic acid and α -linolenic acid content. It was established that the arachidonic acid and α -linolenic acid content of the blood of breast-feeding mothers considerably influenced the fatty acid composition of the milk fat.

Xiang et al. [52] determined long-chain essential fatty acid composition of milk of 41 mothers living in country environment of North China. Concentration of linoleic acid (21.47–22.69%) and α -linolenic acid (1.19–1.29%) was found to be very high in the mother's milk. The linoleic acid/ α -linolenic acid ratio was measured to be 21.6, which was substantially higher than that reported in case of other countries. Concentration of arachidonic acid (0.51–0.63%) and docosahexaenoic acid (0.18–0.33%) was low, and both were in a positive relationship with the weight of the baby in month 3. The arachidonic acid/docosahexaenoic acid ratio was much higher (2.8) than that was found in case of the vegetarian mothers. As the concentration of arachidonic acid and especially that of docosahexaenoic acid decreased considerably during the lactation, after the third-fourth month of the lactation a docosahexaenoic acid deficiency is expected in case of the breast-fed Chinese country babies. The authors find further studies necessary in order to clarify whether it is necessary to supplement the mother's food with arachidonic acid and docosahexaenoic acid e.g. by adding of fish oil, so that the mother's milk composition becomes optimal for the satisfaction of the babies needs.

According to Sousa et al. [50] docosahexaenoic acid content of milk of Chilean mothers is significantly influenced by the local diet.

Fidler et al. [10] examined the transfer of the increased docosahexaenoic acid content of the food into the milk. As the docosahexaenoic acid is extremely important for the growth of the babies and its conversion from the mother's food into the mother's milk was not circumstantially investigated therefore docosahexaenoic acid labelled with ^{13}C isotope was added to the food and its transfer into the mother's milk was analyzed. Out of 10 breast-feeding mothers 5 received docosahexaenoic acid labelled with ^{13}C isotope, and 5 received placebo. The docosahexaenoic acid labelled with the carbon isotope was administered in one single dose on day 14 of the experiment to the mothers,

then the samples were collected 48 hours afterwards. The docosahexaenoic acid labelled with the isotope was determined by gas chromatography and mass spectrometer measuring the isotope ratio, the fatty acid composition of the milk fat was determined by gas-liquid chromatography. At the beginning of the experiment docosahexaenoic acid content of the mother's milk did not differ significantly for the group received placebo (0.29%) and the group received the supplementation (0.28%), however, two weeks after the docosahexaenoic acid supplementation its concentration increased almost to the double for the group received the supplementation. From the experiment it was concluded that the docosahexaenoic acid supplementation in the mother's food considerably increased its concentration in the mother's milk.

Hibbeln [21] examined docosahexaenoic acid content of the mother's milk due to consumption of various foods of marine origin. It was established that foodstuff of marine origin increased somewhat the docosahexaenoic acid content of the mother's milk. Both consumption of foods of marine origin and docosahexaenoic acid content of the mother's milk were brought into connection with afterbirth depression of the mothers.

Brenna et al. [6] examined long-chain fatty acid composition of milk of 106 mothers. Docosahexaenoic acid content was measured on the average to be 0.23–0.32% (extreme values 0.06 and 1.4%), arachidonic acid content to be 0.13–0.47% (extreme values 0.24–1.0%). A significant relationship was established between the change of the docosahexaenoic acid and that of arachidonic acid.

Xiang et al. [53] examining the essential fatty acid content of milk of Chinese and Swedish mothers analyzed the effect of food on the composition of milk. The Chinese mothers consumed mainly rice, steamed bean, noodles, Chinese cabbage and pork. Food of Swedish mothers consisted of bread, potato, paste, milk, sour milk and cheese. The linoleic acid intake of the Chinese mothers was 14.06 g/day, that of the Swedish mothers 9.91 g/day. The linoleic acid/ α -linolenic acid ratio was significantly higher for the Chinese than for the Swedish. It was established that the linoleic acid concentration in the milk of the Chinese mothers was significantly higher (22.69%) than that of the Swedish mothers (10.93%); whereas concentration of α -linolenic acid was in the milk of the Chinese mothers lower (1.19%) than in that of the Swedish mothers (1.60%). It was also established that the linoleic acid/ α -linolenic acid ratio was much higher in the milk of the Chinese mothers (22.97) than in that of the Swedish ones (7.50) and also the arachidonic acid/docosahexaenoic acid ratio (3.14; 1.56) was higher. Docosahexaenoic acid content of the food had a positive effect on the milk composition of both the Chinese and Swedish

mothers.

Sala-Vila et al. [44] examined the fatty acid composition of the colostrum (day 1–5), transitional milk (day 6–15) and ripe milk (day 15–30) of 66 mothers of Granada bearing at normal time. Determining the essential fatty acid content of the phospholipids it was established that the amount of C18:2n6 (16.16–18.57%), C18:3n3 (0.17–0.27%) and C20:4n6 (3.66–3.95%) fatty acids increased significantly from the colostrum to the ripe milk. The colostrum contained on the other hand more C22:6n3 (1.53–0.97%) fatty acid than the ripe milk. It was established that the milk of mothers of Granada did not differ significantly from the average fatty acid composition of milk of mothers examined in other parts of the world, it contained only less arachidonic acid (0.2%) than e.g. the milk of the German mothers (1.0%).

López-López et al. [27] compared two direct methods for determination of the fatty acid composition of mother's milk. Fatty acids converted into methyl esters were determined by capillary gas chromatography in human colostrum. According to the first method the fatty acids were transesterified using acetyl chloride, while according to the second method a mixture of boron trifluoride and methanol. No difference was found between the traditional and the elaborated direct method, both of the methods gave the same result. In case of docosahexaenoic acid the results were 112.3 and 114.6 $\mu\text{g}/100\text{ cm}^3$, while in case of arachidonic acid 195.3 and 194.7 $\mu\text{g}/100\text{ cm}^3$. Advantage of the boron trifluoride-methanol method is that it is much quicker, can be performed more safely and gives a better yield. In the human colostrum the concentration of the linoleic acid was measured to be between 18.25–18.38%.

Fidler et al. [11] examined essential fatty acid composition of the colostrum of mothers living in Slovenia in town and in country environment, which was in case of linoleic acid (18:2n6) 15.26%, for α -linolenic acid (18:3n3) 0.91%, for docosahexaenoic acid (22:6n3) 0.43%, and for arachidonic acid (20:4n6) 1.03%.

Serra et al. [46] examining essential fatty acid composition of milk of Italian mothers nourishing according to appetite established that with the advance of the lactation reduced significantly the amount of arachidonic acid and docosahexaenoic acid. The amount of linoleic acid in the ripe milk was 9.79%, while that of α -linolenic acid 0.36%.

According to Laryea et al. [25] the essential linolenic acid content (18.28%) of milk fat of Sudanese mother is similar to that of mothers living in the developed countries, on the other hand concentration of the C22:6n3 fatty acid was very low in the milk fat. Bahrami and Rahimi [2] examining essential fatty acid content of milk of West Iranian mothers established that linoleic acid

represented 13.8%, linolenic acid 1.1% and arachidonic acid 1.4% of the total fatty acids of the milk.

According to Koletzko et al. [24] arachidonic acid ranged in most of the studies between 0.4–0.6%, docosahexaenoic acid between 0.2–0.4%. It was established that the different researches did not find significant difference in the linoleic acid and α -linolenic acid content of the mother's milk irrespective of the mothers' living place. The essential linoleic acid and α -linolenic acid content of the mother's milk increases with the ripening of the milk, at the same time arachidonic acid decreases by 38%, docosahexaenoic acid by 50% in the first month of the lactation. The DHA content decreases by approx. 20% between week 6 and week 16 of the lactation, after that it does not change until week 30 of the lactation.

Fidler and Koletzko [10] summarized the results of 15 studies dealing with fatty acid composition of colostrum of mothers from the world's 16 regions. Out of the studies 11 derived from Europe, one from Central America, one from the Caribic, one from Australia and one from Asia. It was established that the amount of the essential fatty acids was similar in the South European countries (Spain, France, Slovenia). In case of mothers living in St. Lucia the rich fish consumption increased the amount of docosahexaenoic acid. Comparing the concentration of docosahexaenoic acid for mother living in different regions it can be established that this was the lowest (0.1–0.2%) in the colostrum of the Italian and German mothers, followed by the Spanish, Slovenian, Swedish, French, Panamian, Chinese and Australian (0.4–0.7%), and it was the highest in the colostrum of mother living in St. Lucia (1.0–1.1%). In two French studies [18, 31] it was described that during a two-year period the fatty acid composition of the colostrum did not change practically, two German studies [14, 19], however, reported that during 14 years docosahexaenoic acid and arachidonic acid content of the colostrum increased. According to a Spanish study of Pita et al. [39] covering 13 years α -linolenic acid content of the colostrum decreased during the experiment. According to Gibson and Knebone [15] in the colostrum of the Australian mothers was the lowest the amount of linoleic acid (7.8%) and α -linolenic acid. In contrast with the above docosahexaenoic acid content (0.6%) of the milk of Australian mothers was higher than that of the European mothers. It was concluded that the fatty acid composition of the mother's colostrum was affected considerably by the geographical and nutritional differences.

Patin et al. [37] examined the effect of the sardine consumption on the essential fatty acid content of the ripe mother's milk. The mothers were divided into two groups regarding sardine consumption. The first group contained

mothers who consumed sardine within 3 days prior to the sampling, while to the second group belonged mothers who consumed sardine four days before the sampling. It was established that there was a significant difference in case of docosahexaenoic acid at all the three sampling time (day 1, day 15, day 30) within the groups (Group 1: 0.35%, 0.61%, 0.67%, Group 2: 0.44%, 0.45%, 0.41%). In case of the n-6 fatty acids a significant difference could be established between the two groups only in the linoleic acid concentration at all the three sampling time (Group 1: 21.48%, 22.59%, 24.11%, Group 2: 21.05%, 19.63%, 20.88%). In case of arachidonic acid and linolenic acid there were only minor differences between the two groups. Examining during the lactation the change of the concentration of the n-6 fatty acids it was established that in case of both groups only the concentration of linoleic acid increased, while concentration of linolenic acid and arachidonic acid decreased.

According to Picciano [38] absorption of the essential fatty acids of the mother's milk in the point of view of the newborn is important not only because of the energy supply but because they contribute to the formation of retina and the nervous tissue. Mother's milk is a rich source of linoleic acid (8–17%), α -linolenic acid (0.5–1%) as well as long-chain fatty acids, arachidonic acid (0.5–0.7%) and docosahexaenoic acid (0.2–0.5%).

Minda et al. [33] examined essential fatty acid content of milk of mothers living in Pécs, on the days 1, 2, 3, 4, 5, 6, 7 and then on day 14 and day 28 after the childbirth. In the course of the examinations it was established that out of the essential fatty acids the amount of linoleic acid decreased until day 4 of the lactation (15.00–13.46%), then rose significantly until day 28 of the lactation (15.12–17.24%). The amount of arachidonic acid (1.09–0.41%) decreases significantly, that of α -linolenic acid increases (0.49–0.67%), while the other fatty acids do not show a considerably change during days 1–28 after the childbirth. According to the authors docosahexaenoic acid content of milk of Hungarian mothers is lower than that of many other population.

3.4 Trans fatty acid

Glew et al. [16] examined trans fatty acid content of milk of North Nigerian Fulani nomadic tribes and townmothers. From 41 Fulani breast-feeding mothers and 41 townmothers who were all in a good health condition, around 15 ml milk sample was taken between 8 and 10 a.m., applying a 4–8 minute-hand milking. The fatty acids were transesterified (0.5 M NaOH in methanol, 14% boron trifluoride) and the fatty acid methyl esters were determined by a gas chromatographic method. Main target of the experiment was to compare milk

fat composition of country and townmothers. The Fulani consumed mainly dairy products deriving only from cows, trans fatty acid content of which was lower than that of the townmothers whose diet contained only a few dairy product. It was surprising that the belief that different nutrition results in different milk fat fatty acid composition was proved to be untrue, as regarding the trans fatty acids there was no difference between the two groups of the mothers. Trans fatty acid content in the milk of the Fulani mothers was 0.22%, in the milk of townmothers 0.34%. The t11-C18:1 vaccenic acid represented more than 85% of the trans C18:1 fatty acids in both groups, the rumenic acid (c9, t11-C18:2) isomer, however, represented approx. 40% of the conjugated linoleic acids in both populations. Average amount of the trans fatty acids in both Nigerian populations (0.22–0.32%) was 7–10 times smaller than that of the French mothers or of the ones living in other developed countries.

Jahreis et al. [22] analyzing the trans vaccenic acid content of cow's, goat's, sheep's, sow's, mare's and mother's milk established that its concentration changed in the milk of ruminants seasonally. According to Silva et al. [49] trans fatty acid content of ripe milk of Brazil mothers is only 2.3% which is very low compared to mother's milk samples examined in other parts of the world.

Hayat et al. [20] examined trans fatty acid content of milk of 19 healthy Kuwaiti mothers aged between 20–30 years. Relating to trans fatty acids C14:1t, C16:1t, C17:1t, C18:1t, C20:1t, and C18:2t in case of the Kuwaiti mothers altogether 2.8% was obtained. Comparing with the trans fatty acid content of milk of Canadian and German mothers (7.2%, 4.4%) it can be established that trans fatty acid content of the milk of the Kuwaiti mothers is the lowest, which is attributed to regional difference.

Wijga et al. [51] examined the composition of the mother's milk and the relationship with allergic diseases in case of allergic and non-allergic women. It was established that in case of the children of allergic mothers the amount of trans fatty acids in the mother's milk could be brought into connection with the allergic symptoms, whereas in case of children of non-allergic mothers no such relationship could be found.

Chen et al. [7] examined trans fatty acid isomers of milk of Canadian mothers. Milk samples were collected from 98 mothers 3–4 weeks after the child-birth, which were daily averages. The fatty acids were converted into methyl esters, and the analyses were carried out by gas liquid chromatography using capillary column. Average concentration of the trans fatty acids was found to be 7.19%, where the lower limit was 0.10, the upper limit 17.15%. Out of the 198 samples 25 contained more than 10% trans fatty acid and 13 samples

contained less than 4%. All the trans isomers of linoleic acid were present in the milk fat in 0.89%, with C18:2 c9,t13 in the highest concentration, followed by c9,t12 and c12,t9. On the basis of the results the average daily trans fatty acid consumption of the Canadian breast-feeding mothers was estimated to be 10.6 g per person, but there were ones who consumed even 20.3 g trans isomer. The proportion of the C18:1 trans isomers in the mother's milk was different than in the cow's milk, and was extremely similar to the partially hydrogenated soya and sunflower oil, which supported the hypothesis that the main sources of the trans fatty acids are the partially hydrogenated vegetable oils.

Precht and Molkentin [40] examined linoleic acid, linolenic acid, oleic acid and trans fatty acid content of milk of 40 German mothers. The amount of C18:1 t11 fatty acid was measured to be 2.4%. In the milk the t4 (0.02%), t5 (0.02%), t6–8 (0.21%), t9 (0.37%), t10 (0.32%), t11 (0.68%), t12 (0.23%), t13 (0.15%), t14 (0.18%), t15 (0.09%) and t16 (0.14%) fatty acid isomers containing one unsaturated bond were identified with vaccenic acid as the dominating one. Also the tC14:1 (0.08%) and tC16:1 (0.15%) fatty acids were identified. Further 6 cis and trans linoleic acid isomers were identified with total amount of 1.07%, and also four trans α -linolenic acid isomers with total concentration of 0.11%. In summary, milk fat of milk of German mothers contained 3.81% trans fatty acid where the extreme values were 2.38 and 6.03%. A direct relationship was established between the trans 18:1 fatty acids of the foodstuffs and composition of the lipids of mother's milk. The amount of the fatty acids was as follows: C12:0 3.12%; C14:0 6.43%; C16:0 25.28%; C18:0 7.41%, C18:1 (total) 33.67%; C18:2 (total) 10.63% and α -C18:3 0.87%.

Bahrami and Rahimi [2] comparing fatty acid composition of milk of West Iranian mothers to that of European and American mothers established that the milk of Iranian mothers contained much middle-chain fatty acids and trans fatty acids which can be explained by the low animal protein and animal fat consumption, the high carbohydrate consumption and by the consumption of partially hydrogenated vegetable oils containing much trans fatty acids. They recommend that the Iranian mothers should consume less trans fatty acid containing foods in order to prevent the harmful effect of the trans fatty acids. According to Minda et al. [33] trans fatty acid content of milk of mothers living in Pécs did not change during the lactation.

3.5 Conjugated linoleic acids

Glew et al. [16] examining conjugated linoleic acid (CLA) content of milk of Fulani nomadic tribes and townmothers compared milk fat composition of Fulani country and townmothers. The Fulani consumed mainly dairy products deriving only from cows, CLA content of which was higher than that of the townmothers whose diet contained only a few dairy product. It was surprising that even due to the different nutrition there was no difference regarding the CLA between the two groups of the mothers. The CLA content was in the milk of the Fulani mothers 0.16%, while in the milk of the townmothers 0.14%.

Mosley et al. [35] studied the synthesis of c9,t11-CLA from vaccenic acid in lactating mothers. Four mothers took part in the experiment on the average on day 247 after the childbirth, who were breast-feeding at least six times a day and consumed foods ordered according to the experiment. Subsequent to starvation in the night they received 25 mg/body mass kilogram trans11-vaccenic acid, and sample was taken in 0, 2, 4, 6, 8, 12, 18, 24 and 48 hours after the vaccenic acid consumption. 8 hours after the consumption the milk's average vaccenic acid content was 3.1%, and it reached its maximum in the hour 18 with 7.6%. c9,t11-CLA content of the milk of the ones consumed a diet supplemented by vaccenic acid reached its maximum in the hour 18 with 0.4%, supporting the hypothesis that from the vaccenic acid δ -9-desaturase enzyme formed conjugated linoleic acid. It was established that around 10% of the c9,t11-CLA content of the milk was formed in the milk gland from vaccenic acid.

Bertschi et al. [3] examined the effect of Alpenbutter consumption of German mothers on the CLA content of the mother's milk with special respect to the CLA isomers. They started to collect the milk samples in the Zurich University Hospital from 20 healthy mothers 2–4 days after the childbirth. The mothers were divided into groups based on the food consumption. Group 1 contained mothers who had a normal diet until day 20 after the childbirth, and received between day 1–10 a food supplementation of 40 g margarine/day, containing 24 g fat and 16 g water, and which was given to the food in four equal portions. Between day 11–20 the food was supplemented with extra 30 g alpine butter per day in three portions, containing 25.7 g fat and 4.3 g water, and 2.09 g conjugated linoleic acid in 100 g, which corresponds to around 0.5 g conjugated linoleic acid intake a day. The mothers recorded their food consumption, during which they did not consume alpine butter and beef. Group 2 contained mothers with normal nutrition, for which the daily estimated milk, dairy product and meat consumption. The difference between Group 2 and

Group 1 was that mothers of Group 2 received between day 1–10 30 g/day margarine, between day 11–20 40 g/day alpine butter in four equal portions. The butter originated from Graubünden (Switzerland), from 2100 m altitude; the 2 kg packings were stored at -20°C until they were utilized. The milk samples were taken on day 1, 5, 10, 15 and 20 of the experiment between 8–11 a.m. CLA content was determined by high-performance liquid chromatography. It was established that due to the alpine butter supplementation the CLA content of the mother's milk increased. The amount of the c9,t11-CLA isomer increased by 49.7%, and a significant increase could be experienced for the t9,t11, t7,c9, t11,c13 and t8,c10 isomers. The remaining nine isomers did not show any change, their concentration was below 5 mg/100 g fat. From the experiments it was concluded that the mother can consciously influence the CLA content of their milk by alpine butter consumption.

McGuire et al. [32] examined CLA content of the mother's milk and the milk replacing food preparations, during which they took milk samples from 14 mothers 3–10 days after the childbirth. The analyses were done using gas chromatograph. Each milk sample contained the c9,t11 CLA isomer in a measurable concentration ranging 2.23–5.43 mg/g with an average and dispersion of 3.64 ± 0.93 mg/g fat. The c9,t11 isomer was 83–100% of the total CLA amount, and out of 14 sample in case of 8 sample only this isomer could be identified. No relationship was found calculating either in fat or milk basis in the CLA content of the mother's milk according to the time elapsed after the childbirth. It was established that the total CLA content of the mother's milk including also the c9,t11 isomer was considerably higher than that of the milk replacing food preparations.

Jahreis et al. [22] recognizing the anti-cancer effect of the c9,t11 CLA isomer analyzed the composition of cow's, goat's, sheep's, sow's, mare's and mother's milk. After the sampling the milks were immediately frozen down to -18°C . To the esterification a chloroform:methanol 2:1 mixture, to the methylation potassium methylate was used, the analyses were carried out gas chromatographically. It was established that in milk of each species the c9,t11 CLA isomer occurred in the majority, with an amount ranging between 0.07–1.35% depending on species in the relative weight percent of the fatty acid methyl esters. As the micro flora of the rumen influences the isomerization of linoleic acid, also the foddering and seasonal effects were taken into consideration during the examinations. The CLA content in the milk of each ruminant changed seasonally (1.28% in July; 0.54% in March). Out of the ruminants, the sheep's milk was the richest in CLA (1.1%), followed by the cow (1.0%) and goat (0.64%). Out of the non-ruminants the mare's milk contained the

least (0.09%) CLA, while that of the sow's 0.2%. The mother's milk contained significantly more conjugated linoleic acid (0.42%) than that of the monogastric domestic animals. In the CLA content of the mother's milk a difference was found between the milk consuming and non-consuming mothers. Comparing the CLA content measured in the individual species it was established that the mother's milk is between the milk of non-ruminants (mare, sow) and that of the ruminants (goat, cow, sheep).

Marangoni et al. [28] examining the essential fatty acid composition of the mother's milk and mother's plasma during the first and third month of the lactation obtained a significant relationship in case of linoleic acid and α -linolenic acid between the composition of the milk and the plasma. In case of the arachidonic acid and docosahexaenoic acid a significant relationship was obtained once, in month 3. It was concluded that in case of linoleic acid and α -linolenic acid there was a close relationship between the composition of the plasma and that of the milk.

Precht and Molkentin [40] examining CLA content of milk of 40 German mothers measured the amount of the main CLA isomer (c9,t11) to be 0.4%.

4 Cholesterol

Clark et al. [8] took milk sample from 10 mothers in the week 2, 6, 12, and 16 of the lactation and determined its total cholesterol and free cholesterol content. The average cholesterol and free cholesterol content of the milk was measured to be 10.3 and 8.3 mg/100 cm³, which values did not change significantly in the time elapsed after the childbirth.

According to Koletzko et al. [24] the mother's milk has high cholesterol content (10–20 mg/100 cm³, 250–500 mg/100 g fat). Cholesterol is 90.1% of the total sterols, followed by desmosterol 8.6%, whereas the amount of the phytosterols is negligible. The mother's food appears not to influence the milk's cholesterol content. Children fed with mother's milk receive around 25 mg cholesterol per body mass kilograms a day, this is around 4 mg for the adults. Plasma cholesterol level in breast-fed babies is higher than that of babies fed with milk replacing food preparations, no relationship was found, however, in the plasma lipid level after the breast-feeding depending on whether the baby was breast-fed or fed with food preparation.

According to Picciano [38] cholesterol content of the mother's milk is low at the beginning of the lactation, and increases gradually during the lactation.

Bitman et al. [4] examined the cholesterol content of the mother's milk

2–3 days after the childbirth, as well as on the day 7, 21 and 42 of the lactation. Milk was taken from 18 mothers with very premature childbirth (in week 26–30 of the lactation), from 28 mothers with premature childbirth (in week 31–36 of the lactation) and from 6 mothers bearing at normal time (week 37–47). Colostrum of mothers bearing at normal time contained significantly less out of these fatty acids compared to mothers with premature childbirth. To the transesterification of the fatty acids a chloroform-methanol mixture was used and their amount was analyzed by thin-layer and gas chromatography. Fatty acid composition of the cholesterol esters was determined by gas liquid chromatography after the cholesterol esters had been isolated by preparative thin-layer chromatography. During the lactation concentration of the total cholesterol and cholesterol esters decreased from 5 mg/dm³ measured in the colostrum to 1 mg/dm³ in the ripe milk. Fatty acid composition of the cholesterol esters was similar in all the three groups after the childbirth. As weight% proportion of the fatty acids esterified by cholesterol the following was obtained: C10:0, 0.7%; C12:0, 2.6%; C14:0, 2.3%; C16:0, 11.4%; C16:1, 5.0%; C18:0, 8.8%; C18:1, 32.9%; C18:2, 30.6%; C18:3, 1.7%; C20:3, 0.9% and C20:4, 1.8%. Proportion of the unsaturated fatty acids in the cholesterol fatty acid esters was 73%, which is considerably higher than in the milk triglycerides. The biggest difference was obtained in the linoleic acid content, which was 30.6% in the cholesterol esters and 13% in the milk fat. From the results it was concluded that in the fatty acid composition of the cholesterol esters the unsaturated fatty acids dominated and that the fatty acid composition of the cholesterol esters considerably differed from the fatty acid composition of the milk fat.

Clark and Hundrieser [9] compared the cholesterol esters of the mother's milk to the total lipid content. By the analysis of 25 milk samples for total lipid, total cholesterol and free cholesterol, the cholesterol esters and triglycerides were isolated and fatty acid composition of each fraction was determined. Total cholesterol content of the mother's milk was 13.5 mg/dm³, which was in a significant positive relationship with the total fat content of the milk. Average of the free cholesterol was 10.9 mg/dm³ which similarly was in a significant positive relationship with the total fat content. With increasing total fat content the fatty acid composition of the cholesterol esters shifted to the saturated fatty acids. The biggest changes were experienced in case of linoleic acid and arachidonic acid that were in negative relationship with the total lipid content. Fatty acid content of the triglycerides exhibited no relationship with the total fatty acid content. From the results it was concluded that the fatty acid composition of the cholesterol esters and that of the triglycerides

differed considerably from each other.

5 Phospholipids

Clark et al. [8] examined the phospholipid content of milk taken from 10 mothers in the week 2, 6, 12, and 16 of the lactation and measured its average amount to be $3.9 \text{ mg}/100 \text{ cm}^3$, which remained unchanged in the examined period. According to Picciano [38] phospholipid content of mother's milk is lower in the early phase of the lactation, it increases in the course of the lactation, however. According to Koletzko et al. [24] phospholipid concentration of the milk is $25 \text{ mg}/100 \text{ cm}^3$ and $0.6 \text{ g}/100 \text{ g}$ lipid, respectively. Within the phospholipids phosphatidyl choline represented 28.4%, phosphatidyl ethanolamine 27.7%, phosphatidyl serine 8.8%, phosphatidyl inositol 6.1% and sphingomyelin 37.5%. Phospholipids have emulsion forming feature, they contribute to the stability of the milk fat micelles. Sphingo- and glykolipids as well as ganglioside contribute to the protective mechanism of the body by absorbing bacterium toxins.

6 Triglycerides

Morera et al. [34] examined triglycerides of the ripe mother's milk and fatty acid composition of the triglycerides in the milk of 40 mothers. They tried to ensure that the milk samples derived from circumstances as various as possible, therefore they took samples from different mothers, on different days, at different hours of the day, from the right and left breast by turns, before and after the baby was breast-fed and before and after the mother ate. The triglycerides were determined by high-performance liquid chromatography and linked mass spectrometer, the fatty acid composition was determined by gas chromatography. Analyzing the obtained results by various statistical methods it was established that the triglyceride content of the mother's milk and fatty acid composition of the triglycerides are relatively stable, showed a minimal variability despite subsequent to the statistical analysis they could be arranged into different groups. Between the concentration of the triglycerides and fatty acid composition of the fat in some cases significant relationship could be found. It was established that the properties of the triglycerides in the mother's milk were considerably influenced by external factors like nutrition, nourishment level, length of the lactation and part of the day. Despite this, some triglycerides can be considered as marker of the ripe mother's milk,

as these, their concentration were not affected by the extremely different sampling conditions. According to Picciano [38] in the mother's milk the lipids are the most important energy supplying compounds, occurring in 97–98% as triglycerides. Fatty acid content of the triglycerides is around 88%.

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References

- [1] Y.Y. Al-Tamer, A.A. Mahmood, Fatty-acid composition of the colostrums and serum of fullterm and preterm delivering Iraqi mothers, *European Journal of Clinical Nutrition*, 58, 8 (2004) 1119–1124.
- [2] G. Bahrami, Z. Rahimi, Fatty acid composition of human milk in Western Iran, *European Journal of Clinical Nutrition*, 59 (2005) 494–497.
- [3] I. Bertschi, M. Collomb, L. Rist, P. Eberhard, R. Sieber, U. Bütikofer, D. Wechsler, G. Folkers, U. Mandach, Maternal dietary alpine butter intake affects human milk: fatty acids and conjugated linoleic acid isomers, *Lipids*, 40, 6 (2005) 581–587.
- [4] J. Bitman, D.L. Wood, N.R. Mehta, P. Hamosh, M. Hamosh, Comparison of the cholesteryl ester composition of human milk from preterm and term mothers, *Journal of Pediatric Gastroenterology and Nutrition*, 5, 5 (1986) 780–786.
- [5] M. Boylan, C. Kuratko, S. Hart, B. Border, Fatty acid composition of breast milk from low income lactating mothers in lubbock, Texas, *Journal of the American Dietetic Association*, 99, 9 (1999) 475–477.
- [6] J.T. Brenna, B. Varamini, R.G. Jensen, Docosahexaenoic and arachidonic acid concentrations in human breast milk worldwide, *American Journal of Clinical Nutrition*, 85 (2007) 1457–1464.
- [7] Z.Y. Chen, G. Pelletier, R. Hollywood, W.M.N. Ratnayake, Trans fatty acid isomers in canadian human milk, *Lipids*, 30, 1 (1995) 15–21.

-
- [8] R.M. Clark, A.M. Ferris, M. Fey, P.B. Brown, K.E. Hundrieser, R.G. Jensen, Changes in the lipids of human milk from 2 to 16 weeks post-partum, *Journal of Pediatric Gastroenterology and Nutrition*, 1, 3 (1982) 311–315.
 - [9] R.M. Clark, K.E. Hundrieser, Changes in cholesteryl esters of human milk with total milk lipid, *Journal of Pediatric Gastroenterology and Nutrition*, 9, 3 (1989) 347–350.
 - [10] N. Fidler, B. Koletzko, The fatty acid composition of human colostrum, *European Journal of Nutrition*, 39 (2000) 31–37.
 - [11] N. Fidler, K. Salobir, V. Stibilj, Fatty acid composition of human colostrums in Slovenian women living in urban and rural areas, *Biology of the Neonate*, 79, 1 (2001) 15–20.
 - [12] N. Fidler, T. Sauerwald, A. Pohl, H. Demmelmair, B. Koletzko, Docosahexaenoic acid transfer into human milk after dietary supplementation: a randomized clinical trial, *Journal of Lipid Research*, 41 (2000) 1376–1383.
 - [13] D.A. Finley, B. Lönnerdal, K.G. Dewey, L.E. Grivetti, Breast milk composition: fat content and fatty acid composition in vegetarians and non-vegetarians, *The American Journal of Clinical Nutrition*, 41 (1985) 787–800.
 - [14] B.O. Genzel, J. Wahle, B. Koletzko, Fatty acid composition of human milk during 1st month after term or preterm delivery, *European Journal of Pediatric*, 156 (1997) 142–147.
 - [15] R.A. Gibson, G.M. Kneebone, Effect of sampling on fatty acid composition of human colostrum, *The Journal of Nutrition*, 110 (1980) 1671–1675.
 - [16] R.H. Glew, J.H. Herbein, M.H. Moya, J.M. Valdez, M. Obadofin, W.A. Wark, D.J. Vander Jagt, Trans fatty acids and conjugated linoleic acids in the milk of urban women and nomadic Fulani of northern Nigeria, *Clinica Chimica Acta*, 367 (2006) 48–54.
 - [17] R.H. Glew, Y.S. Huang, T.A.V. Vander Jagt, L.T. Chuang, S.K. Bhatt, M.A. Magnussen, D.J. Vander Jagt, Fatty acid composition of the milk lipids of Nepalese women: correlation between fatty acid composition of serum phospholipids and melting point, *Prostaglandins, Leukotrienes and Essential Fatty Acids*, 65, 3 (2001) 147–156.

-
- [18] P. Guesnet, J.M. Antonie, L.J.B. Rochette, A. Galent, G. Durand, Polyunsaturated fatty acid composition of human milk in France: changes during the course of lactation and regional differences, *European Journal of Clinical Nutrition*, 47 (1993) 700–710.
- [19] G. Harzer, M. Haug, I. Dietrich, P.R. Gentner, Changing patterns of human milk lipids in the course of the lactation and during the day, *American Journal of Clinical Nutrition*, 37 (1983) 612–621.
- [20] L. Hayat, M.A. Al-Sughayer, M. Afzal, Fatty acid composition of human milk in Kuwaiti mothers, *Comparative Biochemistry and Physiology*, 124 (1999) 261–267.
- [21] J.R. Hibbeln, Seafood consumption, the DHA content of mothers' milk and prevalence rates of postpartum depression: a cross-national, ecological analysis, *Journal of Affective Disorders*, 69 (2002) 15–29.
- [22] G. Jahreis, J. Fritsche, P. Mockel, F. Schbne, U. Moller, H. Steinhart, The potential anticarcinogenic conjugated linoleic acid, cis-9,trans-11 C18:2 in milk of different pecies: cow, goat, ewe, sow, mare, woman, *Nutrition Research*, 19, 10 (1999) 1541–1549.
- [23] E. Knox, D.J. Vander Jagt, D. Shatima, Y.S. Huang, L.T. Chuang, R.H. Glew, Nutritional status and intermediate chain-length fatty acids influence the conservation of essential fatty acids in the milk of northern Nigerian women, *Prostaglandins, Leukotrienes and Essential Fatty Acids*, 63, 4 (2000) 195–202.
- [24] B. Koletzko, M. Rodriguez-Palmeroa, H. Demmelmaira, N. Fidler, R. Jensen, T. Sauerwalda, Physiological aspects of human milk lipids, *Early Human Development*, 65, 2 (2001) S3–S18.
- [25] M.D. Laryea, M. Leichsenring, M. Mrotzek, E.O. el Amin, A.O. el Kharib, H.M. Ahmed, H.J. Bremer, Fatty acid composition of the milk of well-nourished Sudanese women, *International Journal of Food Sciences and Nutrition*, 46, 3 (1995) 205–214.
- [26] L. Lautitzen, L.B. Halkjaer, T.B. Mikkelsen, S.F. Olsen, K.F. Michaelsen, L. Loland, H. Bisgaard, Fatty acid composition of human milk in atopic Danish mothers, *American Journal of Clinical Nutrition*, 84 (1) (2006) 190–196.

-
- [27] A. López-López, A.I. Castellote-Bargalló, M.C. López-Sabater, Comparison of two direct methods for the determination of fatty acids in human milk, *Chromatographia*, 54 (2001) 743–747.
- [28] F. Marangoni, C. Agostoni, A.M. Lammardo, M. Bonvissuto, M. Giovannini, C. Galli, E. Riva, Polyunsaturated fatty acids in maternal plasma and in breast milk, *Prostaglandins, Leukotrienes and Essential Fatty Acids*, 66, 5-6 (2002) 535–540.
- [29] F. Marangoni, C. Agostoni, A.M. Lammardo, M. Giovannini, C. Galli, E. Riva, Polyunsaturated fatty acids concentrations in human hindmilk are stable throughout 12-month lactation and provide a sustained intake to the infant during exclusive breastfeeding, An Italian study, *British Journal of Nutrition*, 84 (2000) 103–109.
- [30] M.C. Marín, A. Sanjurjob, M.A. Rodrigob, M.J.T. Alaniza, Long-chain polyunsaturated fatty acids in breast milk in La Plata, Argentina: Relationship with maternal nutritional status, *Prostaglandins, Leukotrienes and Essential Fatty Acids*, 73 (2005) 355–360.
- [31] J.C. Martin, T. Niyongabo, L. Moreau, J.M. Antonie, M. Lanson, C. Berger, F. Lamisse, P. Bougnoux, C. Couet, Essential fatty acid composition of human colostrums triglycerides: its relationship with adipose tissue composition, *American Journal of Clinical Nutrition*, 54 (1991) 829–835.
- [32] M.K. McGuire, Y. Park, R.A. Behre, L.Y. Harrison, T.D. Shultz, M.A. McGuire, Conjugated linoleic acid concentrations of human milk and infant formula, *Nutrition Research*, 17, 8 (1997) 1277–1283.
- [33] H. Minda, A. Kovács, S. Funke, M. Szász, I. Burus, Sz. Molnár, T. Marosvölgyi, T. Décsi, Changes of fatty acid composition of human milk during the first month of lactation: a day-to-day approach in the first week, *Annals of Nutrition and Metabolism*, 48 (2004) 202–209.
- [34] S. Morera, A.I. Castellote, O. Jauregui, I. Casals, M.C. López-Sabater, Triacylglycerol markers of mature human milk, *European Journal of Clinical Nutrition*, 57 (2003) 1621–1626.
- [35] E.E. Mosley, M.K. McGuire, J.E. Williams, M.A. McGuire, Cis-9, trans-11 conjugated linoleic acid is synthesized from vaccenic acid in lactating women, *Journal of Nutrition*, 136, 9 (2006) 2297–2301.

-
- [36] A.S. Olafsdottir, I. Thorsdottir, K.H. Wagne, I. Elmadfa, Polyunsaturated fatty acids in the diet and breast milk of lactating Icelandic women with traditional fish and cod liver oil consumption, *European Journal of Nutrition, Metabolic Diseases and Dietetics*, 50, 3 (2006) 270–276.
- [37] R.V. Patin, M.R. Vítolo, M.A. Valverde, P.O. Carvalho, G.M. Pastore, F.A. López, The influence of sardine consumption on the omega-3 fatty acid content of mature human milk, *Jornal de Pediatria*, 82 (2006) 63–69.
- [38] M.F. Picciano, Nutrient composition of Human milk, *Pediatric Clinics of North America*, 48, 1 (2001) 53–67.
- [39] M.L. Pita, J. Morales, A. Sanchez-Pozo, J.A. Martinez-Valverde, Influence of mother's weight and socioeconomic status on the fatty acid composition of human milk, *Annals of Nutrition and Metabolism*, 29 (1985) 366–373.
- [40] D. Precht, J. Molkentin, C18:1, C18:2 and C18:3 trans and cis fatty acid isomers including conjugated cis delta 9, trans delta 11 linoleic acid (CLA) as well as total fat composition of German human milk lipids, *Die Nahrung*, 43, 4 (1999) 233–244.
- [41] G. Roquelin, S. Tapsoba, M.C. Dop, F. Mbemba, P. Traissac, Y. Martin-Prevel, Lipid content and essential fatty acid (EFA) composition of mature Congolese breast milk are influenced by mothers nutritional status: impact on infants EFA supply, *European Journal of Clinical Nutrition*, 52, 3 (1998) 164–171.
- [42] G. Roquelin, S. Tapsoba, F. Mbemba, G. Gallon, C. Picq, Lipid content and fatty acid composition in foods commonly consumed by nursing Congolese women: incidences on their essential fatty acid intakes and breast milk fatty acids, *International Journal of Food Sciences and Nutrition*, 49, 5 (1998) 343–352.
- [43] T. Saarela, J. Kokkonen, M. Koivisto, Macronutrient and energy contents of human milk fractions during the first six months of lactation, *Acta Paediatrica*, 94 (2005) 1176–1181.
- [44] A. Sala-Vila, A.I. Castellote, M. Rodriguez-Palmero, C. Campoy, M.C. López-Sabater Lipid composition in human breast milk from Granada (Spain): Changes during lactation, *Nutrition*, 21 (2005) 467–473.

-
- [45] B.L. Schmeits, J.A. Cook, D.J. VanderJagt, M.A. Magnussen, S.K. Bhatt, E.G. Bobik, Y.S. Huang, R.H. Glew, Fatty acid composition of the milk lipids of women in Nepal, *Nutrition Research*, 19, 9 (1999) 1339–1348.
- [46] F. Scopesi, S. Ciangherotti, P.B. Lantieri, D. Risso, I. Bertini, F. Campone, A. Pedrotti, W. Bonacci, G. Serra, Maternal dietary PUFAs intake and human milk content relationships during the first month of lactation, *Clinical Nutrition*, 20, 5 (2001) 393–397.
- [47] G. Serra, A. Marletta, W. Onacci, F. Campone, I. Bertini, P.B. Lantieri, D. Risso, S. Ciangherotti, Fatty acid composition of human milk in Italy, *Biology of the Neonate*, 72, 1 (1997) 1–8.
- [48] J.T. Shores, D.J. VanderJagt, M. Millson, Y.S. Huang, R.H. Glew, Correlation between the content of intermediate chain-length fatty acids and copper in the milk of Fulani women, *Prostaglandins, Leukotrienes and Essential FattyAcids*, 63, 4 (2000) 203–207.
- [49] M.H.L. Silva, M.T.C. Silva, S.C.C. Brandao, J.C. Gomes, L.A. Peternelli, S.C.C. Franceschini, Fatty acid composition of mature breast milk in Brazilian women, *Food Chemistry*, 93, 2 (2005) 297–303.
- [50] B. Sousa, G. Rocha, S. Dorina, J.R. Alves, B. Guedes, H. Guimaraes, Fatty acid composition of human milk lipids in Chilean women, *Acta Padiatrica*, 93, 6 (2004) 855–859.
- [51] H. Wijga Alet, A.C. Houwelingen, M. Kerkhof, C. Tabak, J.C. Jongste, J. Gerritsen, H. Boshuizen, B. Brunekreef, H.A. Smit, Breast milk fatty acids and allergic disease in preschool children: The Prevention and Incidence of Asthma and Mite Allergy birth cohort study, *American Academy of Allergy, Asthma and Immunology*, (2006)
- [52] M. Xiang, S. Lei, R. Zetterström, Composition of long chain polyunsaturated fatty acids in human milk and growth of young infants in rural areas of northern China, *Acta Padiatrica*, 88 (1999) 126–131.
- [53] M. Xiang, L. Harbige, R. Zetterstrom, Long-chain polyunsaturated fatty acids in Chinese and Swedish mothers: Diet, breast milk and infant growth *Acta Padiatrica*, 94 (2005) 1543–1549.

- [54] N. Yamawaki, T. Yamada, Kanno, T. Kojima, T. Kaneko, A. Yonekubo, Macronutrient, mineral and trace element composition of breast milk from Japanese women, *Journal of Trace Elements in Medicine and Biology*, 19, 2–3 (2005) 171–181.

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