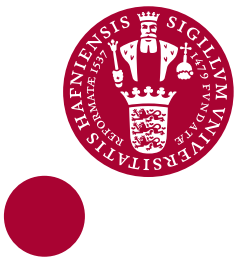

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The stereospecific triacylglycerol structures and fatty acid profiles of human milk and infant formulas

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ABSTRACT

Background: The stereospecific structures of the triacylglycerol molecules in human milk differ from that of cow's milk and vegetable oils, which are the fat sources used in infant formula. In human milk, palmitic acid (16:0) is predominantly esterified in the *sn*2-position, whereas vegetable oils or cow's milk fat contain most of their 16:0 in the outer positions of the triacylglycerol molecules. Furthermore, human milk contains long-chain polyunsaturated fatty acids (LCPUFA), which are not present in either cow's milk or vegetable oils.

Methods: By standard lipid analysis procedures we examined the triacylglycerol structures and fatty acid profiles of fats from 28 infant formulas or formulas for special indications available on the Danish market 1999-2003.

Results: The total fatty acid compositions of the formulas showed a 16:0 content almost similar to human milk, whereas the content in the *sn*2-position was considerably lower. The content of oleic acid was found to be equal to or higher than in human milk in 21 out of 28 formulas; whereas the content in the *sn*2-position was higher in all but one formula. Most formulas had linoleic acid levels considerably above that of human milk. LCPUFA (arachidonic acid and docosahexaenoic acid) were present in all preterm formulas, but only in three of the term formulas.

Conclusion: We found that most of the examined infant formulas, both preterm and term as well as special formulas, had stereospecific structures and fatty acid profiles that differed considerably from that of human milk.

KEYWORDS: Infant formulas, fat, human milk, triacylglycerol structure, polyunsaturated fatty acid

INTRODUCTION

During the last decades there has been increasing interest in the fatty acid composition of infant formulas (1,2). The interest has focused on the content of polyunsaturated fatty acids (PUFA), especially the balance between n-3 and n-6 PUFA and the possible need to add the long-chain PUFA (LCPUFA), docosahexaenoic acid (22:6n-3, DHA) and arachidonic acid (20:4n-6, ARA). Recently, the importance of the stereospecific triacylglycerol structures has been demonstrated (3,4). The target has been to produce an infant formula with a fat content, composition and structure close to that found in human milk. Using a blend of different fats, mainly vegetable oils, it has been possible to match the overall fatty acid composition of human milk, but not the triacylglycerol structure.

Fat absorption is higher from human milk than from infant formula, despite the similarities between the fatty acid profiles (5). This may partly be explained by the unique triacylglycerol structure of human milk. Palmitic acid (16:0) is abundant in human milk and is an important source of energy. Most of the 16:0 in human milk is located in the *sn*2-position of the triacylglycerol molecules (6), in contrast to cow's milk and vegetable oils which have 40 % (7) and 5-20 %, respectively, of the 16:0 in the *sn*2-position (8). Therefore, hydrolysis of human milk fat result in 16:0 mainly as *sn*2-monoacylglycerol, which are well absorbed (7,9). In contrast, after hydrolysis 16:0 from vegetable oils will be present as free fatty acids, which tend to bind calcium and form insoluble calcium-soaps in the intestine that may cause constipation

LCPUFA are present in human milk but have not until now been added to the majority of standard infant formulas avialable in the Danish market. DHA is important for development of the nervous system (2) and ARA is the precursor of eicosanoids (10), which are local mediators involved in, for example, the regulation of the immune function and platelet aggregation. It is presently recommended that the content of the precursors for these

LCPUFA, linoleic acid (18:2n-6, LA) and α-linolenic acid (18:3n-3, LNA), are 500-1200 mg/100 kcal and above 50 mg/100 kcal, respectively, to the infant formulas without LCPUFA and that the ratio of LA to LNA should be between 5 and 15 (11). It is generally agreed that LCPUFA should be added to formulas for preterm infants, whereas no agreement has been reached on whether to add LCPUFA to formulas for term infants (11,12,13).

The aim of this study was to describe the fatty acid compositions and the stereospecific triacylglycerol structures of a selection of formulas in the market in Denmark, to compare these with human milk, when appropriate, and to discuss some of the consequences of these issues. Our focus was on the content and position in the triacylglycerols of 16:0, oleic acid (18:1n-9), LA, LNA, DHA and ARA. Furthermore, we studied structure and profile differences of the fat from formulas with different applications (for premature, term infants or infants with various disorders), with special focus on the presence of medium-chain fatty acids (MCFA, 8:0 and 10:0).

MATERIALS AND METHODS

Twenty-eight different formulas were analyzed. Five of the formulas were for premature infants; eight for term newborn infants (term infant formulas), four were follow-on formulas for infants >4 mo of age, and 11 were special formulas for infants and young children with different disorders (Table 1). The fatty acid profiles and structures were compared to values from different types of human milk. We analysed a pooled sample of human milk derived from mothers delivering prematurely before the gestational age of 34 weeks. The mothers emptied both breasts with the help of an electrical pump and each mother collected the milk in a 24 hour pool. The milk was collected between the second and fourth week after delivery. Furthermore, we included in Table 3 sets of values from the literature (6,9,14). We also

analysed cow's milk (standard full fat pasteurized cow's milk bought during the month of February).

The formulas were purchased and analyzed between 1999-2003. Seven of the formulas were purchased and analyzed both in 1999 and in 2003 (Allomin-1, Allomin-2, soured Allomin, Baby Milk, Enfalac, Nutramigen and NAN H.A). These analyses gave similar results with respect to profile and structure for all except one of the formulas. In 2003 Enfalac had increased proportions of 18:1n-9, ARA and DHA and decreased proportions of lauric acid (12:0) and LA compared to that in the 1999 formula. This paper presents the results of the most recent analyses.

Formula fat analysis

Powdered formulas were dissolved in water (250 mg formula/ml water), whereas liquid formulas, human milk and cow's milk were extracted from their origin. The fats were extracted by the Folch procedure (15) and fatty acids were dissolved in heptane. Fatty acid methyl esters (FAME) were prepared from total lipids through transesterification catalysed by KOH in methanol (16). The FAME were analysed by gas-liquid chromatography using a Hewlett-Packard 5890 series II Chromatograph with flame-ionisation detection (Hewlett-Packard GmbH, Waldbronn, Germany), and a fused silica capillary column (SP-2380, 60 m, ID 0.25 mm, Supelco, Bellefonte, PA). Helium was used as carrier gas. A split ratio of 1:11 was applied in the injector. The column flow was constant at 1.2 mL/min. Initial oven temperature was 70 ^{o}C for 0.5 min and temperature programming was as follows: 15 ^{o}C/min to 160 ^{o}C, 1.5 ^{o}C/min to 200 ^{o}C, which was maintained for 15 min followed by a rate of 30 ^{o}C/min to 225 ^{o}C, which was then maintained for 5 min. FAME peaks in the chromatogram (from octanoic acid (8:0) to DHA (from 4:0 for cow´s milk)) were identified from external

standards (Nu-Chek-Prep, Inc. Minnisota, USA). The chromatogram areas of FAME with fewer than 12 carbons were corrected by response factors.

Regiospecific analyses of the formula fats were performed by degradation of the triacylglycerol molecules with allylmagnesium bromide as Grignard reagent (17). The *sn*2-monoacylglycerol fraction was isolated by thin-layer chromatography on boric acid-impregnated thin-layer chromatography-plates developed twice (2*60 min) in chloroform:acetone (90:10 v/v), methylated, and analysed by gas-liquid chromatography. The fatty acid profiles of triacylglycerol and the *sn*2-position (Tables 2-4) are given as the distribution in wt% of all fatty acids (set to 100 %). The relative proportion of specific fatty acids in the *sn*2-position of the triacylglycerol molecule was calculated as: (M/T*3)*100, where M is the percentage of the fatty acid in the *sn*2-position and T is the percentage of the fatty acid in triacylglycerol (18). Data for the fatty acid profiles represent the mean of two determinations, whereas the analyses of the *sn*2-position represent the mean of three or four determinations. The standard error of the mean (SEM) was <3 % for fatty acids in triacyglycerol and <5 % for the *sn*2-monoacylglycerols.

RESULTS

The fatty acid profiles and the *sn*2-fatty acids of the analysed infant formulas were compared with that of a range of human milk values and cow's milk (Table 2-4). Values market in bold are higher than the range found in human milk and values market in italic are lower. In general, the content of 18:1n-9, LA and LNA were higher in the infant formulas than in human milk both in total fatty acids and in the *sn*2-position. The content of MCFA was more than 20 fold higher than in human milk in six of the formulas: two preterm, two for use in malabsorption, and two for use as energy supplement. DHA was detected in seven

out of the 28 formulas, and in the *sn*2-position of two, whereas ARA was detected in eight formulas and in the *sn*2-position of six.

The ratios of LA to LNA in all of the formulas and cow's milk were within the interval recommended for standard infant formula of 5:1 to 15:1 (Tables 2-4), except Pregestimil, Super Soluble Duocal, Generaid Plus, Neocate and Therapeutic milk (all special formulas), which all had ratios >15:1. The proportions of LA in preterm infant formulas were about twice that in human milk, whereas that of LNA was similar to or twice that in human milk, resulting in LA-to-LNA-ratios that in most of the formulas were higher than in human milk.

DISCUSSION

Most infant formula fats are based on mixtures of vegetable oils or a blend of cow's milk fat and vegetable oils that to some extent mimic the fatty acid profile of human milk, as observed in the present study. However, the stereospecific structure in the formulas differed considerably from that in human milk. Most (about 75 %) of the 16:0 in human milk was located in the *sn*2-position, whereas most of the 16:0 in the formulas was located in the outer positions of the triacylglycerols (75-97 %). Comparison of infant formulas and human milk showed that 18:1n-9 replaced 16:0 in the *sn*2-position, as in vegetable oils (e.g. rapeseed and palm oils). This indicates that the largest part of the fat used in the formulas was of vegetable origin, except for Baby Milk, which was primarily based on cow's milk fat.

The human milk values we have used for comparison show a quite constant fatty acid pattern, despite the types of human milk being quite different (preterm milk, colostrums and mature milk). As expected the largest variation was in the content of DHA which is highly dependant on the mothers intake of DHA (19).

Constipation is more often observed in formula fed infants than in breast-fed infants (20). The structure differences between infant formula fats and human milk is one of the major reasons for the formation of insoluble calcium-soaps in the intestine. Betapol (Loders Croklaan, Wormerveer, The Netherlands) is a synthetic fat produced to mimic human milk fat both in total fatty acid profile and in structure (45 % of the 16:0 in the *sn*2-position). Studies with Betapol and other structured human milk substitutes showed that fats rich in *sn*2-16:0 compared to fats with a lower proportion of the 16:0 in the *sn*2-position improved absorption of 16:0 and calcium and reduced the excretion of calcium-soaps in the faeces of preterm infants (3), term infants (4) and rats (21). These studies support a beneficial physiological effect of the specific structured triacylglycerols on fat and calcium absorption. However, problems with calcium soap formation can also be solved by substituting 16:0 with other fatty acids, *e.g.* 18:1n-9, as in many of the infant formulas, or with medium chain fatty acids (MCFA.).

High proportions of MCFA were found in special formulas for infants with malabsorption, lymphatic disorders, renal disease, liver disease (Pregestimil, Monogen, Super Soluble Duocal and Generaid Plus), and for preterm infants (PreNAN, Enfalac). These were added primarily instead of 16:0 as a readily available energy source. Infants with malabsorption can easier degrade, absorb and transport MCFAs than fatty acids of longer chain length. MCFAs are absorbed mainly to the portal vein and transported directly to the liver for β-oxidation (22). Formation of insoluble calcium-soaps in the intestine is low to non-existing, when MCFAs replace 16:0, due to the higher absorption (23,24). The nutritional value of special formulas with a high content of MCFA may be increased by addition of LCPUFA, possibly even further if the fat is structured (3). LCPUFA absorption has been shown to be improved in rats with malabsorption, if LCPUFA is supplied in fat with

MCFA in the outer positions and LCPUFA in the *sn*2-position (25,26) and so have fat utilisation and nitrogen retention in piglets (27).

The LA and LNA content of infant formulas are believed to cover the need of n-6 and n-3 LCPUFA in term infants through elongation and desaturation to ARA and DHA. According to the current Nordic recommendations for infants 6-11 months of age the dietary intake of n-6 and n-3 PUFA should supply at least 4.0 % and 1.0 % of the energy intake, respectively (28). Since the fat content of breast-milk and formulas constitutes about 50 % of the energy, this is equivalent to a n-6 and n-3 PUFA content of approximately 8 and 2 wt%, respectively. Only four of the formulas in our study were found to have LNA content of around 2 wt%. The ESPGHAN Committee on Nutrition (29) and the Scientific Committee on Food (15) recommend that the ratio of LA to LNA in infant formulas should be 5-15. This recommendation was made in the absence of data on functional or clinical outcomes (30). Lowering the ratio of LA to LNA from 10:1 to 5:1 in formula fats resulted in modest increase in plasma DHA, but with no detectable effect on visual acuity or growth rate (30). Most of the formulas were found to have a high LA content well above that in human milk. A few of the formulas, mostly special formulas intended for infants with special needs, had a very high content of LA and ratios of LA to LNA between 17-55:1. Recent studies indicate that DHA formation is inhibited by a high supply of LA (31,32). Therefore, there may be a need to decrease the LA content, or supply LCPUFA, in order to meet the n-3 LCPUFA needs in infants. However, the ratio of LA to LNA in infant formulas has improved since we analysed infant formulas in the Danish market in the mid 1990s (33).

Only seven of the 28 infant formulas contained DHA and only eight of them had ARA. In human milk 55 % of DHA was found to be specifically located in the *sn*2-position of the triacylglycerol. Of the seven infant formulas that contained DHA, only PreNAN and Enfalac had high levels in the *sn*2-position (34-50 %). Preterm infants have significantly

lower ARA and DHA status than full-term infants, because they do not receive the intrauterine supply of these fatty acids during late pregnancy (34). Dietary deficiency of ARA and DHA has therefore become an issue for the nutrition of preterm infants. Our results showed that the contents of these fatty acids in the formulas were similar to or lower than in human milk in four out of five formulas for ARA, and in all the preterm formulas for DHA. However, compared to other countries Danish mothers have a high n-3 LCPUFA intake and, thus, high levels of DHA in their milk (2).

The ratio of LA to LNA and the presence of LCPUFA in some of the formulas demonstrate that an improvement of the fatty acid profiles of the infant formulas has taken place over the last decades, although the content of LNA is still low and that of LA high compared to current recommendations and compared to the content in human milk from Danish mothers. In the present study the structure analyses of the formulas showed that there was a discrepancy between the locations of the fatty acids in formula fats compared with that in human milk. In contrast to human milk, 16:0 in infant formulas was located primarily in the outer positions of the triacylglycerol molecules, which may increase the risk of constipation. Only few formulas contained LCPUFA, most of which was located in the outer position of the triacylglycerol molecules, and thus at potential risk of slow and low absorption.

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ABBREVIATIONS

ARA	Arachidonic acid
DHA	Docosahexaenoic acid
FAME	Fatty acid methyl esters
LA	Linoleic acid
LCPUFA	Long-chain polyunsaturated fatty acid
LNA	α-linolenic acid
MCFA	Medium-chain fatty acid
PUFA	Polyunsaturated fatty acid

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Table

Table 2. *The fatty acid profiles and composition in the sn2-position of triacylglycerols of human milk, cow's milk and infant formulas intended for preterm infants*[a]

	Human milk				Cow's milk	Standard preterm formula				
	Pooled sample Preterm milk	Innis et al (9) 3 mo after elivery	Jensen et al (6) Mature milk	Martin et al (14) Colostrum		Enfalac	Pre-Aptamil	Pre-Babymin A	Pre-Babymin B	Pre-NAN
Triacylglycerol										
8:0[b]	0.2				**1.1**	**22.3**	**2.3**	**0.7**	**2.0**	**15.8**
10:0	1.4		2.9	0.4	2.8	**12.1**	1.7	1.3	1.5	**10.6**
12:0	5.7	4.1	7.3	4.8	*3.4*	*1.6*	**13.5**	5.2	**11.4**	*0.5*
14:0	6.9	5.5	9.4	8.5	**11.1**	*1.0*	5.6	5.8	4.7	*0.7*
16:0	25.7	21.0	27.0	25.8	**32.3**	*6.1*	*15.9*	**28.6**	*17.1*	*11.2*
16:1	2.8	3.1	3.6	3.2	*2.1*	*0.1*	*0.5*	*1.1*	*0.5*	*0.3*
18:0	8.1	7.1	7.1	5.9	**11.2**	*2.5*	*4.4*	6.8	*4.5*	*3.0*
18:1t	0.7				**2.9**	-	*0.2*	*0.3*	*0.1*	-
18:1n-9	33.1	40.2	34.2	32.6	*20.7*	*29.0*	**40.4**	33.4	37.3	35.9
18:1n-7	1.8				*0.6*	*0.7*	*1.0*	*0.9*	*1.0*	*1.0*
18:2 n-6	9.5	13.4	7.9	13.2	*1.8*	**20.5**	11.9	12.5	**16.8**	**16.7**
18:3 n-3	1.1	1.5	trace	0.7	*0.2*	1.8	1.3	0.9	1.4	2.2
20:4n-6	0.4	0.5		0.6	-	**0.8**	0.4	*0.3*	*0.3*	*0.2*
22:6n-3	0.4	0.2		0.5	-	0.4	0.2	0.2	0.2	0.3
others	2.3	1.2		3.5	**9.8**	1.2	*0.6*	2.1	1.2	1.4
18:2n-6/18:3n-3	8.8	8.9		18.9	9.9	11.6	9.3	14.3	12.2	7.6
sn-2 position										
8:0	0.2				**0.8**	**21.3**	0.2	*0.1*	*0.1*	**13.6**
10:0	0.9		1.6	0.4	**3.3**	**12.9**	*0.9*	1.1	0.7	**11.7**
12:0	6.1	2.5	6.9	3.8	4.9	2.7	**24.0**	6.4	**19.7**	*0.8*
14:0	12.0	6.2	15.4	11.1	**18.0**	*0.8*	*3.6*	9.1	*2.9*	*0.9*

16:0	57.1	54.2	57.1	53.5	*37.8*	*1.2*	*3.3*	*19.4*	*4.7*	*3.7*
16:1	2.9	3.5	1.6	3.2	2.6	*0.1*	*0.3*	*1.1*	*0.3*	*0.3*
18:0	1.6	2.9	4.9	1.7	**5.5**	*0.3*	*0.6*	2.7	*0.7*	*0.7*
18:1t	-				**2.3**	-	**0.1**	**0.2**	**0.1**	-
18:1n-9	9.5	17.1	8.1	13.8	15.3	**31.8**	**45.5**	**39.1**	**44.0**	**41.2**
18:1n-7	0.7				*0.4*	*0.3*	*0.5*	*0.6*	*0.6*	*0.2*
18:2n-6	5.4	8.1	3.7	8.4	*1.8*	**25.5**	**18.7**	**17.7**	**24.3**	**23.0**
18:3n-3	0.5	0.9		0.4	0.4	**1.5**	**2.1**	0.8	**1.6**	**3.1**
20:4n-6	0.3	0.7		0.7	-	0.7	*0.1*	*0.1*	*0.1*	-
22:6n-3	0.6	0.4		0.7	-	0.6	-	-	-	*0.3*
Others	1.7	0.9		3.4	**6.9**	*0.3*	*0.2*	1.5	*0.3*	*0.4*

[a]Data represent the average of two determinations for triacylglycerols and 3-4 determinations of the sn2-position and are expressed in wt% of total fatty acids in triacylglycerol or the sn2-position, respectively.
[b]Fatty acids are designated by the number of carbon atoms followed by the number of double bonds. The position of the first double bond relative to the methyl (n) end of the molecule is also indicated.
Values in **bold** are higher than the range of human milk values and values in *italic* are lower.

Table

Table 3. *The fatty acid profiles and composition in the sn2-position in triacylglycerols of infant formula fat*[a]

	Standard infant formula for term infants								Follow-on formula (from 4 months)			
	Allomin	Aptamil	Baby Milk (liquid)	Babymin	HIPP-1	NAN-1 new	Nidina	Soured Allomin	Allomin-2	Allomin + rice flour	HIPP-2	NAN-2
Triacylglycerol												
8:0[b]	**0.4**	**1.2**	**1.0**	**2.1**	**-**	**1.6**	**2.1**	**0.5**	-	**0.5**	-	**1.2**
10:0	0.9	1.4	1.7	1.7	*0.1*	1.1	1.2	1.0	-	1.1	*0.1*	0.9
12:0	*1.3*	6.0	*3.6*	**13.6**	*0.2*	**8.5**	**8.5**	*1.4*	*0.2*	*1.4*	*0.2*	7.0
14:0	*4.4*	5.8	7.0	5.7	*0.9*	*3.9*	*4.0*	*4.7*	*0.7*	*4.7*	*0.9*	*3.3*
16:0	**29.1**	26.6	**31.7**	*15.9*	**29.7**	24.7	*24.0*	**28.9**	**28.6**	**30.8**	**31.4**	*22.3*
16:1	*0.7*	*1.1*	*1.1*	*0.5*	*0.2*	*0.2*	*0.2*	*0.7*	*0.2*	*0.8*	*0.2*	*0.2*
18:0	6.8	6.3	7.7	*4.4*	*3.8*	*3.3*	*3.2*	7.2	*4.1*	6.3	*3.8*	*3.7*
18:1t	**1.5**	-	**1.2**	-	-	-	-	**1.6**	-	-	-	-
18:1n-9	33.6	34.7	*29.5*	40.2	**41.0**	**36.6**	**37.1**	**34.7**	**41.7**	**34.2**	40.2	37.2
18:1n-7	*1.7*	*1.2*	*0.9*	*1.0*	*1.3*	*1.1*	*1.1*	*1.6*	*1.2*	*1.0*	*1.2*	**1.9**
18:2n-6	**15.6**	11.2	10.0	11.9	**18.9**	**16.2**	**15.5**	**13.5**	**19.5**	12.7	**18.6**	**19.2**
18:3n-3	1.8	1.7	1.2	1.3	1.9	2.0	1.6	1.5	1.9	1.4	1.7	2.4
20:4n-6	-	*0.3*	*0.1*	0.4	-	-	-	-	-	-	-	-
22:6n-3	-	0.2	-	0.2	-	-	-	-	-	-	-	-
others	2.3	2.2	3.3	*1.1*	2.1	*0.8*	1.5	2.7	1.9	**5.1**	1.8	*0.8*
18:2n-6/18:3n-3	8.5	6.5	8.5	9.2	10.0	8.1	9.5	9.1	10.1	9.0	11.2	8.1
*sn*2-position												
8:0	**0.5**	**0.3**	0.2	0.2	-	**0.4**	0.2	-	-	*0.1*	-	-
10:0	0.7	0.9	1.6	0.8	-	0.5	0.6	0.5	-	0.6	-	-

12:0	*1.4*	**9.4**	5.8	**23.6**	*0.2*	**13.9**	**14.3**	*1.6*	*0.1*	*1.1*	*0.2*	4.4
14:0	6.9	7.2	11.2	*3.6*	*0.7*	*2.1*	*2.4*	7.1	*0.6*	*3.9*	*0.7*	*1.7*
16:0	*20.7*	*16.6*	*26.3*	*3.4*	*10.3*	*5.3*	*5.6*	*18.4*	*9.3*	*14.4*	*12.3*	*6.0*
16:1	*0.8*	*1.1*	*1.4*	*0.3*	*0.1*	*0.1*	*0.1*	*0.9*	-	*0.5*	*0.1*	-
18:0	3.6	2.6	3.4	*0.6*	*0.6*	*0.7*	*0.5*	3.0	1.8	2.1	*0.8*	*0.9*
18:1t	**1.3**	-	**1.0**	-	-	-	-	**1.3**	-	-	-	-
18:1n-9	**39.1**	**40.1**	**31.2**	**46.0**	**54.2**	**49.1**	**48.0**	**44.2**	**55.3**	**48.2**	**53.2**	**52.1**
18:1n-7	*0.6*	*0.6*	*0.5*	*0.5*	*0.6*	*0.6*	*0.5*	-	*0.6*	*0.6*	*0.6*	**0.8**
18:2n-6	**21.1**	**17.4**	**13.9**	**18.6**	**29.0**	**24.5**	**23.9**	**19.7**	**27.0**	**22.5**	**27.4**	**30.0**
18:3n-3	**2.6**	**2.3**	**1.5**	**2.1**	**3.1**	**2.9**	**2.6**	**2.1**	**2.7**	**2.3**	**2.7**	**4.0**
20:4n-6	-	*0.1*	-	*0.1*	-	-	-	-	-	-	-	-
22:6n-3	-	-	-	-	-	-	-	-	-	-	-	-
Others	*0.7*	1.4	1.9	*0.3*	1.2	-	1.3	1.2	2.6	**3.8**	1.9	-

[a]Data represent the average of two determinations for triacylglycerols and 3-4 determinations of the sn2-position and are expressed in wt% of total fatty acids in triacylglycerol or the sn2-position, respectively.
[b]Fatty acids are designated by the number of carbon atoms followed by the number of double bonds. The position of the first double bond relative to the methyl (n) end of the molecule is also indicated.
Values in **bold** are higher than the range of values for human milk (table 2) and values in italic are lower.

Table

Table 4. *The fatty acid profiles and composition in the sn2-position of triacylglycerols of foods for special medical purpose*[a]

	Foods for special medical purpose										*Other foods*
	Generaid plus	Monogen	NAN H.A.	Neocate	Nutramigen	Nutramigen 2	Pregestimil	Profylac	Prosobee	Super Soluble Duocal	Therapeutic milk
Triacylglycerol											
8:0[b]	**23.5**	**51.5**	**1.2**	**2.2**	**1.4**	**1.5**	**35.4**	-	**1.4**	**23.3**	**3.9**
10:0	**5.6**	**33.7**	**1.0**	**1.7**	**1.1**	**1.1**	**16.4**	-	**1.2**	**5.8**	2.8
12:0	**13.6**	*0.5*	**7.8**	**13.0**	**9.1**	**8.8**	*0.1*	*0.3*	**9.5**	**13.8**	**22.2**
14:0	*5.4*	*0.6*	*3.8*	*5.2*	*4.2*	*3.9*	-	*0.8*	*4.3*	5.5	**9.5**
16:0	*8.3*	*2.7*	24.3	*8.3*	22.6	22.9	*4.4*	**27.7**	22.2	*7.9*	25.6
16:1	*0.1*	-	*0.2*	-	*0.1*	*0.1*	-	*0.2*	*0.1*	*0.2*	-
18:0	*2.7*	*2.0*	*4.0*	*4.1*	*3.7*	*3.8*	*1.4*	*3.3*	*4.1*	*2.4*	**8.4**
18:1t	*0.3*	-	-	-	-	-	-	*0.4*	-	-	**1.3**
18:1n-9	*13.7*	*2.6*	35.8	**46.6**	37.9	36.5	*20.3*	**48.2**	36.2	*13.8*	*20.0*
18:1n-7	*0.3*	-	1.8	*0.6*	*1.4*	*0.8*	*0.4*	**2.2**	*0.8*	*0.3*	-
18:2n-6	**25.2**	*5.3*	**17.1**	**16.3**	**17.1**	**18.3**	**20.1**	**14.5**	**17.7**	**26.0**	*5.2*
18:3n-3	0.7	1.0	2.0	1.0	1.2	1.4	1.0	1.7	1.8	*0.5*	*0.3*
20:4n-6	-	-	-	-	-	-	-	-	-	-	-
22:6n-3	-	-	-	-	-	-	-	-	-	-	-
Others	*0.4*	-	*1.0*	*0.9*	*0.1*	*1.0*	*0.5*	*0.7*	*0.7*	*0.6*	*0.7*
18:2n-6/18:3n-3	**36.4**	5.5	8.4	**16.8**	14.5	13.5	**20.3**	8.7	9.9	**54.8**	**17.8**
*sn*2-position											
8:0	**20.4**	**52.0**	-	0.2	*0.1*	0.2	**36.1**	-	**0.4**	**22.7**	-
10:0	**5.6**	**39.0**	-	0.9	0.4	0.4	**19.6**	-	0.6	**5.9**	1.0
12:0	25.7	0.9	**5.8**	**23.7**	**14.6**	**14.6**	*0.1*	-	**15.8**	**23.5**	**35.5**
14:0	3.3	1.1	*1.8*	*3.2*	*2.4*	*2.4*	-	*0.2*	*2.1*	*2.9*	*5.1*
16:0	2.3	2.1	*5.7*	*3.0*	*6.2*	*6.1*	*0.4*	*5.0*	*4.9*	*1.4*	*10.1*
16:1	0.1	-	*0.2*	-	-	-	-	*0.1*	*0.1*	-	-
18:0	1.7	1.9	*0.6*	2.6	*1.4*	*1.4*	*0.1*	*0.7*	*0.5*	*1.2*	**6.7**
18:1t	0.3	-	-	-	-	-	-	**0.6**	-	-	**1.7**
18:1n-9	12.7	1.1	**52.3**	**46.9**	**50.8**	**50.6**	**19.8**	**63.6**	**49.2**	**13.0**	**30.1**
18:1n-7	0.1	-	**1.3**	-	*0.4*	*0.4*	*0.2*	**1.3**	*0.4*	*0.1*	-
18:2n-6	27.4	1.6	**28.6**	**18.7**	**22.5**	**22.5**	**22.8**	**26.0**	**25.0**	**28.9**	**9.4**
18:3n-3	0.4	0.3	**3.7**	**0.8**	**1.0**	**1.0**	**0.8**	**2.5**	**1.1**	0.4	0.5
20:4n-6	-	-	-	-	-	-	-	-	-	-	-
22:6n-3	-	-	-	-	-	-	-	-	-	-	-
Others	-	-	*0.1*	-	-	*0.3*	*0.1*	-	-	-	-

[a]Data represent the average of two determinations for triacylglycerols and 3-4 determinations of the sn2-position and are expressed in wt% of total fatty acids in triacylglycerol or the sn2-position, respectively.
[b]Fatty acids are designated by the number of carbon atoms followed by the number of double bonds. The position of the first double bond relative to the methyl (n) end of the molecule is also indicated.
Values in **bold** are higher than for human milk and values in italic are lower.

Table 1. *List of infant formulas and foods for special medical purpose, the year they were purchased, manufacturer and type and indications for special medical foods.*

Formula	Purchased	Manufacturer
Formula for preterm infants		
Enfalac	2003	Mead Johnson
Pre-Aptamil	2001	Milupa GmbH
Pre-Babymin A	2000	Milupa GmbH
Pre-Babymin B	2000	Milupa GmbH
Pre-NAN	2000	Nestlé
Infant formula for term infants		
Allomin	2003	Beauvais
Allomin Soured	2003	Beauvais
Aptamil	2001	Milupa GmbH
Babymilk	2003	Arla
Babymin	1999	Milupa GmbH
HIPP 1	2002	HIPP GmbH & Co Vertrieb KG
NAN 1 new	2003	Nestlé
Nidina 1	2002	Nestlé
Follow-on formula (from 4 months)		
Allomin 2	2003	Beauvais
Allomin rice flour	2003	Beauvais
HIPP 2	2002	HIPP GmbH & Co Vertrieb KG
NAN 2	1999	Nestlé
Foods for special medical purpose		
Generaid Plus	1999	SHS international *(For hepatic disorders, for sole source of nutrition it is recommended to supplement with a source of α-linolenic acid)*
Monogen	1999	SHS international *(High content of MCT for use in lipid and lymphatic disorders)*
NAN H.A	2003	Nestlé *(Hydrolyzed protein for infants at risk of allergy)*
Neocate	2003	SHS international *(Protein as amino acids, for cow's milk allergy and multiple food intolerance)*
Nutramigen	2000	Mead Johnson *(Hydrolyzed protein, for prevention and treatment of cow's milk allergy)*
Nutramigen 2	2003	Mead Johnson *(Hydrolyzed protein, for prevention and treatment of cow's milk allergy from 4 months)*
Pregestimil	1999	Mead Johnson *(Hydrolyzed protein for fat malabsorption)*
Profylac	1999	Alk (*Hydrolyzed protein, for prevention and treatment of cow's milk allergy)*
Prosobee	2001	Mead Johnson *(Soy-protein, for cow's milk allergy)*
Super Soluble Duocal	2001	SHS international *(Energy supplement with carbohydrate and fat, for liver disease and catabolic states)*
Other foods		
Therapeutic milk	1999	Compact *(For "therapeutic feeding" in severely malnourished children in developing countries)*