Fatty Acid Composition of Commercially Available Nutrition Supplements

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Abstract

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We analysed the fatty acid (FA) composition of plant and fish oil supplements available in the Czech Republic. Total lipid FA composition was analysed by gas chromatography. A total of 62 plant and 50 fish oil supplements were analysed. Their FA composition ranged widely. Linoleic acid was a dominant FA in soya lecithin (45–60%), evening primrose (65–75%), amaranth (20–50%), pumpkin seed (45–55%), and borage oil supplements (40%). α-Linolenic acid ranged between 2% and 8% in soya lecithin and from 0.2% to 1% in the majority of the other plant oil supplements. Saw palmetto oil supplements were rich in saturated FA (40–90%). γ-Linolenic acid was found in evening primrose and borage oil supplements (10–20%). Sea buckthorn oil composition varied according to the part of the plant used. The majority of fish oil supplements contained 12–23% of eicosapentaenoic and 7–17% of docosahexaenoic acids. Oil supplements may be beneficial for patients with metabolic disorders because of their FA as well as antioxidant and phytosterol content.

Keywords: dietary fat; plant oil; fish oil

The type of dietary fat ingested is determined by the fatty acid (FA) composition of foods and nutrition supplements (if consumed) and can substantially influence the human health. It is nowadays considered that the composition of dietary fat is very important in determining health outcomes of metabolic disorders (Kremmyda *et al.* 2011; Tvrzicka *et al.* 2011). Dietary FA influence their composition in plasma lipoproteins, cell membranes, as well as in adipose tissue (Pedersen *et al.* 2011). This tissue has a plethora of endocrine and autocrine/paracrine functions associated with the secretion of adipokines (Virtue & Vidal-Puig 2010) and inflammatory mediators (Browning *et al.* 2008). Composition of FA in cell membranes may in turn affect gene expression and metabolism (Flachs *et al.* 2009).

Polyunsaturated FA (PUFA) include the n-6 and n-3 PUFA families. In the n-6 PUFA family the parent FA is linoleic acid (LA). Its metabolic products are γ-linolenic (GLA), dihomo-γ-linolenic (DHGLA), and arachidonic (AA) acids. High concentrations of n-6 PUFA are found in soybean oil, sunflower seed oil, safflower oil, evening primrose oil, and borage seed oil. As ligands of peroxisome proliferator-activated receptor-γ (PPAR-γ), n-6 PUFA increase insulin sensitivity, and change the distribution of fat and the size of adipocytes (Staels 2000). Importantly, AA is a major precursor of eicosanoids which are potent signalling molecules both inside and outside the cell (Vergroesen 1989).

In the n-3 PUFA family the parent FA is α-linolenic (ALA). Its main metabolic products are eicosapentaenoic (EPA) and docosahexaenoic (DHA) acids. Dietary sources of ALA are seeds and leaves of some plants – soybeans, linseed, blackcurrant seeds and borage leaves. Its metabolites, EPA and DHA, can be taken from the diet through oily fish.

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In humans, LA and ALA cannot be synthesised endogenously and must be taken from the diet (essential fatty acids; EFA). Further elongation and desaturation of EFA to produce long-chain (LC) PUFA (EPA, DHA, AA) is possible but not very efficient in humans. Long-chain n-3 PUFA are thought to activate PPAR-α, decrease lipogenesis and very low density lipoprotein (VLDL) secretion (Burdge 2009). The immunomodulatory properties of LC n-3 PUFA are related to altered T-lymphocyte activity (Calder 2009) and eicosanoid and docosanoid production (Serhan 2011).

In persons with metabolic disorders, FA intake may be inappropriate, characterised by high saturated FA (SFA) and low monounsaturated FA (MUFA) and PUFA intake, especially those of the n-3 PUFA family. Similar changes in plasma FA profiles were found in such diametrically different metabolic disorders as metabolic syndrome (characterised by hypernutrition) on the one side, and different types of malnutrition (marantic type, kwashiorkor-type, cancer cachexia) on the other one. These changes were characterised by significantly decreased content of LA and increased content of palmitoleic acid (Žák *et al*. 2005, 2007) as well as lower content of plasma n-3 PUFA in cancer patients. Inadequate or inappropriate FA intake may be compensated by nutrition supplements. Furthermore, recent trials have provided strong support for supplementation of n-3 PUFA in patients with cancer. The supplementation of n-3 PUFA resulted in the preservation of fat mass and skeletal muscle during the natural course of cancer cachexia and/or antineoplastic therapy (Murphy *et al.* 2012).

The aim of the present study was to analyse the FA composition of nutrition supplements with plant and fish oil extracts, commercially available in the Czech Republic from health food/drug stores or the internet. Information on the FA composition of food supplements should be useful to specialists (physicians, nutritional therapists) as an aid for nutritional recommendations.

Table 1. Soya lecithin containing supplements

Supl. No.	Product name	Producer
1	Bio Pharma® Lecithin	Bio-Pharma®
2	GS Lecithin 1200	Green-Swan Pharmaceuticals™
3	Lecithin	VitaHarmony™
4	Lecithin 1200 mg	Walmark™
5	Lecithin 1200 mg	Alier™
6	Lecithin	Brain Pharma™
7	Lecithin	Intercaps™
8	Lecithin 1200 mg	MedPharma™
9	Lecithin Fit	Silvita™
10	Lecithin Forte	Liftec™
11	Lecithin Natural	Magador™
12	Soya Lecithin granulate	Sunpharm™
13	Super Lecithin 1250 mg	Unios Pharma
14	Soyafemin capsules	Dr. Theiss Naturwaren™ GmbH
15	Sarapis Soya	Sanamed™ GmbH

MATERIAL AND METHODS

Supplements analysed. Commercially available nutrition supplements containing plant or fish oils were identified and purchased from health food and drug stores in the Czech Republic during 2005–2011. The supplements are categorised and presented according to their main oil extract:

Table 2. Evening primrose and borage oil containing supplements

Supl. No.	Product name	Producer	Note
16	Evening primrose 'healthy heart and veins'	Delpharmea™	borage oil
17	Evening primrose oil	Swiss Herbal Remedies™ Ltd.	
18	Evening primrose	Walmark™	
19	Evening primrose	Walmark™	vitamin E
20	Evening primrose	Ivax-CR™	vitamin E, iron
21	Evening primrose 500 mg	MedPharma™	
22	Evening primrose	Intercaps™	vitamin E
23	Evening primrose oil	Aromatica™	
24	Evening primrose oil	HM Harmonie™	
25	Evening primrose oil	Aromatica™	β-carotene, vitamin E
26	Evening primrose oil	Aromatica™	vitamin E
27	Vital evening primrose	Achatpharma™	
28	Evening primrose	Walmark™	
29	Evening primrose Forte	Virde™	
30	Borage oil	Herb-Pharma™	
31	Borage oil 250 mg	Walmark™	
32	Vital Borage GLA	Achatpharma™	

Table 3. Amaranth oil and sea buckthorn containing supplements

Supl. No.	Product name	Producer	Note
Amaranth oil			
33	Amarantol SQr-C	AMR Amaranth™	
34	Amarantfibre lecithin mix	AMR Amaranth™	lecithin
35	Amaven	AMR Amaranth™	
36	Ive	Simply You™	
Sea buckthorn			
37	Sea buckthorn tablets	Virde™	
38	Sea buckthorn oil	Pharma Activ™	
39	Sea buckthorn oil	Relikt-Art Engel™	
40	Sea buckthorn oil	Dr. Jiri Pantucek-Topvet™	
41	Sea buckthorn Forte	Virde™	

soya lecithin, evening primrose, borage, amaranth, sea buckthorn, saw palmetto, pumpkin seed, and fish oil. The nutrition supplements are listed in supplementary Tables 1–5.

Fatty acid analysis. A sample of 5 µl or 5 mg from each oil supplement (capsule or syrup/tablet) was analysed from one single batch. Samples were converted directly to fatty acid methyl esters (FAME) as previously described (Tvrzicka *et al.* 2002) and analysed by capillary gas chromatography.

Table 4. Saw palmetto and/or pumpkin seed oil containing supplements

Supl. No.	Product name	Producer	Note
42	Decolen	GSN™	
43	Prostachol	Valosun™	
44	Prostasun	Valosun™	lycopene, vitamin E
45	ProstaX	SVUS Pharma™	
46	Proval® EPI	Valosun™	
47	GS Triomen	Green-Swan Pharmaceuticals™	
48	Healthy prostate	Swiss Herbal Remedies™ Ltd.	
49	Natrodale® BHP – Prostate	Vital Health Foods (PTY)™ Ltd.	
50	Peponen®	Biogal Pharmaceutical Works™ Ltd.	
51	Pumpkin	Walmark™	

Table 5. Fish oil containing supplements

Supl. No.	Product name	Producer
1	Seven Seas omega 3 plus calcium	Merck™
2	Haliborange Omega 3 syrup	Merck™
3	Seven Seas omega 3 plus evening primrose oil	Merck™
4	Cod Liver Oil	Herb-Pharma™
5	Seven Seas JointCare Cod liver oil	Merck™
6	Omefor 3-6-9	Walmark™
7	Omegacord	Pharmadon™
8	Ocuvite® Reti-Nat	Bausch & Lomb™
9	Omega 3	ProFitness™
10	Marin 1000	Uniforma™
11	GS maxEPA	Green-Swan Pharmaceuticals™
12	EPA fish oil 1000 mg	Walmark™
13	Natural Omega 3	NaturaMed Pharma™
14	Fish oil EPA DHA 1000 mg	MedPharma™
15	Omega 3	Nef de Sante™
16	Alfa Omega 3 fish oil capsules	Alfa Vita™
17	Fish oil	Pro.Med. Prague™
18	GS Omega 3	Green-Swan Pharmaceuticals™
19	Omega 31000mg	Noventis™
20	Hema® Fish Fat	Hemax®
21	Seven Seas omega 3525 mg	Merck™
22	Extra High Strength Omega 3	Merck™
23	Seven Seas Extra High Strength Omega-3	Merck™
24	Bioactive Marin Plus	Pharma Nord Prague™
25	MaxiCor	SVUS Pharma™
26	CordiMax	Ipsum Grade™
27	NutriCare Omega	T Care™
28	Bruin OMEGA 3	Valosun™
29	Hema Forte fish oil 500	Pharmachem A/S
30	Blue Care fish oil	VitaHarmony
31	VITAX cholesterol heart and vessels	Solvent
32	MaxiVita Omega 3 – fish oil	Vitar™
33	Iskial shark liver oil	Naturrell AB
34	Harmony Line fish oil Baby	Alfa Vita™
35	Liftea Fish Oil Omega-3	Swiss Caps AG™

RESULTS

Fatty acid composition of plant oil containing supplements

Soya lecithin

Nutrition supplements with soya lecithin were characterised by a high content of LA (45–60%; Table 6). The next most abundant FA were oleic (15–20%) and palmitic acids (14–18%). α-Linolenic acid was present in relatively substantial amounts accounting for 2–8% of total FA. Two supplements (Nos 9 and 15) had a completely different FA profile containing predominately SFA or ALA, and they had a low content of LA, possibly related to the content of other ingredients (floral pollen, fermented pollen, Royal jelly, vitamin C, soybean extract, and red clover extract).

Evening primrose oil

Evening primrose containing supplements were characterised by a high content of LA (65–75%; Table 7), followed by oleic and palmitic acids (both around 6–8%). α-Linolenic acid was found in very low concentrations (0.2–1%), with the exception of one supplement where its content slightly exceeded 2% (No. 28). Borage oil supplements presented in Table 2 had a relatively homogeneous FA profile, containing about 40% LA, followed by oleic and palmitic acids. Total n-6 PUFA levels were around 62% due to the presence of GLA (about 20%). Evening primrose oil supplements also contained a relatively substantial amount of GLA (8–13%).

Amaranth and sea buckthorn oils

Nutrition supplements containing amaranth and sea buckthorn oil had a greatly heterogeneous FA profile as shown in Table 8. Specifically about amaranth oil supplements, LA varied between 20% and 50% and palmitic acid between 20% and 40%. The content of ALA varied between 0.8% and 4%. The wide range of FA percentages may be explained by the addition of other ingredients to the products concerned (No. 36).

Moreover, sea buckthorn oil supplements followed one of two different patterns. The first pattern had high levels of LA (50%) and a relatively low content of palmitic (15%) and palmitoleic (0.5–11%) acid. The second pattern had a high content of palmitic (35%) and palmitoleic (25–27%) acid and a low content of LA (5%).

Saw palmetto and/or pumpkin seed oils

Non-homogeneous results were also obtained for supplements containing saw palmetto and/or

Table 6. Fatty acid composition of soy lecithin containing supplements (molar percentage)

Suppl. No.	Fatty acid								
	16:0	18:0	18:1n-9	18:2n-6	18:3n-3	SFA	MUFA	n-6 PUFA	n-3 PUFA
1	12.4	3.7	29.8	44.0	4.6	19.2	31.8	44.2	4.8
2	16.6	3.4	15.8	55.1	6.2	21.0	17.5	55.3	6.2
3	14.7	3.6	24.2	47.9	5.7	20.2	25.9	48.8	5.8
4	15.5	3.6	15.3	55.2	7.7	19.8	16.9	55.5	7.8
5	15.3	4.4	12.4	56.8	8.1	20.2	13.9	57.0	8.8
6	15.7	3.7	15.3	54.9	7.2	20.5	17.0	55.2	7.3
7	14.0	4.1	17.3	54.7	7.1	19.1	18.9	54.9	7.1
8	12.9	3.9	18.0	54.4	8.0	17.6	19.7	54.6	8.1
9	37.4	9.9	21.2	24.0	1.4	49.0	25.2	24.1	1.6
10	15.7	3.4	16.2	55.7	6.0	20.0	17.8	56.2	6.0
11	18.8	3.8	6.4	61.8	7.1	23.3	7.8	61.9	7.1
12	22.3	3.5	11.2	56.4	4.2	26.6	12.6	56.5	4.3
13	14.2	3.8	21.6	50.0	6.2	20.1	23.4	50.2	6.2
14	13.5	5.4	33.3	37.4	2.4	20.4	39.5	37.5	2.6
15	25.7	4.3	13.7	8.7	37.3	35.7	17.4	9.2	37.7

Table 7. Fatty acid composition of evening primrose and borage oil containing supplements (molar percentage)

Suppl. No.	Fatty acid								
	16:0	18:0	18:1n-9	18:2n-6	18:3n-3	SFA	MUFA	n-6 PUFA	n-3 PUFA
16	7.3	2.5	10.0	63.1	0.4	10.3	12.7	76.4	0.6
17	6.1	1.8	5.8	74.0	0.4	8.4	6.8	84.3	0.5
18	6.9	2.2	8.7	70.2	1.1	9.7	9.9	78.8	1.6
19	7.0	2.1	8.5	70.5	1.2	9.7	9.6	79.2	1.4
20	8.4	4.1	13.4	60.2	0.6	13.3	17.5	68.6	0.6
21	6.4	1.8	6.4	72.8	0.9	8.9	7.4	82.8	1.0
22	6.7	1.8	8.0	71.9	0.4	9.1	8.9	81.6	0.4
23	6.4	1.8	6.2	74.1	0.2	8.7	7.2	83.9	0.2
24	6.2	2.0	8.6	71.4	0.6	9.0	9.8	80.3	0.9
25	6.2	1.8	6.0	74.7	0.2	8.5	7.0	84.3	0.2
26	6.4	1.8	6.0	74.4	0.2	8.6	7.0	84.1	0.2
27	6.5	2.2	7.4	72.6	0.3	9.2	8.4	82.1	0.4
28	7.7	2.4	12.3	66.5	2.1	10.8	13.6	73.4	2.2
29	8.4	2.1	8.9	67.8	0.4	11.2	12.4	76.0	0.5
30	9.6	2.9	14.1	41.0	0.4	13.1	22.0	64.3	0.6
31	9.8	3.7	14.7	40.1	0.2	14.0	22.7	62.8	0.4
32	10.5	3.8	16.3	37.4	0.3	14.9	23.7	60.0	1.4

pumpkin seed oils (Table 9). Supplements containing saw palmetto (and pumpkin seed) oil greatly varied in their FA profiles. In general terms, saw palmetto oil supplements had a low content of LA (3–6%) and a higher content of oleic (25–40%) and palmitic (8–13%) acid. Saw palmetto oil supplements were dominated by SFA (40–90%); mainly due to high lauric (10–33%) and myristic (5–10%) acid, followed by MUFA and n-6 PUFA. Supplements containing mainly pumpkin seed oil were characterised by a high content of LA (45–55%), followed by oleic (25–35%) and palmitic acid in lower amounts (11%). Supplements which showed a completely different FA profile were Nos 42 and 48.

Fatty acid composition of fish oil containing supplements

A total of 35 fish oil supplements were identified and their FA composition is presented in Table 10. Most of the fish oil supplements identified did not indicate the origin of the fish oil, although some of them declared whether it was cod or shark liver oil, seal oil, or fish oil of marine origin.

Eicosapentaenoic acid content ranged between 12% and 23% for the majority of the fish oil supplements. However, three supplements had a very high EPA content (60–70%). Only a few supplements had an EPA content of about 5–10% (n = 7) and below 5%

Table 8. Fatty acid composition of amaranth and sea buckthorn oil containing supplements (molar percentage)

Suppl. No.	Fatty acid								
	16:0	18:0	18:1n-9	18:2n-6	18:3n-3	SFA	MUFA	n-6 PUFA	n-3 PUFA
33	19.9	3.4	21.3	51.2	1.2	25.0	22.5	51.3	1.2
34	32.8	16.1	7.1	37.3	4.0	50.5	8.1	37.4	4.0
35	37.3	6.9	24.3	25.2	0.8	47. 9	25.9	25.4	0.8
36	39.1	26.7	7.6	18.3	3.9	69.1	8.6	18.4	3.9
37	34.1	1.2	25.2	5.7	1.6	35.8	56.8	5.8	1.6
38	16.6	3.8	12.4	51.4	0.5	21.7	26.3	51.5	0.5
39	12.9	4.3	23.1	51.0	6.0	18.1	24.8	51.1	6.0
40	36.0	1.0	20.8	5.5	1.6	37.6	55.2	5.6	1.6
41	13.9	4.5	20.0	52.2	6.6	19.3	21.7	52.4	6.6

Table 9. Fatty acid composition of saw palmetto and pumpkin seed oil containing supplements (molar percentage)

Suppl. No.	Fatty acid								
	16:0	18:0	18:1n-9	18:2n-6	18:3n-3	SFA	MUFA	n-6 PUFA	n-3 PUFA
42	47.4	38.7	5.8	2.6	0.5	89.1	7.7	2.7	0.5
43	13.6	9.0	30.3	3.6	0.2	64.9	31.1	3.8	0.2
44	8.0	2.5	34.7	5.3	1.1	58.3	35.2	5.4	1.1
45	13.5	4.0	26.5	12.9	0.9	58.8	27.3	13.0	0.9
46	9.3	3.3	40.7	7.0	0.9	50.8	41.3	7.0	0.9
47	12.2	3.6	23.0	33.2	2.6	40.1	24.0	33.2	2.6
48	13.0	3.6	17.6	27.8	21.4	32.0	18.7	27.8	21.4
48	11.5	5.8	37.3	42.7	0.5	18.0	38.5	42.9	0.5
50	10.4	5.4	36.9	45.3	0.2	16.5	37.9	45.3	0.2
51	12.3	5.0	24.7	55.7	0.5	18.0	25.7	55.8	0.6

(n = 5). As far as DHA is concerned, its content was mainly lower or comparable to EPA, ranging between 7% and 17% in most supplements. There were only a few supplements with DHA ranging between 20% and 30% (n = 6) and between 50% and 60% (n = 2). Also, only a small number of supplements had a DHA content below 5% (n = 5). Three fish oil supplements were identified to have a relatively much higher DHA content compared to EPA (Nos 2, 8, 19).

DISCUSSION

Dietary supplements with fish or plant oils are high in PUFA and are often used as a support in the treatment of a number of diseases. Specifically, they are used as a support in body weight and blood lipid management, as well as in metabolic syndrome, because of their pleiotropic effects (Carpentier *et al*. 2006). Also, these oils are used in enteral and parenteral nutrition as a supportive treatment of patients in critical care (Novák *et al.* 2010).

Soya lecithin and evening primrose oil supplements were the most frequent plant oil supplements. Fatty acids in evening primrose oil supplements originate mainly from triglycerides, and in soya lecithin mainly from phospholipids isolated from soybean oil. Due to its high content of GLA, evening primrose oil is used in diabetic neuropathy and in Δ6-desaturase deficiency (Horrobin 1992). Essential FA of the n-3 PUFA family, ALA, was found in relatively substantial amounts in soya lecithin.

Importantly, saturated FA were low in most plant oil supplements. Specifically, the lipogenic FA, myristic acid, was low in most of the plant oil supplements. Only saw palmetto oil supplements had a higher SFA content but that was mainly due to having a high lauric acid content rather than myristic acid (Abe *et al.* 2009).

It can be speculated that plant oil supplements which showed a completely different FA profile compared to the expected one either contained plant oils from various plants not declared by the producers, or different parts of the plant and/or different manufacturing procedures were used.

For most of the fish oil supplements there was no indication about the origin or types of fish used. Eicosapentaenoic acid and DHA contents depend primarily on the type of fish whose flesh is used as a source of oil and on the effectiveness of the enrichment technology during manufacturing. Marine fish that feed on phytoplankton have a high content of n-3 PUFA. On the contrary, freshwater fish have a very low content of n-3 PUFA and their oil should not be used for dietary supplements.

For some supplements it is obvious that SFA and MUFA had been partially removed, resulting in the total n-3 PUFA content higher than 66%, even exceeding 90%. These products do not contain any natural fish oil but PUFA ethyl esters from which other FA are removed based on different melting points of particular esters, or re-esterified triacylglycerols. The advantage of LC n-3 PUFA supplements in the form of ethyl esters is that they are manufactured more easily and less expensively compared to triacylglycerols. However, EPA and DHA ethyl ester bioavailability is debatable with recent evidence showing that it might be lower than that of re-esterified triacylglycerols (Neubronner *et al.* 2011).

In conclusion, not all plant and fish oil supplements had a representative FA profile of the main constituent declared. Ideally, FA analysis should be

Table 10. Fatty acid composition of fish oil containing supplements sorted by EPA content (molar percentage)

Suppl. No.	Fatty acid									
	16:0	18:0	18:1 n-9	18:2 n-6	20:5 n-3	22:6 n-3	SFA	MUFA	n-6 PUFA	n-3 PUFA
1	16.7	2.8	23.5	3.8	10.3	13.3	25.7	39.2	5.4	28.8
2	17.4	3.0	19.4	3.2	11.1	16.9	27.5	32.2	5.2	35.1
3	12.3	2.5	15.6	21.6	12.0	12.5	19.3	25.8	25.1	29.0
4	14.8	2.5	15.9	3.4	12.1	12.8	23.3	38.9	5.0	32.9
5	22.2	3.4	23.1	4.3	12.9	13.0	30.0	32.6	5.7	30.8
6	5.6	3.4	15.4	19.2	13.1	7.7	9.4	19.5	28.0	43.1
7	18.5	3.1	13.5	8.8	15.0	9.9	29.4	27.0	10.5	33.1
8	2.8	2.4	6.5	0.7	15.9	58.5	6.1	8.9	4.7	79.7
9	18.1	3.4	9.9	1.7	19.6	13.2	30.0	24.8	3.8	41.4
10	18.3	3.4	9.1	1.5	19.6	13.5	30.3	24.0	3.5	42.1
11	17.5	3.2	11.0	1.6	19.8	13.3	29.4	26.3	3.6	40.6
12	18.3	3.5	9.1	1.4	19.9	13.5	30.3	23.9	3.5	42.2
13	19.0	3.3	8.8	1.3	20.4	14.4	32.9	21.2	3.3	41.7
14	17.5	3.5	10.0	1.8	20.5	13.8	28.6	25.0	4.0	42.4
15	17.7	3.3	9.6	1.7	20.8	14.2	32.0	23.0	4.0	40.3
16	17.6	3.5	8.2	1.3	21.0	14.6	29.1	23.2	3.6	44.1
17	17.5	3.4	9.8	1.2	21.8	16.3	29.0	22.4	3.2	45.4
18	17.7	3.4	10.3	1.2	22.3	14.8	29.3	23.3	3.2	44.2
19	16.7	3.2	10.8	1.9	22.4	14.2	27.7	24.0	4.2	44.1
20	21.3	4.1	11.6	1.7	23.4	0.1	34.1	29.1	4.2	32.6
21	9.6	3.2	14.4	1.9	26.1	20.1	16.8	23.7	4.2	53.6
22	8.4	2.7	10.9	1.5	27.3	20.8	14.5	24.4	4.0	57.0
23	8.4	2.9	13.8	1.6	28.1	21.5	14.6	23.0	4.2	56.9
24	2.8	2.3	5.2	1.1	36.8	28.7	6.4	12.6	4.6	76.3
25	0.2	0.1	0.6	0.4	59.8	26.0	0.4	1.0	3.6	95.1
26	1.0	0.9	2.4	0.7	72.6	11.3	2.7	4.4	4.9	88.0
27	15.5	3.6	10.0	1.5	18.0	11.6	30.2	24.6	5.3	39.9
28	7.4	9.4	6.0	4.7	0.01	0.01	74.3	5.4	5.3	15.0
29	2.3	3.6	7.7	0.7	39.0	23.3	7.0	13.6	7.5	72.0
30	16.4	3.4	10.0	1.2	20.4	11.7	28.6	24.1	4.9	42.3
31	16.4	3.6	9.6	1.2	19.5	10.6	30.3	24.5	4.9	40.3
32	12.1	2.8	19.2	1.3	8.4	11.2	18.6	42.2	9.2	29.9
33	14.4	1.5	32.0	1.1	1.2	5.2	20.3	55.3	8.4	16.0
34	16.9	3.5	10.7	2.3	20.5	7.7	32. 7	27.0	5.3	35.1
35	12.8	11.3	9.1	1.0	7.0	39.3	28.2	14.8	8.6	48.4

conducted by an independent institution before using an oil supplement for severe health conditions. Each supplement should be considered as a unique product irrespective of its trade name.

References

Abe M., Ito Y., Oyunzul L., Oki-Fujino T., Yamada S. (2009): Pharmacologically relevant receptor binding

characteristics and 5α-reductase inhibitory activity of free fatty acids contained in saw palmetto extract. Biological and Pharmaceutical Bulletin, **32**: 646–650.

Browning L.M., Krebs J.D., Magee E.C., Fruhbeck G., Jebb S.A. (2008): Circulating markers of inflammation and their link to indices of adiposity. Obesity Facts, **1**: 259–265.

Burdge G.C., Powell J., Dadd T., Talbot D., Civil J., Calder P.C. (2009): Acute consumption of fish oil improves postprandial VLDL profiles in healthy men aged 50–65 years. British Journal of Nutrition, **102**: 160–165.

Calder P.C. (2008): The relationship between the fatty acid composition of immune cells and their function. Prostaglandins Leukotrienes Essential Fatty Acids, **79**: 101–108.

Carpentier Y.A., Portois L., Malaisse W.J. (2006): n-3 fatty acids and the metabolic syndrome. American Journal of Clinical Nutrition, **83**: 1499S–1504S.

Flachs P., Rossmeisl M., Bryhn M., Kopecky J. (2009): Cellular and molecular effects of n-3 polyunsaturated fatty acids on adipose tissue biology and metabolism. Clinical Science (London), **116**: 1–16.

Horrobin D.F. (1992): Nutritional and medical importance of gamma-linolenic acid. Progress in Lipid Research, **31**: 163–194.

Kremmyda L.S., Tvrzicka E., Stankova B., Zak A. (2011): Fatty acids as biocompounds: Their role in human metabolism, health and disease – A review. Part 2: fatty acid physiological roles and applications in human health and disease. Biomedical Papers, **155**: 195–218.

Murphy R.A., Mourtzakis M., Mazurak V.C. (2012): n-3 polyunsaturated fatty acids: the potential role for supplementation in cancer. Current Opinion in Clinical Nutrition and Metabolic Care, **15**: 246–251.

Neubronner J., Schuchardt J.P., Kressel G., Merkel M., von Schacky C., Hahn A. (2011): Enhanced increase of omega-3 index in response to long-term n-3 fatty acid supplementation from triacylglycerides versus ethyl esters. European Journal of Clinical Nutrition, **65**: 247–254.

Novák F., Borovská J., Vecka M., Vávrová L., Kodyd ková J., Mračková M., Novák F., sr., Nováková O., Žák A. (2010): Alterations in fatty acid composition of plasma and erythrocyte lipids in critically ill patients during sepsis. Časopis lékařů českých, **149**: 324–331.

Pedersen M.H., Lauritzen L., Hellgren L.I. (2011): Fish oil combined with SCFA synergistically prevent tissue accumulation of NEFA during weight loss in obese mice. British Journal of Nutrition, **106**: 1449–1456.

Serhan C.N., Krishnamoorthy S., Recchiuti A., Chiang N. (2011): Novel anti-inflammatory-pro-resolving mediators and their receptors. Current Topics in Medical Chemistry, **11**: 629–647.

Staels B. (2000): The PPAR system and regulation of lipoprotein metabolism In: Betteridge J.: Lipids and Vascular Disease. Taylor & Francis Group, London: 27–37.

Tvrzicka E., Vecka M., Stankova B., Zak A. (2002): Analysis of fatty acids in plasma lipoproteins by gas chromatography-flame ionization detection: Quantitative aspects. Analytica Chimica Acta, **465**: 337–350.

Tvrzicka E., Kremmyda L.S., Stankova B., Zak A. (2011): Fatty acids as biocompounds: their role in human metabolism, health and disease – A review. Part 1: classification, dietary sources and biological functions. Biomedical Papers, **155**: 117–130.

Vergroesen A.J. (1989): Essential fatty acids, biomembranes and eicosanoid metabolism. In: Vergroesen A.J., Crawford M. (eds): The Role of Fats in Human Nutrition. Academic Press, London: 17–29.

Virtue S., Vidal-Puig A. (2010): Adipose tissue expandability, lipotoxicity and the Metabolic Syndrome – an allostatic perspective. Biochimica Biophysica Acta, **1801**: 338–349.

Žák A., Vecka M., Tvrzická E., Hrubý M., Novák F., Papežová H., Lubanda H., Veselá L., Staňková B. (2005): Composition of plasma fatty acids and noncholesterol sterols in anorexia nervosa. Physiological Research, **54**: 443–451.

Žák A., Tvrzická E., Vecka M., Jáchymová M., Duffková L., Staňková B., Vávrová L., Kodydková J., Zeman M. (2007): Severity of metabolic syndrome unfavorably influences oxidative stress and fatty acid metabolism in men. Tohoku Journal of Experimental Medicine, **212**: 359–371.

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