Opinion of the Scientific Panel on Dietetic Products, Nutrition and Allergies on a request from the Commission related to nutrition claims concerning omega-3 fatty acids, monounsaturated fat, polyunsaturated fat and unsaturated fat

(Request N° EFSA-Q-2004-107)

(adopted on 6 July 2005)

SUMMARY

The European Commission has requested EFSA to issue an opinion on the scientific substantiation of nutrition claims relating to omega-3 fatty acids, mono-unsaturated fat, poly-unsaturated fat and unsaturated fat. In this context EFSA was asked to review the scientific merits of the following proposed claims and advise on their addition to the Annex of the Regulation on the use of nutrition and health claims on foods proposed by the Commission in July 2003.

- *Omega-3 fatty acid source*: The food must contain more than 15% of the Recommended Nutritional Intake (with RNI set at 2 g/day for an adult male) for an adult male of the omega-3 fatty acids concerned per 100 g or 100 mL or 100 kcal.

- *High in omega-3 fatty acids*: The food must contain more than 30% of the Recommended Nutritional Intake for an adult male of the omega-3 fatty acids concerned per 100 g or 100 mL or 100 kcal.

- *High monounsaturated fat*: A claim that a food is high in monounsaturated fat, and any claim likely to have the same meaning for the consumer, may only be made where at least 45% of the fatty acids present in the product derive from monounsaturated fat under the condition that saturated fat must not provide more than 10% of energy.

- *High polyunsaturated fat*: A claim that a food is high in polyunsaturated fat, and any claim likely to have the same meaning for the consumer, may only be made where at least 45% of the fatty acids present in the product derive from polyunsaturated fat and saturated fat must not provide more than 10% of energy.

- *High unsaturated fat*: A claim that a food contains high amount of unsaturated fat and any claim likely to have the same meaning for the consumer may only be made where the amount of unsaturated fat is 70% of the total fat content in the product.

The Scientific Panel on Dietetic Products, Nutrition and Allergies has considered the proposed claims and concludes as follows.

Omega-3 fatty acids claims

There are two categories of omega-3 fatty acids (n-3 polyunsaturated fatty acids [n-3 PUFA]) - α-linolenic acid (ALA) and long chain n-3 polyunsaturated fatty acids (LC n-3 PUFA, mainly eicosapentaenoic acid [EPA] and docosahexaenoic acid [DHA]) - which differ in function and requirements. The proposed claims do not distinguish between ALA and LC n-3 PUFA which have different nutritional roles. ALA is a nutritionally essential fatty acid required for synthesis of important fatty acids and eicosanoids. Available evidence suggests that LC n-3 PUFA (EPA and DHA) may reduce the risk of cardiovascular disease, possibly mediated by prevention of cardiac arrhythmias.

The RNI proposed in the claim (2 g/day) is in the same range as intakes of ALA recommended by some national and international authorities to meet dietary requirements in adults (1-3 g/day). However, it is much greater than intakes recommended by some authorities for LC n-3 PUFA (EPA and DHA) in adults for cardio-protective effects (200-500 mg/day). In many EU populations intakes of both ALA and LC n-3 PUFA are typically lower than these recommendations.

Claim: Omega-3 fatty acid source - more than 15% of the Recommended Nutritional Intake (2 g/day) of the omega-3 fatty acids concerned per 100 g or 100 mL or 100 kcal

As outlined, the claim could be made for a number of foods both on an energy and weight/volume basis, e.g. most plant oils, some nuts, some vegetables (mainly as ALA) and most fish (mainly as LC n-3 PUFA).

Some foods would qualify for the claim on a weight/volume, but not energy basis (e.g. safflower oil, soy bean, peanut, butter) while other foods (e.g. radish, cod) would qualify on an energy, but not weight/volume basis. Some foods qualify although a typical serving provides little n-3 PUFA (e.g. radish, safflower oil, butter). These anomalies arise because the reference food quantity (100 g, 100 mL, 100 kcal) is not linked to the typical intake of the food.

Claim: High in omega-3 fatty acids - more than 30% of the Recommended Nutritional Intake (2 g/day) of the omega-3 fatty acids concerned per 100 g or 100 mL or 100 kcal

As outlined, the claim could be made for a number of foods both on an energy and weight/volume basis, e.g. most vegetable oils and some nuts (mainly as ALA) and fatty fish (mainly as LC n-3 PUFA).

Some foods would qualify for the claim on a weight/volume, but not energy basis (e.g. pecan nut, some vegetable margarines). Other foods qualify on an energy, but not a weight/volume basis although a typical serving provides only modest amounts of n-3 PUFA (e.g. kale). These anomalies arise because the reference food quantity (100 kcal) is not linked to the typical intake of the food.

Monounsaturated fat claim

Monounsaturated fatty acids (MUFA) are not nutritionally essential as they can be synthesised from other (saturated) fatty acids and carbohydrates. Substitution of saturated fatty acids (SFA) in the diet by an equal amount of MUFA reduces low density lipoprotein (LDL) cholesterol; elevated plasma LDL-cholesterol has been causally linked to coronary heart disease. Because SFA intakes of many EU populations exceed levels (about 10% energy) widely recommended for maintenance of lower plasma levels of LDL-cholesterol, MUFA consumption plays an important nutritional role in limiting SFA intake. In some EU populations, intakes of MUFA are at the lower end of recommended levels (in the range 10-18% of energy, which corresponds to about 30-50% of fatty acids for a diet containing 35 E% from total fat).

Claim: High monounsaturated fat - at least 45% of the fatty acids derive from monounsaturated fat and saturated fat must not provide more than 10% of energy
The claim as outlined may be made for a range of foods. These include good sources of MUFA, e.g. rapeseed oil, some fluid margarines, some nuts (e.g. hazelnuts, peanuts, pistachio nuts, almonds). However, the claim could also be made for some foods which provide only low amounts of MUFA in a typical serving, e.g. some fish (e.g. whiting), lean meat (e.g. veal, beef, pork), white bread and some biscuits. These anomalies arise because the MUFA threshold is expressed as % of total fatty acids content which is not directly related to the typical intake of the food. In addition, some foods which provide significant amounts of MUFA may not qualify for the claim e.g. foods that are naturally high in MUFA such as olive oil and fatty fish (e.g. herring, salmon) and some margarines. This anomaly arises because the SFA content of these foods may exceed the disqualifying threshold of 10 E%.

Polyunsaturated fat claim
In addition to n-3 PUFA (ALA and the LC n-3 PUFA, EPA and DHA), PUFA also include n-6 PUFA (mainly linoleic acid). Linoleic acid is nutritionally essential and is required for synthesis of long chain fatty acids and eicosanoids and linoleic acid and its metabolites have important roles in membrane function and regulation of metabolism.

In addition to the evidence for a cardio-protective effect of the LC n-3 PUFA and a nutritional requirement for ALA and linoleic acid, the substitution of SFA in the diet by an equal amount of *cis*-PUFA reduces LDL-cholesterol. Thus PUFA consumption plays an important nutritional role in limiting SFA intake. In EU populations, intakes of total PUFA are generally within the recommended range (about 5-10% of energy), which corresponds to about 15-30% of fatty acids for a diet containing 35 E% from total fat.

Claim: High polyunsaturated fat - at least 45% of the fatty acids derive from polyunsaturated fat and saturated fat must not provide more than 10% of energy
The claim as outlined may be made for some vegetable oils (e.g. safflower oil), some nuts (e.g. walnut) and seeds (e.g. sunflower, seed, linseed) which are good sources of PUFA. However, several vegetable oils which provide significant amounts of PUFA may not qualify for the claim, e.g. corn oil, grapeseed oil, rapeseed oil, soya oil, sunflower oil. This is because the SFA content of these foods may exceed the disqualifying threshold of 10 E%. In addition, the claim could be made also for some foods which provide only low amounts of PUFA in a typical serving, e.g. some breads, cereal products, beans, and white fish (e.g. cod, turbot). This anomaly arises because the PUFA threshold is expressed as % of total fatty acids content which is not directly related to the typical intake of the food.

Unsaturated fat claim
(*Cis*) unsaturated fatty acids (UFA) comprise MUFA, n-6 PUFA (mainly linoleic acid) and n-3 PUFA (ALA and the LC n-3 PUFA, EPA and DHA) and represent the balance of total fatty acids when SFA and *trans* fatty acids (TFA) are excluded. Specific nutritional roles have been identified for n-6 PUFA and n-3 PUFA (ALA and the LC n-3 PUFA). In addition to the evidence for a cardio-protective effect of the LC n-3 PUFA and a nutritional requirement for ALA and linoleic acid, substitution of SFA in the diet by an equal amount of *cis*-UFA (both MUFA and PUFA) reduces LDL-cholesterol. Thus UFA consumption may play an important

nutritional role in limiting SFA intake.

Claim: High unsaturated fat - the amount of unsaturated fat is 70% of the total fat content
The claim as outlined may be made for a wide range of foods which are good sources of UFA, e.g. most vegetable oils, some fat spreads, nuts and seeds (mainly n-6 and n-3 PUFA) and fatty fish (mainly LC n-3 PUFA). The claim could be made for some foods which have a relatively high content of SFA and/or TFA, e.g. foods such as oils and fat spreads, in which most or all of the energy is derived from fat, could qualify for the claim while containing up to 30 E% from SFA and/or TFA. The claim could be made also for some foods which provide only low amounts of UFA in a typical serving, e.g. beans and lentils, berries, cereals and white fish. This anomaly arises because the UFA threshold is expressed as % of total fat content which is not directly related to the level of fat in the food or to typical intake of the food.

KEY WORDS

Nutrition claims, omega-3 fatty acids, polyunsaturated fat, monounsaturated fat, unsaturated fat.

BACKGROUND

In July 2003, the Commission adopted a Proposal for a Regulation on the use of nutrition and health claims on foods (EC, 2003). This proposal covers nutrition and health claims used in the labelling, presentation and advertising of foods. Only nutrition and health claims that are in conformity with the provisions of this Regulation will be allowed on the labelling, presentation and advertising of foods placed on the market within the Community and delivered as such to the final consumer. At the time of the Opinion drafting, this proposal has not yet been adopted.

In order to present consumers and industry with clear benchmarks concerning the use of nutrition claims, a list of permitted nutrition claims and their specific conditions of use has been set in the Annex of the proposed Regulation. At international level, Codex Alimentarius has developed guidelines for the most commonly used nutrition claims. Similar criteria also exist in some Member States. This Annex takes into account existing provisions of some Member States, the Codex Alimentarius guidelines, and some Community provisions. The proposed Regulation provides for the possibility to revise and adapt the Annex when necessary. Modifications to this Annex shall be adopted through the Committee procedure referred and, where appropriate, after consulting EFSA.

TERMS OF REFERENCE

In accordance with article 29 (1) (a) of Regulation EC 178/2002, the European Commission requests the European Food Safety Authority to issue an opinion on the scientific substantiation of nutrition claims relating to omega-3 fatty acids, mono-unsaturated fat, poly-unsaturated fat and unsaturated fat. In this context the Authority is asked to review the scientific merits of the following proposed claims and advise on their addition to the Annex of the proposed Regulation.

- *Omega-3 fatty acid source*: The food must contain more than 15% of the Recommended Nutritional Intake (with RNI set at 2 g/day for an adult male) for an adult male of the omega-3 fatty acids concerned per 100 g or 100 mL or 100 kcal.

- *High in omega-3 fatty acids*: The food must contain more than 30% of the Recommended Nutritional Intake for an adult male of the omega-3 fatty acids concerned per 100 g or 100 mL or 100 kcal.

- *High monounsaturated fat*: A claim that a food is high in monounsaturated fat, and any claim likely to have the same meaning for the consumer, may only be made where at least 45% of the fatty acids present in the product derive from monounsaturated fat under the condition that saturated fat must not provide more than 10% of energy.

- *High polyunsaturated fat*: A claim that a food is high in polyunsaturated fat, and any claim likely to have the same meaning for the consumer, may only be made where at least 45% of the fatty acids present in the product derive from polyunsaturated fat and saturated fat must not provide more than 10% of energy.

- *High unsaturated fat*: A claim that a food contains high amount of unsaturated fat and any claim likely to have the same meaning for the consumer may only be made where the amount of unsaturated fat is 70% of the total fat content in the product.

ASSESSMENT

1. INTRODUCTION

The proposed Regulation defines:

- "Nutrition claim" meaning any claim which states, suggests or implies that a food has particular nutrition properties due to: (a) the energy (calorific value) it provides, or provides at a reduced or increased rate, or does not provide, and/or; (b) the nutrients or other substances it contains, or contains in reduced or increased proportions, or does not contain.

- "Health claim" meaning any claim that states, suggests or implies that a relationship exists between a food category, a food or one of its constituents and health.

The proposed claims evaluated in this Opinion are nutrition claims which focus on the content of particular categories of fatty acids in foods.

2. DEFINITIONS, STRUCTURE AND FUNCTION

Table 1 provides an overview of main fatty acids identified in food.

2.1 Unsaturated fat

An unsaturated fat is a fat or fatty acid in which there is one or more double bonds between carbon atoms of the fatty acid chain. Such fat molecules are monounsaturated if they contain one double bond, and polyunsaturated if they contain more than one. These double bonds may be either *cis* or *trans*. *Cis* isomers are the most common in unprocessed foodstuffs. *Trans* forms (i.e. *trans*-MUFA, *trans*-PUFA) and conjugated forms of fatty acids are not addressed in the scope of the claims considered in this Opinion, because only unsaturated fatty acids with one or more *cis*-double bonds are included in the definition of the nutrition labelling Directive 90/496/EEC.

Hydrogenation converts unsaturated fats to saturated fats, while dehydrogenation accomplishes the reverse.

Table 1. Main fatty acids (FA) in food

Systematic nomenclature	Common name	Abbreviation
Saturated fatty acids (SFA)		
Butanoic	Butyric	4:0
Hexanoic	Caproic	6:0
Octanoic	Caprilic	8:0
Decanoic	Capric	10:0
Dodecanoic	Lauric	12:0
Tetradecanoic	Myristic	14:0
Pentadecanoic	Pentadecilic	15:0
Hexadecanoic	Palmitic	16:0
Heptadecanoic	Margaric	17:0
Octadecanoic	Stearic	18:0
Eicosanoic	Arachidic	20:0
Docosanoic	Behenic	22:0
Tetracosanoic	Lignoceric	24:0
Hexacosanoic	Cerotic	26:0
Monounsaturated fatty acids (MUFA)		
Dodecenoic	Lauroleic	12:1 δ9c (n-3; ω3)
Tetradecenoic	Myristoleic	14:1 δ9c
Hexadecenoic	Palmitoleic	16:1 δ9c
Octadecenoic	Oleic	18:1 δ9c (n-9; ω9)
Octadecenoic	Elaidic	18:1 δ9t
Octadecenoic	Vaccenic	18:1 δ11t
Eicosenoic	Gadoleic	20:1 δ9c
Docosenoic	Cetoleic	22:1 δ9c
Docosenoic	Erucic	22:1 δ13c (n-9; ω9)
Polyunsaturated fatty acids (PUFA)		
Octadecadienoic	Linoleic	18:2 δ9c,12c (n-6; ω6)
Octadecadienoic	Rumenic	18:2 δ9c,11t
Octadecatrienoic	α-linolenic (ALA)	18:3 δ9c,12c,15c (n-3; ω3)
Octadecatrienoic	γ-linolenic	18:3 δ6c,9c,12c (n-6; ω6)
Eicosatetraenoic	Arachidonic	20:4 δ5c,8c,11c,14c (n-6; ω6)
Eicosapentaenoic	EPA	20:5 δ5c,8c,11c,14c,17c (n-3; ω3)
Docosapentaenoic	DPA	22:5 δ7c, 10c, 13c, 16c,19c (n-3; ω3)
Docosahexaenoic	DHA	22:6 δ4c,7c,10c,13c,16c,19c (n-3; ω3)

2.2 Monounsaturated fatty acids (MUFA)

Monounsaturated fatty acids (MUFA) have one double bond in the fatty acid chain. The quantitatively most important representative in the diet is oleic acid (C18:1, n-9) with a double bond at the n-9 (ω-9) position.

MUFA are almost completely absorbed from the intestine and are oxidised (for energy production), converted into other fatty acids, or incorporated into tissue lipids. Humans can synthesize MUFA from other fats and from carbohydrates, and therefore MUFA are not required as such from the diet.

2.3 Polyunsaturated fatty acids (PUFA)

Polyunsaturated fatty acids (PUFA) have 2 to 6 double bonds. Humans lack the enzymes Δ12- and Δ15-desaturase that are capable of introducing double-bonds in the n-6 and n-3 positions, respectively (the first double bond located at the third or sixth carbon atom from the methyl end, ω or n-). Two PUFA with methylene-interrupted *cis*-double bonds of the omega-3 (alpha-linolenic acid, 18:3, n-3) and omega-6 series (linoleic acid, 18:2, n-6) are thus essential to humans and must be provided by the diet. They are also most abundant in the diet. The n-6 and n-3 PUFA are metabolised (desaturated and elongated) further by the same enzyme systems. Other important n-6 and n-3 PUFA occurring in foods are mentioned in Table 1.

Other non-essential *cis*-PUFA can be formed from saturated and monounsaturated fatty acids, e.g. in the n-7 and n-9 series. These are generally found in small amounts in foods.

The essential PUFA serve important physiological functions in the organism. Linoleic acid, when incorporated into skin ceramides, is essential for maintaining the water-permeability barrier of the skin thereby avoiding excessive trans-epidermal water loss and the accompanying energy loss from water evaporation. Linoleic acid is metabolised to e.g. gamma-linolenic acid (C18:3, n-6), dihomo-gamma-linolenic acid (C20:3, n-6, DHGLA) and arachidonic acid (C20:4, n-6, AA). From ALA, eicosapentaenoic acid (C20:5, n-3, EPA), docosapentaenoic acid (C22:5, n-3, DPA) and, to a limited extent, docosahexaenoic acid (C22:6, n-3, DHA) are formed. DHGLA, AA and EPA can be further transformed to eicosanoids, a group of biologically active substances including prostaglandins, prostacyclins and leukotrienes, which participate in the regulation of blood pressure, renal function, blood coagulation, inflammatory and immunological reactions and other functions in tissues. Furthermore, n-6 and n-3 PUFA, particularly the long-chain metabolites, are important structural components of cell membranes. They are essential for various membrane functions such as fluidity, permeability, activity of membrane-bound enzymes and receptors, and signal transduction.

2.4 Omega-3 fatty acids (n-3 PUFA)

Omega-3 (n-3) fatty acids are polyunsaturated fatty acids with one of the double bonds located at three carbon atoms from the methyl end. The quantitatively most important n-3 PUFA in the diet are: C18:3 (ALA); C20:5 (eicosapentaenoic acid, EPA); C22:5 (docosapentaenoic acid, DPA); and C22:6 (docosahexaenoic acid, DHA).

From the diet, n-3 PUFA are almost completely absorbed and either oxidised, incorporated into tissue lipids or converted to eicosanoids. EPA is the precursor for series 3 prostanoids and series 5 leukotrienes.

ALA is essential in human nutrition as precursor for the long-chain polyunsaturated n-3 fatty acids EPA and DHA. Apart from this, ALA has no known specific function. EPA, DPA and to a lesser degree DHA are synthesised from ALA through the sequential action of various desaturases and elongases in animal tissues but not in plants. There is competition by linoleic acid for the enzymes involved. DHA is a component of membrane structural lipids, especially of phospholipids in nervous tissue and the retina. The developing brain accumulates large amounts of DHA both pre- and postnatally (until two years of age), which is predominantly acquired from the mother via placental transfer and breast milk, although the capacity of the brain to synthesise DHA increases with gestational age (Clandinin, 1999).

3. FOOD SOURCES, CONTENT AND DIETARY INTAKE

3.1 MUFA

3.1.1 Occurrence in food/contribution from food groups

MUFA are present in both plant and animal-derived foods. Most plant oils, especially olive oil and rapeseed oil, are rich sources. Besides, seeds and nuts contain significant amounts. Animal products such as dairy and meat products, including fish, may also contain significant amounts of MUFA, but generally with a relative higher SFA content than the vegetable products.

According to data presented in the TRANSFAIR study, oils and fats are an important source of MUFA in the various EU countries, and the main source in southern Europe. Contributions vary from *circa* 10% in Sweden, up to *circa* 60% of the total *cis*-MUFA intake in Spain and Italy. In some European countries meat and meat products are the main source, with contributions varying between 30% in The Netherlands and 43% in Germany (Table 2).

3.1.2 Dietary intake

According to the TRANSFAIR study, the total intake of *cis*-MUFA in 19-64 years old adults varies between 9 and 18% of energy (E%) (highest in Greece, lowest in Germany), for most countries around 10-12 E% (Hulshof *et al*., 1999). It should be noted that the TRANSFAIR study is based upon food sampling and analysis in 1995/1996, and calculations based upon food consumption survey data collected between 1980 and 1996. These intake data may be somewhat outdated as fat sources and fatty acid composition of products have changed over recent years. Additional data from more recent national food consumption surveys are summarised in Table 3.

In several (north-European) countries, such as The Netherlands, there is a tendency towards an increased use of olive and other PUFA/MUFA-rich vegetable oils at the expense of SFA-rich "hard" fats. The average *cis*-MUFA intake in The Netherlands for adults reported in the TRANSFAIR study was 10.2 E%, while in the more recent national survey (1998/1999), this figure was 13 E% (Table 3). Also the more recent (1998) German data are higher (ca +3 E%) than those presented in the TRANSFAIR study.

Table 2. Contribution (%) to the total intake of *cis*-MUFA of selected food groups in adults in various European countries from the TRANSFAIR study (Hulshof *et al*., 1999)

Product group	France	Germany	Greece	Italy	Netherlands	Spain	Sweden	UK
Milk and milk products	2.9	5.2	5.3	3.9	4.7	6.1	10.6	8.4
Cheese	8.5	7.1	3.9	6.5	7.4	1.8	10.0	4.1
Eggs	2.8	6.1	0.7	2.1	2.6	2.3	3.9	2.7
Meat (products)	30.0	43.1	10.9	12.6	29.5	24.2	25.5	19.2
Fish	-	2.1	1.9	0.2	2.1	0.3	2.4	1.0
Butter	14.9	10.6	0.1	2.7	2.0	0.4	8.0	3.9
Oils and fats	16.2	19.0	48.4	63.0	16.8	56.5	9.9	31.3
Biscuits and cakes	5.7	3.3	3.9	5.3	7.7	4.4	9.8	9.6
Pizza, meat- and vegetable pies	-	-	5.1	0.4	1.1	0.2	2.2	4.6
Grain (products)	-	0.3	1.9	2.5	2.8	0.9	3.8	3.5
Seeds, kernels, nuts	-	<0.1	3.5	-	7.2	0	1.1	2.2
Chocolate, candy bars and confectionery	2.3	2.2	1.8	0.7	3 .4	0.9	1 .9	1.8
Soups and sauces	-	0.1	1.3	0.1	5.1	<0.1	6.5	1.1
Savoury snacks	-	<0.1	0.2	<0.1	2.6	0.7	0.7	3.7
Chips, French fries	7.0	<0.1	1.2	0	2.1	1.1	4.0	1.4
Industrial meals, restaurant foods	-	0.2	6.3	<0.1	1.8	-	-	1.4
Miscellaneous	-	0.6	3.6	-	0.4	0	1.0	0.2

(-): no information/data available

Table 3. Dietary intake of total fat and MUFA among adults in selected European countries

Country	Survey	Total fat		MUFA	
		Men	Women	Men	Women
Sweden[1]	Riksmaten 1997-1998 Adults 18-74 years	92 g/day 34 E%	72 g/day 34 E%	34 g/day 13 E%	26 g/day 12 E%
Germany[2]	Nutrition Survey (18-79 years)	93 g/day 34 E%	70 g/day 34 E%	34 g/day 12 E%	25 g/day 12 E%
United Kingdom[3]	NDNS (19-64 years)	86 g/day 36 E%	62 g/day 35 E%	29 g/day 12 E%	20 g/day 11 E%
The Netherlands[4]	DNFCS (22-50 years)	109 g/day 36 E%	85 g/day 38 E%	39 g/day 13 E%	30 g/day 13 E%

[1] Becker and Pearson (2002).
[2] Mensink *et al*. (1999).
[3] Henderson *et al*. (2003).
[4] 3rd Dutch National Food Consumption Survey (1998); “Zo eet Nederland 1998”, Voedingscentrum, den Haag.

3.2 PUFA

3.2.1 Occurrence in food/contribution from food groups

Foods rich in PUFA include vegetable oils such as corn oil, soybean oil, and sunflower seed oil (50-80% of total fatty acids) (see Table 11). Medium-high levels are found in rapeseed oil

(30-40%). Also dressings and fat spreads containing these oils have moderate levels of PUFA. Some nuts and seeds, e.g. walnuts, pumpkin seeds and linseeds, are also rich in PUFA. Linoleic acid is the predominating PUFA in many vegetable oils, while a few vegetable foods are important sources of ALA, e.g. linseeds, rapeseed oil and walnuts. In many cereals and vegetables, the proportion of PUFA in the fat is high, although the total fat content is relatively low. Fish generally has a medium to high proportion of long-chain n-3 PUFA in the fat.

According to data from the TRANSFAIR study, fats and oils (including spreads), meat and meat products (mainly pork) and, in some countries (Norway, Iceland, Sweden and France) also soups, sauces were the main sources of PUFA. Other contributors included cereal products and biscuits, cakes and other bakery products (Table 4).

Table 4. Contribution (%) to the total intake of *cis*-PUFA of selected food groups in adults in various European countries from the TRANSFAIR study (Hulshof *et al*., 1999)

Product group	France	Germany	Greece	Italy	Netherlands	Spain	Sweden	UK
Milk and milk products	-	1.2	2.9	1.1	1.3	1.3	4.3	2.1
Cheese	2.1	1.4	1.9	2.0	1.1	0.5	2.0	0.7
Eggs	2.7	6.5	0.7	2.5	2.0	2.3	4.1	1.5
Meat (products)	19.1	21.9	8.9	6.9	12.9	15.8	15.3	12.2
Fish	4.3	1.8	11.9	0.9	2.2	1.4	6.0	1.2
Butter	3.4	6.1	<0.1	0.8	0.3	<0.1	5.9	0.7
Oils and fats	29.2	57.5	33.1	73.9	44.9	67.3	12.7	48.0
Biscuits and cakes	5.2	2.2	6.2	5.1	5.1	4.7	13.6	5.7
Pizza, meat- and vegetable pies	-	-	3.3	0.3	0.6	0.6	2.6	3.5
Grain (products)	7.9	0.5	7.2	5.8	7.0	3.3	11.7	6.8
Seeds, kernels, nuts	1.2	0.0	8.5	0.0	8.5	0.0	2.1	2.3
Chocolate, candy bars and confectionery	-	0.6	3.6	0.4	1.3	0.3	0.7	0.4
Soups and sauces	10.9	0.1	3.4	0.3	6.6	<0.1	12.2	5.4
Savoury snacks	-	<0.1	0.3	<0.1	2.2	0.9	0.6	6.4
Chips, French fries	6.5	0.1	11.1	0.0	1.2	0.6	3.8	1.7
Industrial meals, restaurant foods	-	0.1	3.3	<0.1	2.0	-	-	1.2
Miscellaneous	-	0.1	2.6	0.0	0.7	0.0	1.2	0.1

(-): no information/data available

3.2.2 Dietary intake

In the TRANSFAIR study (Hulshof et *al.*, 1999), average intakes of *cis*-PUFA ranged from 3 to 7 E%. In more recent dietary surveys, average intakes range from about 5 to 7 E% (Table 5).

Table 5. Dietary intake of PUFA among adults according to recent dietary surveys in some European countries

Country	Survey	Total PUFA		n-6		n-3	
		Men	Women	Men	Women	Men	Women
Germany[a]	GeNuS	12.8 g/d 4.6 E%	10.0 g/d 4.8 E%	-	-	-	-
Finland[b]	Finndiet	12.9 g/d 5.2 E%	8.8 g/d 4.9 E%	10.1 g/d 4.1 E%	6.9 g/d 3.8 E%	2.6 g/d 1.1 E%	1.7 g/d 1.0 E%
Greece[c]	Adults 25- 75+	17 g/d 6 E%	15 g/d 7 E%	-	-	-	-
Italy[c]	Adults 18-64 years	12 g/d 5 E%		-	-	-	-
The Netherlands[d]	Adults 22-65 years DNFCS	21 g/d 7.0 E%	15 g/d 6.8 E%	-	-	-	-
Sweden[e]	Riksmaten Adults 18-74 years	13 g/d 4.6 E%	10 g/d 4.7 E%	9.8 g/d 3.7 E%	7.9 g/d 4.0 E%	2.0 g/d 0.7 E%	1.5 g/d 0.7 E%
United Kingdom[f]	NDNS	15.2 g/d 6.4 E%	11.1 g/d 6.3 E%	12.9 g/d 5.4 E%	9.4 g/d 5.3 E%	2.3 g/d 1.0 E%	1.7 g/d 1.0 E%

[a] Mensink and Ströbel (1999). Calculated from median values
[b] Männistö *et al.* (2003).
[c] Elmadfa *et al.* (2005).
[d] Hulshof *et al.* (1998).
[e] Becker and Pearson (2002).
[f] Henderson *et al.* (2003).
(-): no information/data available

3.3 Omega-3 fatty acids

3.3.1 Occurrence in food/contribution from food groups

Human milk contains ALA (about 1% of fatty acids or 1% of energy), EPA and DHA in amounts which vary with the diet of the mother (van Houwelingen *et al*., 1995; Henderson *et al*., 1992).

The major sources of n-3 PUFA are certain vegetable oils and fish. Vegetable oils from soybean, rape, walnut and linseed contain high amounts of ALA (7.7, 9.2, 12.9 and 54 g/100 g, respectively) (Souci *et al*., 2000). These oils do not contain DHA or EPA, which occur in fatty fish like salmon, tuna and mackerel (19.2, 22.2 and 14.8 g/100 g fat or 1.1, 1.5 and 0.95 g/100 kcal) and to a lesser extent in egg yolk (180 mg/100 g) or meat (pork 47 mg/100 g) (Table 6).

Table 6 lists foods which (with the exception of radish, human milk, chicken, whole egg and cod) contain more than 0.3 g total n-3 PUFA per 100 g. Whereas this total n-3 PUFA content is ALA only in all foods of plant origin, it includes long-chain n-3 PUFA (LC n-3 PUFA) in foods of animal origin. Because of the variable energy content, the amount of n-3 PUFA and LC n-3 PUFA per 100 kcal is different from the amount per weight. In most but not all cases, it is lower than the weight related amount. With respect to kale, this conversion per energy value results in a n-3 PUFA content comparable to rapeseed oil, soybean oil and higher than in eel. However, to achieve an intake of 0.5 g of n-3 PUFA, 5 g of rapeseed oil, 6.5 g of soybean oil, 27 g of eel or 139 g kale would have to be consumed.

Dietary intakes of n-3 PUFA vary with nutritional habits, especially with the amounts and types of vegetable oils and of fish in the diet. The type of vegetable oil in the diet is the most important determinant for the intake of ALA, and the consumption level and type of fish determines the LC n-3 PUFA intake.

More recently, foods (e.g. bread, dressings, meat products, eggs) enriched with LC n-3 PUFA and food supplements with LC n-3 PUFA have become available. No data are available to estimate their influence on intake of n-3 PUFA and especially LC n-3 PUFA in the population.

3.3.2 Dietary intake

In the TRANSFAIR study (Hulshof *et al*., 1999), the linoleic acid and ALA intake in 14 European countries was estimated. In several countries (France, Germany, Greece, Portugal, Spain), the intake of ALA was below the recommended intake for total n-3 PUFA given in 1993 by the Scientific Committee on Food (SCF).

The available more recent data on ALA, EPA, DHA and total n-3 fatty acid intake are listed in Table 7.

Whereas the observed intakes of total n-3 PUFA and of ALA both as absolute amounts and as percent of the energy intake are close to the Population Reference Intake (PRI) defined by the SCF (1993), the intakes of LC n-3 PUFA are mostly lower than recommended by national authorities. Generally, the intake of LC n-3 PUFA increases with age parallel to an increase in fish consumption (DGE, 2004).

4. NUTRITIONAL REQUIREMENTS AND HEALTH EFFECTS

4.1 MUFA

Humans can synthesise MUFA from (saturated) fatty acids and from carbohydrates, and MUFA are not required from the diet. A deficiency therefore does not occur.

Cis-MUFA, but not *trans*-MUFA, in the diet have a beneficial effect on the serum lipid profile, i.e. the total cholesterol:HDL cholesterol ratio, as compared to saturated fatty acids (SFA), while PUFA have a slightly stronger effect than MUFA. The effects of isoenergetic exchange of the various classes of fatty acids against carbohydrate on the serum LDL- and HDL-cholesterol levels are summarised in Table 8. Isoenergetic exchange of carbohydrates with MUFA also results in lowering of the serum triacylglycerol level, another independent risk factor for coronary heart disease (CHD), but this effect is comparable to that found for SFA and PUFA.

There is ample evidence that these changes induced by replacing SFA and *trans*-fatty acids with MUFA/PUFA will have a beneficial effect on the risk of CHD (Kris-Etherton, 1999). Isocaloric replacement of about 5 E% SFA by MUFA/PUFA has been estimated to reduce CHD risk by 20-40%. Based on epidemiological data, replacement of *trans*-fatty acids by unsaturated fats may have a stronger effect: a reduction of relative risk by *circa* 25% for each 2 E% (NDA, 2004; Hu, 1997; Mensink *et al*., 2003). These estimates are based upon the effects of changes in dietary lipid composition that determine the serum cholesterol profile.

Evidence from controlled clinical studies indicates that MUFA may favourably affect, in the context of a low saturated fat diet, a number of other risk factors for CHD, such as factors related to thrombogenesis, *in vitro* LDL oxidative susceptibility (compared with PUFA), and insulin sensitivity (Kris-Etherton, 1999; Wahrburg, 2004; DGAC Report, 2005).

4.2 PUFA

Modulation of dietary fat composition affects serum lipid concentrations (see Table 8). Replacing SFA and *trans* fatty acids (TFA) with *cis*-PUFA lowers serum LDL-cholesterol concentration, while HDL-cholesterol remains largely unchanged (NDA, 2004). Increasing intakes of LC n-3 PUFA reduce serum triglyceride levels. LC n-3 PUFA in the form of fish or fish oils have been associated with a decreased risk of cardiovascular disease, while evidence from trials with ALA is inconclusive (see section 4.3).

Clinical symptoms of essential fatty acid deficiency (skin changes and growth retardation) have been found in healthy newborn babies fed for 2-3 months with a diet low (<1 E%) in linoleic acid. Essential fatty acid deficiency in adults is rare. Reported cases have been associated with chronic diseases or prolonged parenteral or enteral nutrition, either without fat or very low in fat. The minimum requirement for linoleic acid remains unknown.

Clinical signs (skin changes) of insufficient supply of ALA have been reported at intakes of <0.05 E% during enteral nutrition and <0.1 E% during parenteral nutrition, but the specificity of these findings has been challenged (see section 4.3).

Linoleic acid and ALA compete for the same desaturases and elongases. The latter has a higher affinity for the enzymes. Therefore, a very high intake of ALA reduces the relative proportions of long-chain n-6 PUFA in tissues. Correspondingly, a very high dietary intake of linoleic acid may disturb the metabolism and distribution of n-3 PUFA. Because of the competition for metabolic enzymes between the fatty acids of n-6 and n-3 series, it is important to maintain a balance between n-6 and n-3 PUFA in the diet. The importance of increasing the proportion of n-3 PUFA in dietary fats, in e.g. the USA, has been emphasised in review articles (Harper and Jacobson, 2001), but there is no consensus about the optimal n-6/n-3 ratio in the diet.

Data on the safety aspects of high, i.e. above 10 E% intakes of PUFA, are limited. Infants have been fed formula containing high (60% of total fatty acids) amounts of linoleic acid without apparent harmful effects. Nonetheless, high intakes of PUFA may have untoward consequences through increased peroxidation, altered immune responses or an increased tendency for bleeding. High concentrations of linoleic acid increase *in vitro* oxidation of LDL, but it is not known whether this has harmful effects on health. Prolonged high intake of EPA and DHA (1.5 E% for several months) has been associated with an increased tendency to nasal bleeding (Clarke *et al*., 1990). Reduced activity of leucocytes *ex vivo* has been observed after high intakes of ALA (6.3 E%) or fish oils (1.5 E%) (Kelly *et al*., 1991; Lee *et al*., 1985; Endres *et al*., 1989).

Table 6. Energy value and fat composition of some foods typically high or low in ALA and/or LC n-3 PUFA (values per 100 g and per 100 kcal, respectively)

Food	**Energy**	**Total fat**	**ALA**		**Total n-3 PUFA**		**EPA**		**DHA**		**DPA**		**Total LC n-3 PUFA**	
	kcal	g	g/100 g	g/100 kcal	g/100 g	g/100 kcal	g/100 g	g/100 kcal	g/100 g	g/100 kcal	g/100 g	g/100 kcal	g/100 g	g/100 kcal
Rapeseed oil	900	100.0	9.2	1.0	9.2	1.0	-		-		-		-	
Soybean oil	900	100.0	7.7	0.86	7.7	0.86	-		-		-		-	
Linseed oil	900	100.0	54.0	6.0	54.0	6.0	-		-		-		-	
Walnut oil	900	100.0	12.9	1.4	12.9	1.4	-		-		-		-	
Wheat germ oil	900	100.0	7.8	0.87	7.8	0.87	-		-		-		-	
Safflower oil	900	100	0.47	0.05	0.47	0.05	-		-		-		-	
Soybean	327	18.3	0.9	0.28	0.9	0.28	-		-		-		-	
Soybean flour	347	20.6	1.4	0.4	1.4	0.4	-		-		-		-	
Linseed	376	30.9	16.7	4.4	16.7	4.4	-		-		-		-	
Walnut	663	62.5	7.5	1.1	7.5	1.1	-		-		-		-	
Peanut	564	48.1	0.53	0.09	0.53	0.09	-		-		-		-	
Pecan nut	703	72.0	0.79	0.11	0.79	0.11	-		-		-		-	
Kale	37	0.9	0.36	0.97	0.36	0.97	-		-		-		-	
*Radish***	*15*	*0.15*	*0.055*	*0.370*	*0.055*	*0.370*	-		-		-		-	
*Human milk****	*69*	*4.0*	*0.03*	*0.04*	*0.08*	*0.116*	*0.02*	*0.03*	*0.02*	*0.03*	*0.01*	*0.014*	*0.05*	*0.079*
*Egg whole****	*155*	*11.3*	*0.1*	*0.06*	*0.1*	*0.06*	-		-		-		-	
Egg yolk	353	31.9	0.26	0.07	0.5	0.142	-		0.18	0.05	0.06	0.017	0.24	0.0022
Pork liver	131	4.9	0.02	0.02	0.43	0.328	0.18	0.14	0.2	0.15	0.03	0.023	0.41	0.313
*Chicken****	*166*	*9.6*	*0.11*	*0.07*	*0.24*	*0.143*	*0.007*	*0.004*	*0.11*	*0.07*	*0.01*	*0.006*	*0.127*	*0.080*
Margarine, vegetable	722	80	2.58	0.36	2.56	0.36	-		-		-			
Butter	751	83.2	0.44	0.06	0.48	0.06	-		0.01	0.001	0.031	0.004	0.041	0.005
Herring	233	17.8	0.06	0.03	2.86	1.227	2.0	0.86	0.7	0.3	0.1	0.04	2.8	1.2
Tuna	226	15.5	0.21	0.09	3.96	1.752	1.39	0.62	2.1	0.93	0.26	0.12	3.75	1.67
Salmon	202	13.6	0.36	0.18	3.34	1.653	0.75	0.37	1.85	0.92	0.38	0.19	2.98	1.48
Mackerel	182	11.9	0.25	0.14	2.11	1.159	0.63	0.35	1.1	0.60	0.13	0.07	1.87	1.02
Eel	281	24.5	0.66	0.23	1.86	0.662	0.26	0.09	0.57	0.20	0.37	0.13	1.2	0.42
*Cod***	*77*	*0.64*	*0.004*	*0.005*	*0.28*	*0.36*	*0.07*	*0.09*	*0.19*	*0.25*	*0.009*	*0.012*	*0.28*	*0.36*

(Souci, Fachmann, Kraut, 2000; MAFF, 1998)

** These foods do not qualify for the proposed claims on a weight/volume basis; they qualify on an energy basis.

*** These foods do not qualify for the proposed claims.

(-): no information/data available

Table 7. Dietary intakes of ALA, EPA, DHA, total n-3 PUFA in different countries

	ALA (median)		EPA (median)		DHA (median)		Total n-3 PUFA (mean)	
	Men	Women	Men	Women	Men	Women	Men	Women
USA (FNB, 2002)	1.2-1.6 g/d	0.9-1.1 g/d	4-7 mg/d		52-90 mg/d 0.066-0.093	0.052-0.069	1.3-1.8 g/d	1.0-1.2 g/d
France (Astorg *et al*., 2004)	0.9 g/d 0.36 E% (0.2-1.1)	0.7 g/d 0.38 E% (0.18-1.04)	(mean) 150 mg/d	(mean) 118 mg/d	(mean) 273 mg/d	(mean) 226 mg/d	-	-
Sweden, 1997-98 (Becker and Pearson, 2002)	1.5 g/d 0.6 E%	1.2 g/d 0.6 E%	100 mg/d 0.04 E%	100 mg/d 0.05 E%	240 mg/d 0.09 E%	210 mg/d 0.1 E%	2.0 g/d 0.7 E%	1.5 g/d 0.7 E%
Germany 1998[*] (DGE, 2004)	(mean) 2.2 g/d 0.8 E%	(mean) 2.0 g/d 0.8 E%	(mean) 110 mg/d 0.04 E%	(mean) 60 mg/d 0.02 E%	(mean) 140 mg/d 0.05 E%	(mean) 95 mg/d 0.04 E%	2.45 g/d 0.9 E%	2.15 g/d 0.8 E%
Germany 1996-98[**] (Linseisen *et al*., 2003)	(mean)	(mean)	(mean)	(mean)	(mean)	(mean)	-	-
Center H	1.59 g/d 0.6 E%	1.32 g/d 0.6 E%	100 mg/d 0.04 E%	70 mg/d 0.03 E%	190 mg/d 0.07 E%	140 mg/d 0.07 E%	1.88 g/d 0.7 E%	1.53 g/d 0.7 E%
Center P	2.25 g/d 0.8 E%	1.51 g/d 0.8 E%	130 mg/d 0.05 E%	80 mg/d 0.04 E%	210 mg/d 0.07 E%	140 mg/d 0.07 E%	2.59 g/d 0.9 E%	1.73 g/d 0.9 E%

[*] Income and consumption statistic 1998; n=62,000 households reporting over three months; men and women 25-<51 years old.
[**] German EPIC cohort (European Prospective Investigation into Cancer and Nutrition); n=2121 men and women from center H, n=2173 men and women (age 35-64 years) from center P; computer-guided 24-h recall.
(-): no information/data available

Table 8. Predicted changes (Δ) in the ratio of serum total to HDL cholesterol and in LDL- and HDL-cholesterol concentrations by isoenergetic exchange of 10% of energy from carbohydrates with fatty acids (from Mensink *et al*., 2003)

Effect on serum lipid profile	Effect of replacing 10 E% carbohydrates by[1]: SFA	Cis- MUFA	Trans-MUFA[2]	PUFA
Total cholesterol concentration (mmol/L)	+ 0.39	(- 0.03)	-	- 0.15
LDL-cholesterol concentration (mmol/L)	+ 0.33	(- 0.06)	+ 0.40	- 0.14
HDL-cholesterol concentration (mmol/L)	+ 0.12	+ 0.09	(- 0.01)	+ 0.07
Total / HDL-cholesterol ratio	(+ 0.03)	- 0.26	+ 0.021	- 0.32
Triacylglycerol concentration (mmol/L)	- 0.25	- 0.22	-	- 0.28

[1] Values between brackets are not statistically significant.
[2] Mainly *trans* 18:1 isomers.
(-): no information/data available

4.3 Omega-3 fatty acids

Eicosanoids derived from EPA like those derived from the n-6 fatty acid arachidonic acid (AA) have important effects on physiological processes like platelet aggregation, vascular constriction and immune cell function. The balance between EPA and AA derived eicosanoids is, therefore, relevant for many chronic diseases. EPA has moreover, an inhibitory effect on hepatic triglyceride synthesis and VLDL secretion (Berge *et al*., 1999; Wong and Nestel, 1987).

Like PUFA of the n-6 series, n-3 PUFA in the diet have a positive effect on blood lipid levels. LC n-3 PUFA specifically reduce plasma triglyceride levels and thereby the risk of cardiovascular disease. Other potential mechanisms of cardiovascular protection may include lowering of blood pressure, reduced thrombotic tendency, antiinflammatory and antiarrhythmic effects, improved vascular endothelial function, increased plaque stability, increased paraoxonase levels and improved insulin sensitivity (Hooper *et al.,* 2005). ALA rich diets have been shown to decrease the risk for fatal cardiovascular disease in prospective cohort studies and clinical trials of secondary prevention of fatal coronary heart disease (Brouwer *et al*., 2004). It has been suggested that ALA inhibits vascular inflammation and endothelial activation (Zhao *et al*., 2004). Fish and fish oil (rich in LC n-3 PUFA) consumption have been shown to reduce the risk for coronary artery disease (He *et al*., 2004; Marckmann and Gronbaek, 1999; Yuan *et al*., 2001) and to have beneficial effects in secondary prevention of mortality from coronary artery disease in prospective randomised studies (Kris-Etherton *et al*., 2003).

A recent meta-analysis (Hooper *et al*., 2005) of 48 randomised controlled trials (RCT) assessing the effects of an increased intake of total n-3 PUFA on total mortality or combined cardiovascular events did not find a significant protective effect on deaths (RR 0.98; 95% CI 0.70-1.36) nor on combined cardiovascular events (RR 1.09; 95% CI 0.87-1.37). This conclusion was largely influenced by the inclusion of the results of a one big randomised controlled trial using fish oil (Burr *et al*., 2003). This study has been criticised because of methodological deficits (Kris-Etherton and Harris, 2004). There was a suggestion of a significant reduction in total mortality with high compared to low total n-3 PUFA intake in cohort studies (Hooper *et al*., 2005). Another meta-analysis including 39 RCTs and observational studies that quantified the amount of fish or of LC n-3 PUFA intake and were at least 1 year in duration concluded that consumption of n-3 PUFA from fish or from supplements of fish oil reduces all cause mortality and various cardiovascular disease outcomes and that the evidence for ALA supplements is inconclusive (Wang *et al*., 2004).

Neither a protective nor a promoting effect of dietary ALA against cancer has been convincingly demonstrated (Brouwer *et al*., 2004; de Lorgeril and Salen, 2004; Hooper *et al*., 2005). Despite evidence from *in vitro* and animal studies for a protective effect of EPA and DHA on progression of tumours in various organs, a meta-analysis of recent cohort and case-control studies of marine fatty acid intake and the risk for breast and prostate cancer did not find a significant association. There were indications that an inverse association may exist between the ratio n-3 to n-6 PUFA and risk for breast cancer (Terry *et al*., 2004).

There are no data available on adverse effects of high ALA consumption. Adverse effects of high consumption of n-3 PUFA have mostly been reported for EPA and DHA which are biologically more potent than their precursor fatty acid ALA. High intakes were reported to decrease ALA conversion to DHA (Burdge, 2004) and to increase at a dose of 1.7 g/day the *ex vivo* susceptibility of LDL to oxidation (Finnegan *et al*., 2003). Prolonged high intake of EPA and DHA (1.5 E% for several months) have been reported to be associated with a prolonged bleeding time and an increased tendency to nasal bleeding (Clarke *et al*., 1990; Schmidt *et al*., 1992).

EPA and DHA suppress certain immune reactions which enable the body to attack pathogens (Kelley *et al.*, 1998 and 1999; Meydani *et al.*, 1993) when given in amounts of 2-9 g/day. These effects were in most cases accompanied by antiinflammatory reactions.

Deficiency of n-3 PUFA is rare and has mostly been observed in patients on enteral or parenteral nutrition which did not contain ALA (Bjerve, 1989; Holman *et al.*, 1982).

Tissue levels of DHA and EPA decrease with a low intake of ALA or of n-3 PUFA in general, but these biochemical changes can not be related as yet in a dose response assessment to functional endpoints (impairment of visual or neural function, immune response). This is also true for infants fed formula without DHA but with an adequate ALA content.

5. RECOMMENDED INTAKES

5.1 MUFA

Recommendations for MUFA are derived from considerations on the beneficial partition of dietary fatty acids in the context of the "total fat" recommendation. They are based on considerations of the recommended maximum intake of saturated fatty acids (SFA), and the recommended minimum and maximum intakes for PUFA.

Recommended (reference) intakes for fatty acids are often expressed as a proportion of the total daily energy intake (E%). Reference intakes for the adult population proposed by various national and international organisations are listed in Table 9.

Table 9. Population reference intakes for total fat, SFA, MUFA and PUFA (as E%) in adults according to various national and international bodies

	Total fat	SFA	MUFA	Total PUFA	n-6 PUFA	n-3 PUFA
SCF, 1993	-	-	-	2.5	2	0.5
D-A-CH, 2000	<30	10*	-[a]	3	2.5	0.5
ANC (France), 2001	30-35	-	15-17.5[b]	5	4	1
NNR (Nordic countries), 2004	30 (25-35)	10**	10-15	5-10	≥4	≥1
DRV (UK-DoH), 1991	<35	-	13	6.5	-	-
WHO, 2003	15-30	<10	-	6-10	5-8	1-2
DRI (The Netherlands), 2001[c]	20-35/40	<10	-	3-12	2	1
FNB (USA), 2002[d]	20-35	as low as possible	-	5.6-11.2	5-10	0.6-1.2

[a] No specific recommendation. At least 2/3 of total fat as unsaturated fatty acids.
[b] 50% of total fat intake.
[c] Adequate intakes (AI). Value for n-3 refers to ALA. AI of n-3 from fish is 0.2 g per person/day. The upper level for total PUFA is 12 E%.
[d] n-6 fatty acids calculated as linoleic acid. n-3 fatty acids may include up to 10% LC, e.g. as EPA and/or DHA.
* maximum.
** about 10, including TFA.

5.2 PUFA

The SCF defined Population Reference Intakes (PRI) of 2 E% for n-6 PUFA and 0.5 E% for total n-3 PUFA (SCF, 1993). This corresponds to a daily intake of approximately 5.5 g/day and 7.5 g/day of PUFA for a typical adult female and male, respectively. The corresponding amounts for n-6 PUFA are 4.5 g/day and 6 g/day and for n-3 PUFA 1.0 g/day and 1.5 g/day, respectively. Other scientific bodies have recommended somewhat higher intakes, also expressed as E% (Table 9). The US Food and Nutrition Board of the Institute of Medicine has established "adequate intakes" for linoleic acid (12 g/day and 17 g/day for men and women, respectively) and ALA (1.1 g/day and 1.6 g/day, respectively) (FNB, 2002). These reference values are based on observed intakes in the US population. In addition, the FNB set Acceptable Macronutrient Dietary Ranges (AMDR) for total n-6 PUFA at 5-10 E% and for total n-3 PUFA at 0.6-1.2 E% (FNB, 2002). The lower boundary for n-6 and n-3 PUFA represents the adequate intakes for linoleic acid and ALA, respectively. The upper level of n-6 PUFA is based on the observation that actual intakes of ALA rarely exceed this level and potential adverse effects of higher intakes, although epidemiological evidence on safety are lacking. The upper level for n-3 PUFA corresponds to the highest intakes of ALA observed in the US and Canada. With regard to LC n-3 PUFA it is stated that up to 10% of the AMDR can be consumed as EPA and/or DHA.

For pregnant and lactating women, the SCF suggested the same PRI (expressed as E%) as for non-pregnant females. This is also the case for the Nordic, D-A-CH, and Dutch recommendations. Some organisations, e.g. the French ANC, give somewhat higher reference intakes for pregnancy and lactation than for non-pregnant women.

Generally, intakes of total PUFA above 10-15 E% are not recommended. The SCF recommended that habitual intakes of n-3 PUFA should not exceed 5 E% and that intakes of total PUFA should not exceed 15 E%.

Some recommendations consider the balance between n-6 and n-3 PUFA. Usually the ratio between n-6 and n-3 PUFA is secondary to the reference values. For example in the Nordic Nutrition Recommendations (NNR), a ratio of n-6 to n-3 PUFA between 3 and 9 is considered to be adequate (Becker *et al*., 2004). In the German-Austrian-Swiss recommendations the effective ratio is 5:1 and it is mentioned that an unbalanced ratio may affect the further metabolism to e.g. eicosanoids (D-A-CH, 2000). Using data from Table 9 the effective ratio varies from 2:1 to around 10:1, depending on whether adequate or upper level values are selected. As mentioned in section 4.2 there is no consensus about the optimal n-6/n-3 ratio in the diet.

5.3 Omega-3 fatty acids

The SCF defined the PRI for total n-3 PUFA as 0.5% of the total energy intake of adults and recommended that not more than 5% of the energy intake should be n-3 PUFA (SCF, 1993). Converted to the energy requirement of a sedentary male adult, this is 1.5 g/day. Converted to an energy intake of 1850 kcal/day for a female adult, this recommendation corresponds to 1.0 g n-3 PUFA per day.

Recommendations of different bodies for the intake of ALA, EPA, DHA and total n-3 PUFA are listed in Table 10.

Table 10. Recommended dietary intake of n-3 PUFA

	n-3 fatty acids		ALA		LC n-3 PUFA		DHA		EPA	
	% of energy	g/day	% of energy	g/day	% of energy	mg/day	% of energy	mg/day	% of energy	mg/day
WHO, 2003	1-2	-	-	-	-	-	-	-	-	-
SACN, 2004	-	-	-	-	-	450	-	-	-	-
Eurodiet, 2000	-	-	-	2	-	200	-	-	-	-
NL (Gezondheidsraad, 2001)										
<6 months	-	-	-	m: 0.08	-	-	-	20	-	-
all other	-	-	1	-	-	200	-	-	-	-
Nordic Countries, 2004	1	-	-	-	-	-	-	-	-	-
France, (ANC, 2001)										
Adult men	0.8	2	-	-	0.2	500	0.05	120	-	-
Adult women	0.8	1.6	-	-	0.2	400	0.05	100	-	-
Pregnant women	0.9	2.0	-	-	0.4	1000	0.1	250	-	-
Lactating women	0.9	2.2	-	-	0.4	1000	0.1	250	-	-
Elderly	0.9	1.5	-	-	0.4	400	0.1	100	-	-
USA (FNB, 2002)*										
0-6 months	-	0.5	-	-	-	-	-	-	-	-
7-12 months	-	0.5	-	-	-	-	-	-	-	-
1-3 years	-	-	-	0.7	-	-	-	-	-	-
4-8 years	-	-	-	0.9	-	-	-	-	-	-
9-13 years	-	-	-	1.2/1.0	-	-	-	-	-	-
14-18 years	-	-	-	1.6/1.1	-	-	-	-	-	-
>19 years	-	-	-	1.6/1.1	-	-	-	-	-	-
Pregnancy	-	-	-	1.4	-	-	-	-	-	-
Lactation	-	-	-	1.3	-	-	-	-	-	-
D-A-CH, 2000	0.5	-	-	-	-	-	-	-	-	-

* Adequate intakes
(-): no information/data available

The differences in recommendations reflect different nutritional goals. While FNB (2002) determined the adequate intake levels for infants, children and adults from the intake from human milk and from the (highest) median intakes of ALA observed in the United States in the different age groups, where n-3 PUFA deficiency is basically non-existent in free-living populations, both the SCF (1993) and D-A-CH (2000) values are based on the amounts necessary to correct clinically manifest n-3 PUFA deficiency to which additions were made for safety purposes (Bjerve *et al*., 1989; Bjerve, 1989; Holman *et al*., 1982). ALA in amounts corresponding to 0.2% of the energy intake was reported to be sufficient and was proposed as the minimal requirement. This amount increased deficient plasma levels of EPA, DPA, and DHA but not of ALA and it stimulated growth in non-growing symptomatic children. The same authors estimated via supplementation of long-chain (LC) n-3 PUFA in these deficient patients a minimum and an optimal requirement for LC n-3 PUFA: 100-200 mg/day (0.1-0.2% of energy) and 350-400 mg/day (0.4% of energy), respectively (Bjerve *et al*., 1989).

The recommendations for total n-3 PUFA formulated by WHO (2003) were based on considerations of cardiovascular health and neurodevelopment: ALA 0.7 to 1% of energy corresponding to between 1.0 and 3 g ALA/day (energy intake 1800-2700 kcal/day). This dose has been identified in observational and applied in interventional studies.

Arguments in favour of a requirement for exogenous intake of EPA/DHA in pregnant and lactating women of about 0.2 g/day to satisfy the needs of the foetus and young infant for these LC n-3 PUFA for optimal neurodevelopment have been provided by SACN (2004). With consideration of beneficial effects of LC n-3 PUFA for cardiovascular health several institutions have formulated recommendations for an exogenous intake, e.g. from fish, ranging from 200 to 500 mg/day (Eurodiet, 2000; Gezondheidsraad, 2001; SACN, 2004). No PRI in absolute amounts for total n-3 PUFA has been defined for the European population, neither for LC n-3 PUFA.

5.4 Saturated fatty acids

There is no evidence that SFA are essential or have a beneficial role. Generally it is recommended to keep the intake of SFA as low as possible, if possible below 10 E%. This is not an upper level, but a maximum intake level derived from the observed distribution of SFA intake in the population, generally the 10^{th} percentile, that is considered feasible. Only for infants (0-5 months) a higher adequate level of intake is set by some authorities, based on the SFA content of breast milk (*circ*a 20-25 E%) (Koletzko *et al*., 1992).

5.5 Unsaturated fatty acids

Most authorities have separate recommendations for PUFA, and sometimes MUFA, but only D-A-CH has a recommendation for total unsaturated fatty acids, i.e. at least 2/3 of the total fat intake as unsaturated fatty acids.

CONCLUSIONS

1. OMEGA-3 FATTY ACIDS CLAIMS

There are two categories of n-3 PUFA - ALA and LC n-3 PUFA (mainly as EPA and DHA) - which differ in function and requirements. The proposed claims do not distinguish between ALA and LC n-3 PUFA which have different nutritional roles. ALA is a nutritionally essential fatty acid required for synthesis of important fatty acids and eicosanoids. Available evidence suggests that LC n-3 PUFA (EPA and DHA) may reduce the risk of CVD, possibly mediated by preventing of cardiac arrhythmias.

The RNI proposed in the claim (2 g/day) is in the same range as intakes of ALA recommended by some authorities to meet dietary requirements in adults (1-3 g/day). However it is much greater than intakes recommended by some authorities for LC n-3 PUFA (EPA and DHA) in adults for cardio-protective effects (200-500 mg/day). In many EU populations intakes of both ALA and LC n-3 PUFA are typically lower than these recommendations.

Claim: Omega-3 fatty acid source: more than 15% of the Recommended Nutritional Intake (2 g/day) of the omega-3 fatty acids concerned per 100 g or 100 mL or 100 kcal

As outlined, the claim could be made for a number of foods both on an energy and weight/volume basis, e.g. most plant oils, some nuts, some vegetables (mainly as ALA) and most fish (mainly as LC n-3 PUFA), as illustrated with examples from the German and UK food composition databases (Table 6).

Some foods would qualify for the claim on a weight/volume, but not energy basis (safflower oil, soy bean, peanut, butter) while other foods (radish, cod) would qualify on an energy, but not weight/volume basis. Some foods qualify although a typical serving provides little n-3 (e.g. radish, safflower oil, butter). These anomalies arise because the reference food quantity (100 g, 100 mL, 100 kcal) is not linked to the typical intake of the food.

Claim: High in omega-3 fatty acids - more than 30% of the Recommended Nutritional Intake (2 g/day) of the omega-3 fatty acids concerned per 100 g or 100 mL or 100 kcal

As outlined, the claim could be made for a number of foods both on an energy and weight/volume basis, e.g. most vegetable oils and some nuts (mainly as ALA) and fatty fish (mainly as LC n-3 PUFA) (Table 6).

Some foods would qualify for the claim on a weight/volume, but not energy basis (pecan nut, some vegetable margarines). Other foods qualify on an energy, but not a weight/volume basis although a typical serving provides only modest amounts of n-3 PUFA (e.g. kale). This anomaly arises because the reference food quantity (100 kcal) is not linked to the typical intake of the food.

2. MUFA CLAIM

MUFA are not nutritionally essential as they can be synthesised from other (saturated) fatty acids and carbohydrates. Substitution of SFA in the diet by an equal amount of MUFA reduces LDL-cholesterol; elevated LDL-cholesterol has been causally linked to coronary heart disease. Because SFA intakes of many EU populations exceed levels (about 10% energy) widely recommended for maintenance of lower plasma levels of LDL-cholesterol, MUFA consumption plays an important nutritional role in limiting SFA intake. In some EU populations, intakes of MUFA are at the lower end of recommended levels (in the range 10-18% of energy, which corresponds to about 30-50% of fatty acids for a diet containing 35 E% from total fat).

Claim: High monounsaturated fat: at least 45% of the fatty acids derive from monounsaturated fat and saturated fat must not provide more than 10% of energy

The claim as outlined may be made for a range of foods, as illustrated with examples from the Swedish food composition database (Table 11). These include good sources of MUFA, e.g. rapeseed oil, some fluid margarines, some nuts (hazelnuts, peanuts, pistachio nuts, almonds). However, the claim could also be made for some foods which provide only low amounts of MUFA in a typical serving, e.g. some fish (whiting), lean meat (veal, beef, pork), white bread, and some biscuits. These anomalies arise because the MUFA threshold is expressed as % of total fatty acids content which is not directly related to the typical intake of the food. In addition, some foods which provide significant amounts of MUFA may not qualify for the claim e.g. foods that are naturally high in MUFA such as olive oil and fatty fish (herring, salmon), and some margarines. This anomaly arises because the SFA content of these foods may exceed the disqualifying threshold of 10 E%.

3. PUFA CLAIM

In addition to n-3 fatty acids (ALA and the LC n-3 PUFA EPA and DHA), PUFA also include n-6 PUFA (mainly linoleic acid). Linoleic acid is essential for synthesis of long chain fatty acids and eicosanoids and linoleic acid and its metabolites have important roles in membrane function and regulation of metabolism.

In addition to the evidence for a cardio-protective effect of the LC n-3 PUFA and a nutritional requirement for ALA and linoleic acid, the substitution of SFA in the diet by an equal amount of *cis*-PUFA reduces LDL-cholesterol. Thus PUFA consumption plays an important nutritional role in limiting SFA intake. In EU populations intakes of total PUFA are generally within the recommended range (about 5-10% of energy), which corresponds to about 15-30% of fatty acids for a diet containing 35 E% from total fat.

Claim: High polyunsaturated fat: at least 45% of the fatty acids derive from polyunsaturated fat and saturated fat must not provide more than 10% of energy

The claim as outlined may be made for some vegetable oils (e.g. safflower oil), some nuts (walnut) and seeds (sunflower seed, linseed) (Table 11) which are good sources of PUFA. However, several vegetable oils which provide significant amounts of PUFA may not qualify for the claim, e.g. corn oil, grapeseed oil, rapeseed oil, soya oil, sunflower oil. This is because the SFA content of these foods may exceed the disqualifying threshold of 10 E%. In addition, the claim could be made also for some foods which provide only low amounts of PUFA in a typical serving, e.g. some breads, cereal products, beans, white fish (cod, turbot). This anomaly arises because the PUFA threshold is expressed as % of total fatty acids content which is not directly related to the typical intake of the food.

4. UFA CLAIM

(*Cis*)UFA comprises MUFA, n-6 PUFA (mainly linoleic acid) and n-3 PUFA (ALA and the LC n-3 PUFA EPA and DHA) and represents the balance of total fatty acids when SFA and TFA are excluded. Specific nutritional roles have been identified for n-6 PUFA and n-3 PUFA (ALA and the LC n-3 PUFA). In addition to the evidence for a cardio-protective effect of the LC n-3 and a nutritional requirement for ALA and linoleic acid, substitution of SFA in the diet by an equal amount of *cis*-UFA (both MUFA and PUFA) reduces LDL-cholesterol. Thus UFA consumption may play an important nutritional role in limiting SFA intake.

Claim: High unsaturated fat - the amount of unsaturated fat is 70% of the total fat content

The claim as outlined may be made for a wide range of foods which are good sources of UFA, e.g. most vegetable oils, some fat spreads, nuts and seeds (mainly n-6 and n-3 PUFA) and fatty fish (mainly LC n-3 PUFA) (Table 11). The claim could be made for some foods which have a relatively high content of saturated and/or *trans* fatty acids, e.g. foods such as oils and fat spreads in which most or all of the energy is derived from fat could qualify for the claim while containing up to 30 E% from saturated and/or *trans* fatty acids. The claim could be made also for some foods which provide only low amounts of UFA in a typical serving, e.g. beans and lentils, berries, cereals and white fish. This anomaly arises because the UFA threshold is expressed as % of total fat content which is not directly related to the level of fat in the food or to typical intake of the food.

Table 11. Monounsaturated, polyunsaturated, and unsaturated fatty acids (as percentage of the total fatty acids) and saturated fatty acids (as E%) in selected foods

Group	Name	Energy kJ/100g	Fat g/100g	MUFA g/100g	PUFA g/100g	UFA g/100g	*SFA E%*	MUFA %	PUFA %	UFA %
1	Corn oil	3700	100	27.8	56.5	84.3	*12%*	30%	57%	87%
1	Grapeseed oil	3700	100	18.2	66.7	84.9	*11%*	19%	70%	89%
1	Olive oil	3700	100	72.1	9.1	81.2	*14%*	75%	9%	85%
1	Rapeseed oil	3700	100	58.6	30.2	88.8	*7%*	61%	32%	93%
1	Safflower oil	3700	100	10.9	75.7	86.6	*9%*	11%	79%	91%
1	Soya oil	3700	100	22.3	58.4	80.7	*15%*	23%	61%	84%
1	Sunflower oil	3700	100	20.9	63.6	84.5	*11%*	22%	67%	88%
1	Wheat germ oil	3700	100	19.3	59.7	79	*17%*	20%	62%	83%
1	Mayonnaise fat 80%	3011	80	15.4	50.3	65.7	*9%*	20%	66%	86%
1	Margarine, 70% fat Flora	2590	70	27	11	38	*46%*	39%	16%	55%
1	Fat spread 40% fat	1540	40	15.5	6.7	22.2	*38%*	41%	18%	59%
1	Fat spread 35% fat Becel	1330	35	11	15	26	*25%*	31%	43%	74%
6	Soya beans dried	1551	17.7	4.2	9.9	14.1	*6%*	26%	60%	86%
6	White beans dried	1202	1.6	0.2	0.9	1.0	*1%*	13%	67%	80%
6	Brown beans dried	1188	1.5	0.1	0.9	1.0	*1%*	10%	75%	85%
6	Blackcurrants	266	1.3	0.1	0.6	0.7	*3%*	7%	58%	65%
6	Lentils dried	1270	1	0.2	0.5	0.7	*1%*	22%	59%	81%
6	Blueberries	193	0.8	0.1	0.5	0.6	*1%*	14%	81%	95%
6	Corn kernels frozen	399	0.8	0.2	0.3	0.5	*1%*	35%	51%	86%
6	Kale	187	0.7	0	0.5	0.5	*1%*	3%	66%	69%
6	Raspberries	117	0.6	0.1	0.4	0.4	*10%*	9%	82%	91%
10	Wheat germs	1351	9.4	2	5.2	7.2	*4%*	24%	60%	84%
10	Cereal mix Oats enriched	1530	6.4	2.4	2.6	5	*2%*	40%	43%	83%
10	Wholemeal wheat bread with milk fibre c 5%	1127	5.2	1.1	2.1	3.2	*4%*	24%	45%	68%
10	Barley crushed or flakes	1381	3.1	0.4	1.3	1.7	*2%*	16%	60%	57%
10	Wheat crushed grains or flakes	1284	2	0.3	0.9	1.2	*1%*	21%	63%	84%
10	Rye crushed grains or flakes	1254	1.5	0.2	0.7	0.9	*1%*	14%	68%	82%
10	Pasta macaroni spaghetti	1479	1.2	0.2	0.5	0.7	*0%*	21%	62%	83%
10	Rice parboiled	1488	1	0.3	0.4	0.6	*0%*	30%	42%	72%
17	Beef mince max 10% fat	620	7.6	3.06	0.3	3.36	*22%*	44%	4%	48%
17	Beef inside	458	2.4	1	0.1	1.1	*8%*	46%	5%	57%
17	Moose steak raw	418	1.2	0.3	0.5	0.8	*3%*	23%	49%	72%
19	Sardines canned in oil	1189	21.1	4.5	10.9	15.4	*14%*	24%	57%	81%
19	Herring Atlantic	965	18.5	7.7	4.7	12.4	*16%*	46%	28%	74%
19	Tuna canned in oil whole contents	1059	17.6	3.8	10.2	14	*9%*	24%	64%	88%
19	Salmon Atlantic	757	12	5	3.3	8.3	*13%*	46%	31%	77%
19	Plaice	391	2.7	0.5	0.9	1.4	*5%*	26%	48%	74%
19	Turbot	347	1.7	0.3	0.6	0.9	*4%*	25%	49%	74%
19	Prawns	351	0.8	0.2	0.3	0.5	*1%*	30%	46%	76%
19	Cod	315	0.7	0.1	0.3	0.4	*1%*	20%	61%	82%
23	Pecan nuts	2805	68	42.2	16.7	58.9	*7%*	65%	26%	91%
23	Hazelnuts	2695	62.6	48.8	6.5	55.3	*6%*	82%	11%	92%
23	Walnuts	2760	62	14.2	39.1	53.3	*8%*	24%	66%	90%
23	Almonds dried	2490	52	33.9	11	44.9	*7%*	68%	22%	90%
23	Sesame seeds dried	2341	50	18.8	21.8	40.6	*11%*	39%	46%	85%
23	Sunflower seeds dried	2437	49.5	9.5	32.7	42.2	*8%*	20%	69%	89%
23	Pistachio nuts	2517	48.5	32.7	7.3	40	*9%*	71%	16%	86%
23	Cashew nuts	2431	46.5	27.3	7.9	35.2	*14%*	61%	18%	79%
23	Pumpkin squash seeds dried	2331	46	14.3	21	35.3	*14%*	32%	48%	80%

Data from the Swedish food composition database 2004. Shaded cells indicate foods that would qualify for any of the proposed claims for MUFA, PUFA and UFA, respectively.

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