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Health Significance of Fat Quality of the Diet

Expert Meeting

Barcelona, February 1–2, 2009

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Preface

This supplement of *Annals of Nutrition and Metabolism* contains the Proceedings of the International Expert Meeting (IEM) on Health Significance of Fat Quality of the Diet, held on February 1–2, 2009, in Barcelona, Spain.

The year 2009 has started in a situation with global economic crisis, causing many changes in the societal landscape. For us in the health field, it is critical to consider how to maintain and strengthen good public health work. Health is, indeed, of growing value to people and of increasing interest to societies, also for economic reasons.

Diet plays a critical role in obtaining and maintaining good health and it is quite obvious that the quality of dietary fats is a crucial element in this. The aim of the Barcelona IEM was to review:

(1) existing recommendations and guidelines on fats in order to update the knowledge on health implications of the fat quality of the diet;
(2) the role of high-quality fat sources in contributing to achieving an optimal fat quality of the diet;
(3) consumer perception and insights on fats and fatty acids in order to analyze what consumers actually know about fats and health, and
(4) current dietary fat intakes and evaluate whether they are in line with the (inter)national recommendations for fats and fatty acids.

Furthermore, the goal was to agree on a statement, in which the experts with input from other stakeholders such as health and communication professionals and the food industry, call for concerted actions at all levels to guide consumers in making healthier choices with respect to the fat quality of the diet.

The IEM was organized under the auspices of the International Union of Nutrition Sciences and the World Heart Federation and funded through an unrestricted educational grant from Unilever.

We believe that the papers presented during the IEM and the summary statement provide a global viewpoint on health significance of the fat quality of the diet and hope that it will stimulate the discourse on fat in expert and consumer forums from 'eating less fat' to 'eating the right type of fat'.

March, 2009

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Dietary Fat Quality for Optimal Health and Well-Being: Overview of Recommendations

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Key Words
Cardiovascular diseases · Dietary recommendations · Fat quality · Health · Lipids

Abstract
A century ago, dietary fat was mainly seen as a source of energy. In 1929, George and Mildred Burr introduced the concept of essential fats: certain fats, i.e. linoleic acid and α-linolenic acid, need to be provided by the diet to prevent deficiencies. Although essential fats were initially considered of marginal nutritional importance for humans, clinical deficiency symptoms were recorded for the first time in the 1960s. Beyond the fact that essential fats can prevent deficiencies, research over the past decades has shown that they also play a major role in preventing chronic conditions such as cardiovascular diseases. This has resulted in an increased interest in the quality of the dietary lipid supply as a major determinant of long-term health and well-being, which is also reflected in recent diet guidelines. This paper will give an overview of key aspects of present recommendations on dietary fats.

Introduction

Fats were traditionally considered part of dietary energy needs until George and Mildred Burr in 1929 introduced the concept that fat might be necessary for the proper growth and development of animals and possibly humans. They proposed that linoleic acid (LA; 18:2 n–6), arachidonic acid (20:4 n–6) and α-LA (ALA; 18:3 n–3) be considered essential fatty acids (EFAs) [1]. These were considered of marginal nutritional importance for humans until the 1960s, when signs of clinical n–6 (omega–6) EFA deficiency were first identified in infants given skimmed milk with added coconut oil, providing limited or absent EFAs, and later recorded in children and adults given fat-free parenteral nutrition [2, 3]. More subtle symptoms appear in n–3 (omega–3) EFA deficiency including skin changes unresponsive to LA supplementation, abnormal visual function and peripheral neuropathy in subjects receiving high n–6, low n–3 fat sources in their intravenous nutrition supply [4].

Over the past decades, the focus of lipid nutrition research has shifted beyond the study of their role as essential nutrients for growth and skin health to encompass the role of specific fatty acids (FAs) on cholesterol, lipoprotein and glucose metabolism [5, 6]. It is now well

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established that the plasma concentration of low-density-lipoprotein (LDL), very-low-density-lipoprotein and high-density-lipoprotein (HDL) cholesterol and triglyceride levels are related to the type and amount of FA intake [7, 8]. More recently, evidence on the effect of FAs on insulin sensitivity and glucose metabolism has emerged [9]. The recognition that n–6 and n–3 EFA are precursors to the formation of prostanoids, thromboxanes, leukotrienes and neuroprotectins, which in turn regulate key physiologic functions (blood pressure, vessel stiffness/relaxation, thrombocyte aggregation, fibrinolytic activity, inflammatory responses and leukocyte migration) has added a further dimension to the potential consequences of FAs for human health. Inflammation, vasoconstriction, vasodilatation, blood pressure, bronchial constriction, uterine contractility and reperfusion oxidative damage have been demonstrated to be affected and potentially regulated by n–3 and n–6 EFA or their endogenous metabolic products [10–12].

Interest in the quality of dietary lipid supply as a major determinant of long-term health and well-being is presently growing. We clearly have to go beyond the traditional saturated and polyunsaturated classification that yielded the polyunsaturated/saturated ratio or vegetable versus animal fat division suggesting that animal fat was bad and vegetable fats were good. The role of specific fats which define fat quality and impact health must presently be considered by examining the effects of individual FAs. The key descriptors for fat quality presently include: saturated FAs (SFAs: lauric, myristic, palmitic and stearic acids); monounsaturated FAs (oleic); polyunsaturated FAs [(PUFAs) of the n–6 (LA and arachidonic acid) and n–3 (ALA, eicosapentaenoic acid, EPA, and docosahexaenoic acid, DHA) series] and trans FAs (TFAs, elaidic and conjugated trans LA). Thus recent national/international dietary fat and FA recommendations consider the need to satisfy EFA needs, promote neurodevelopment and cardiovascular health and prevent degenerative diseases at all stages of the life course. The World Health Organization (WHO) and the Food and Agriculture Organization of the United Nations (FAO) have provided international recommendations for fats in human health in 1978 and 1994 [13, 14]; additionally, the WHO/FAO expert group that met in 2002 to address nutrition and the prevention of chronic diseases considered fat quality as an important aspect of the preventive strategies (Technical Report Series 916) [15, 16]. The WHO recently produced an update on TFAs in human nutrition [17], and a new report on fat and FAs in human nutrition based on expert consultation conducted late in 2008 is being edited and will be published in the near future. The Barcelona International Expert Meeting used existing national and international recommendations for its deliberations.

Overview of the Present Knowledge and Recommendations

Essential Fatty Acids

Present knowledge establishes a clear need for essential fats; these are the essential PUFAs, LAs and ALAs. These should be considered essential and indispensable since they cannot be synthesized by humans and must be provided by the diet. Since DHA (22:6 n–3) and arachidonic acid (20:4 n–6) can be synthesized from ALA and LA, respectively, they should be considered dispensable, although a dietary supply may be necessary for long-term health [11, 18]. Given the limited and highly variable formation of DHA from ALA (1–5%) and because of its critical role in normal retinal and brain development in the human, DHA (as provided by human milk) should be considered conditionally essential during early development [19–22]. Similarly, DHA might be considered necessary for life-long health considering intakes required for the prevention of cardiovascular (CVDs) and other chronic diseases [10, 11]. Moreover, considering new knowledge on the role of genetic polymorphisms [(rs174575) FADS2 gene responsible for δ6 desaturase activity] – that might explain the variability in the capacity to form DHA from dietary ALA by humans – it is recommended that preformed long-chain n–3 PUFAs (EPA + DHA) be provided for optimal health at all stages of the life course [23, 24]. Infants and children from conception to birth and throughout the life course need sufficient essential fats of the n–6 and n–3 series in their diet to meet their needs [11, 25]. Breast milk as consumed normally provides adequate amounts of these essential fats and adequate amounts of DHA for normal development. After breast feeding is completed, all children and adults should secure an adequate intake of EFAs not only to meet needs for normal growth and development but also sufficient to promote optimal health and well-being. There is limited and inconclusive evidence of the effect of fish oil (a good source of EPA and DHA) on learning ability and behavior among school-age children; studies are mostly limited to children with neurodevelopmental disorders. Research is needed to determine potential age-specific effects of n–3 PUFAs on depression, aggressiveness, mood swings, attentiveness and learning of school children. The potential impact on learning/behavior in school is of great social,

public health and economic interest [Koletzko et al., pers. commun.].

Fat Intake and Weight Maintenance

Ecological studies, including the recent publication by Marantz et al. [26], show that emphasis on low-fat diets has not resulted in a decreased trend of obesity. The effect of the total fat content of the diet on health is mediated by the quality of fat consumed rather than by the quantity of fat consumed. Consumption of excess energy beyond energy needed for maintenance, growth and physical activity is responsible for excess body fat accumulation independent of whether the energy is derived from fat or carbohydrates. In addition, the fat and water contents of foods are the main determinants of the energy density of the diet. A lower consumption of energy-dense (i.e. high-fat, high-sugars and high-starch) foods and energy-dense (i.e. high free sugars) drinks contributes to a reduction in total energy intake. Conversely, a high intake of energy-dilute foods (i.e. vegetables and fruits) and foods high in non-starch polysaccharide, e.g. wholegrain cereals, contributes to a reduction in total energy intake. It should be noted, that very active groups who have diets high in vegetables, legumes, fruits and wholegrain cereals may sustain a total fat intake of up to 35–40% without the risk of unhealthy weight gain. Despite the role of fat in increasing energy density of diets, the long-term effect of energy density in defining unhealthy weight gain is not well established. Women's Healthy Eating & Living Trial and Women's Health Initiative, two very large and long-term randomized, double-blind, placebo-controlled trials (RCTs) of low fat, both showed minimal effects on weight [27, 28]. Multiple well-controlled RCTs of equal intensity interventions show greater weight loss on high-fat diets [29, 30]. However, recent data [31] suggest that weight loss is attained mainly by achieving a sustained reduction in energy intake independent of the fat, protein or carbohydrate composition of the diet. The recommendations for total fat are usually formulated to include countries where the usual fat intake is typically above 30% as well as those where the usual intake may be very low, for example <15%. Total fat energy of at least 20% is consistent with good health [15, 32]. Highly active groups with diets rich in vegetables, legumes, fruits and wholegrain cereals may, however, sustain a total fat intake of up to 35% without the risk of unhealthy weight gain. For women of reproductive age at least 20% has been recommended by the Joint FAO/WHO Expert Consultation on Fats and Oils in Human Nutrition [13] and confirmed in the WHO Technical Report Series 916 on Diet, Nutrition and the Prevention of Chronic Diseases [15]. The concern for low-fat diets in women from developing countries relates to the high prevalence of young women with low body mass index, especially in the Indian subcontinent, since this condition is associated with low birth weight and a high prevalence of stunted children [32].

Fats, Fatty Acids and Cholesterol, and Risk of Cardiovascular Diseases

The study of the relationship between dietary fats and CVDs, especially coronary heart disease (CHD), with evidence accrued from animal experiments, observational studies, clinical trials and metabolic studies conducted in diverse human populations, reveals strong and consistent associations between diet and CHD [5, 6, 33, 34]. The potential mechanisms have also been well studied focusing mainly on the effect of diet on plasma lipoprotein cholesterol fractions. SFAs raise total and LDL cholesterol, but individual FAs within this group have different effects. Myristic and palmitic acids have the greatest LDL raising effect and are abundant in diets rich in dairy products and meat [7, 8]. Stearic acid has not been reported to elevate blood cholesterol and has been shown to be rapidly converted to oleic acid in vivo, thus it is considered neutral in terms of the plasma cholesterol effect [35, 36]; less is known on other potential adverse effects of stearic acid on the CVD risk [37, 38]. TFAs are similar to SFAs in their effect on LDL, but additionally they lower the protective HDL cholesterol and increase lipoprotein(a), which further increases the CHD risk. TFAs are the geometrical isomers of cis-unsaturated FAs produced in the rumen of ruminant animals or by partial hydrogenation; this process creates TFAs and also removes the critical unsaturated bonds present in EFAs and essential for their action. Metabolic studies have demonstrated that TFAs of natural or as products of partial hydrogenation render the plasma lipid profile even more atherogenic than SFAs, not only by elevating LDL cholesterol to similar levels but also by decreasing HDL cholesterol [7, 39–41]. Several large cohort studies have found that intake of TFAs increases the risk of CHD [42–44]. The most effective replacement for SFAs and TFAs in terms of reducing CHD as an outcome are PUFAs; oils with both LA and ALA predominantly present have been shown to be effective in decreasing LDL cholesterol, CHD events and deaths. This is now supported by the results of several large randomized clinical trials, in which replacement of SFAs and TFAs by vegetable oils rich in essential PUFAs lowered the CHD risk. A recent pooled analysis of 11 large prospective cohort RCTs confirms this statement [45]. TFAs

are presently being reduced or eliminated from retail fats and margarines and spreads in many parts of the world, however deep-fried fast foods and baked goods remain a major source of TFAs [17, 44]. The very-long-chain PUFA of the n–3 series, EPA and DHA, powerfully lower serum triglycerides, but do not modify or may even raise serum LDL cholesterol [45–49]. Most of the epidemiological evidence related to the protective effects of n–3 PUFAs is derived from studies of fish consumption in populations or interventions involving fish oils administered in clinical trials [50–54].

Cholesterol in the blood and tissues is derived from two sources: diet and endogenous synthesis, the former commonly contributes 20–30% to the total body cholesterol pool, thus the regulation of endogenous synthesis plays a key role in the control of plasma levels [55]. Although dietary cholesterol mildly raises plasma cholesterol levels when intake is very high (>400 mg/day), an increase in intake of 100 mg/day would be expected to increase serum cholesterol by approximately 4 mg/dl [56]; epidemiological evidence for an association of dietary cholesterol intake with CVD is contradictory [56–58].

Conclusions

CHD rates can be significantly reduced by dietary changes, which is achieved by replacing saturated fat and trans fats with cis-unsaturated FAs. Advice about dietary fat should focus on the replacement of SFAs and TFAs with PUFA-rich vegetable oils, including sources of n–3 FAs. Replacement of SFAs by carbohydrates provides no benefit in terms of the CHD risk [45]. The food industry should take advantage of the costs and effort of reformulation to make healthier products, avoiding replacing trans and saturated animal fats with vegetable oils rich in palmitic acid (palm oil) and lauric acid (coconut oil). Emphasis should be placed on the need to reduce overall energy intake and increase physical activity rather than recommendations to lower percent energy from fat and reduce fat or 'fatty foods' as a way to lose weight.

The following recommendations on the quality of fat in the diet are made for optimal health across the life course worldwide, from an age of about 2 years onwards:

- fat may provide up to 30–35% of the daily energy intake;
- saturated fat should provide no more than 10% of the daily energy intake;
- essential PUFA (n–6 and n–3) should contribute 6–10% of the daily energy intake;
- trans fats should be less than 1% of the daily energy intake, and
- the remaining of the energy from fat can be provided by monounsaturated fats (based on Technical Report Series 916) [15].

Disclosure Statement

Ricardo Uauy is President of the IUNS, the IUNS has a private public partnership (PPP) agreement with UNILEVER that has as an objective the dissemination of up-to-date scientific information on diet and nutrition, including dietary fat quality. The PPP is in the public domain and is available at www.iuns.org. R.U. has no personal financial gain linked to this PPP or to his participation in this International Expert Meeting.

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Dietary Fat Intake – A Global Perspective

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Key Words
Docosahexaenoic acid · Eicosapentaenoic acid · Fat intake · Fatty acids · Linoleic acid

Abstract
Background/Aim: The objective of this review was to collect data on the dietary intake of total fat and saturated (SFA), monounsaturated (MUFA) and polyunsaturated fatty acids (PUFA), especially linoleic (LA), α-linolenic (ALA), eicosapentaenoic and docosahexaenoic fatty acids, in adults from various countries and to compare them with current recommendations for fat intake. ***Methods:*** Weighted mean intake data were collected from national dietary surveys, large cross-sectional studies and/or studies with focus on health and nutrition. Thereof, only studies with diet recalls, weighing records or food frequency questionnaires were considered. ***Results:*** Data from 28 countries were included, representing Africa (3), America (4), Asia (5), Australia/New Zealand (2) and Europe (14). Total fat intake ranged from 11.1 (China, Guangxi Bai Ku Yao and Han populations) to 50.7 (rural dwellers in Nigeria) percentages of total energy (%E). SFA intake varied from 3.1 (China, Guangxi Bai Ku Yao and Han populations) to 25.4%E (rural dwellers in Nigeria). Mean MUFA and PUFA intake ranged from 3.5 (China, Guangxi Bai Ku Yao and Han populations) to 22.3 (Greece), and 3.3 (India) to 11.3%E (Taiwan), respectively. The mean intake of LA and ALA was between 2.7 (India) and 7.2 (Austria), and 0.4 (France) and 1.0%E (Finland). ***Conclusion:*** With regard to recommendations for fat intake, no general advice for improvements can be given worldwide. Due to different dietary patterns, only regionally specific recommendations can be made about what would be necessary to modify and improve fat quantity and quality of the diet.

Introduction

Coronary heart disease (CHD) is a major contributor to morbidity and mortality worldwide. Risk factors are sedentary lifestyle, overweight/obesity, smoking, high blood pressure, raised total cholesterol, low-density-lipoprotein (LDL) cholesterol and triglycerides, as well as type 2 diabetes [1]. In brief, high intake of saturated (SFAs) and trans fatty acids (TFAs) as a percentage of total energy intake (%E) is known to correlate with CHD due to raised LDL cholesterol levels [2]. A recent pooled analysis of 11 cohort studies has suggested that replacing fatty acids (FAs) with polyunsaturated fatty acids (PUFAs) instead of monounsaturated fatty acids (MUFAs) or carbohydrates prevents coronary heart diseases [3]. However, the type of carbohydrate was not identified in this study [3]. In addition, it is also recognized that commercial foods labeled as 'low-fat/fat-free', which are high in refined carbohydrates and sugars, do not prevent the increasing trend towards obesity and type 2 diabetes [2]. Moreover, low-fat, high-carbohydrate diets are known to reduce the 'good' high-density lipoprotein (HDL) cholesterol and raise triglycerides. Both are associated with an

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increased CHD risk [4]. The results from the Nurses' Health Study demonstrated that replacing SFAs with unsaturated FAs was inversely related to the risk of CHD due to beneficial effects on blood lipids [4], whereas total fat intake was not significantly associated with the risk of CHD [4]. High consumption of linoleic acid (LA, 5–10%E) is regarded to reduce the risk of CHD, which is based on a lowered total/HDL cholesterol ratio [5]. This ratio is considered to be a more specific marker for CHD than LDL cholesterol levels [5]. A number of studies suggested that ALA seems to be similar to LA in decreasing LDL cholesterol levels [6]. In addition, there is also a low biosynthesis of eicosapentaenoic (EPA) and docosahexaenoic acid (DHA) from the parent essential ALA. Especially the intake of both EPA and DHA is inversely related to the risk of fatal (and possibly nonfatal) CHD. The protective tissue levels are reached by an intake of preformed EPA and DHA between 250 and 500 mg/day [7].

Due to different effects on health, the following recommendations for fat intake have been established. Intakes of total fat are recommended from 15 to 35%E, SFAs <10%E, TFAs <1%E and PUFAs from 6 to 10%E [8–10].

Methods

The objective of this review was to gather fat intake data for as many countries as possible to provide a global perspective. The intake data on fat quantity (total fat) and quality (SFAs, MUFAs and PUFAs) in adults were included. In this review, the fat intake data are based on estimates of food purchases and availability. The food balance sheets of the Food and Agricultural Organization of the United Nations (FAO) were excluded. They demonstrate only national trends and facilitate international comparisons. However, they are not suited to consider requirements and intakes with regard to age, sex and ethnic groups. Only individual dietary intake data calculated from 24-hour recalls, weighing records and food frequency questionnaires were included. Therefore, the collected data can only give a rough overview of fat intake in various countries, but are limited to direct comparisons due to the usage of different methods.

Only publications from the past 15 years were considered. Data were collected via internet and the electronic database PubMed between July 2008 and February 2009. The following key words were used: intake or diet of total fat, saturated fatty acids, polyunsaturated fatty acids, linoleic acid, α-linolenic acid, eicosapentaenoic acid, docosahexaenoic acid, essential fatty acids, omega–6 and omega–3 fatty acids, long-chain polyunsaturated fatty acids, and the name of the country included in title and abstract. The search strategy was limited to the English and German languages.

In most publications included in this review, results were presented as means. Some data had to be recalculated because they were given in absolute amounts; they were then related to and expressed as the percentage of fat energy in total energy intake (%E). When only the results of subgroups were presented, a weighted mean was used to give an overview for this country. This was done by weighting the mean fat intake of each subgroup by the number of individuals in the subgroup.

Results

Intake Data

Intake data were found for 28 countries. Three countries were from Africa, four from America, five from Asia, 14 from Europe and one each from Australia and New Zealand. All reports/publications provided data on total fat intake, SFAs, MUFAs and PUFAs, with the exception of Nigeria (only total fat and SFAs). An overview of the characteristics of the surveys found for each of the countries is presented in table 1. The data of 10 countries were obtained from the European Nutrition and Health Report 2004 [11], which included intake data on total fat, SFAs, MUFAs and PUFAs from mainly national dietary surveys. Fourteen countries provided additional specific data on LA and ALA, and for 12 countries intake data on EPA and DHA were available.

Fat Intake – A Global Perspective

Mean daily intake of total fat expressed as percentage of energy ranged from 11.1 to 50.7%E (table 1). The highest variation in total fat intake was observed in Africa (13.1–50.7%E). However, America (25.7–37.2%E), Asia (11.1–35.6%E) and Europe (28.5–46.2%E) also demonstrated great differences in regional fat intakes (table 2).

Total fat intake of 15 countries (Canada, Costa Rica, Mexico, US, China, India, Japan, South Korea, Australia, Finland, Italy, Norway, Portugal, Sweden and the UK) was between 20 and 35%E. Nine countries, the USA (Alaska), Taiwan, New Zealand, Austria, Denmark, France, Germany, Hungary and Spain, demonstrated high fat intakes (≥35%E). In addition, very high fat intakes (>40%E) were observed in Cameroon, Belgium, Nigeria and Greece, while total fat intake in China (Guangxi Bai Ku Yao and Han populations) and Tanzania is ≤15%E.

Eight countries had a lower SFA intake than 10%E, ranging from 3.1%E (China: Guangxi Bai Ku Yao and Han populations) to 9.5%E (Portugal). The remaining countries had a higher SFA intake (10.0–25.4%E) than the recommended <10%E [8, 10]. The highest SFA intake (25.4%E) was observed in rural dwellers in Northern Nigeria, whereas urban dwellers ate only 5.7%E of SFAs. The region comparison demonstrated that SFA intake was

Table 1. Overview of mean intakes (%E) of total fat, SFAs, MUFAs and PUFAs and characteristics of the surveys from various countries

Country and reference	Abbr.	Year of publ.	Data source	Sample size	Dietary method	Age group	Total fat, %E	SFA %E	MUFA %E	PUFA %E
Africa										
Cameroon [15]	CM	2000	habitual diet study of rural and urban subjects in Cameroon	1,785	24-hour recall and FFQ	24–74	42.8	14.1	16.4	5.9
Nigeria [16]	NG	2004	study of urban and rural dwellers in northern Nigeria	135 115	4 × 24-hour recalls and FFQ and 7 day dietary record	20–75	37.9 50.7	5.7 25.4	– –	– –
Tanzania [17]	TZ	1997	food consumption in rural and urban Tanzania	105	24-hour recall	35–44	13.1	4.1	4.7	4.0
America										
Canada [18]	CA	2004	nutrition survey, Canada excluding territories	18,820	24-hour recall	19+	31.4	10.2	12.5	5.6
Costa Rica [19]	CR	2002	comparison of dietary intakes in rural, suburban and urban populations	503	FFQ	~57	32.1	11.2	12.0	5.5
Mexico [20]	MX	in prep.	MHNS (Mexican Health an Nutrition Survey) 2006	15,951	FFQ (data are expressed as medians)	19–69	25.7	7.4	7.2	4.4
US [21] (a)	US (a)	2008	(NHANES) nutrition survey	4,423	2 × 24-hour recall	20+	33.7	11.3	12.4	7.1
US Alaska [22] (b)	US (b)	2005	GOCADAN (Genetics of Coronary Artery Disease in Alaska Natives) Study	734	FFQ (data are expressed as medians)	17–60	37.2	12.2	14.3	6.7
Asia										
China [23] (a)	CH (a)	2007	INTERMAP (International Study of Macro- and Mironutrients and Blood Pressure) Study	839	24-hour recall	~49	20.0	5.0	8.1	5.8
China [24] (b)	CH (b)	2007	dietary intake of Guangxi Bai Ku Yao and Han populations	2,343	24-hour recall	15–89	11.1	3.1	3.5	4.3
India [25]	IN	2005	survey, only women	200	3 × 24-hour recall		26.7	10.6	6.0	3.3
Japan [23]	JP (b)	2007	INTERMAP (International Study of Macro- and Miro- nutrients and Blood Pressure) Study	1,145	24-hour recall	~49	24.9	6.6	9.0	6.4
South Korea [26]	KR	2004	contribution of specific foods to fat and fatty acids	224	FFQ and 3-day dietary record	30–85	21.1	6.0	7.7	5.1
Taiwan [27]	TW	1994	government employees	423	24-hour recall	40–59	35.6	8.8	12.6	11.3
Australia										
Australia [28]	AU	1998	National Nutrition Survey	10,851	24-hour recall and FFQ	19+	32.5	12.7	11.8	5.0
New Zealand [29]	NZ	1999	National Nutrition Survey	4,636	24-hour recall and FFQ	15+	35.0	15.0	12.0	5.0
Europe										
Austria [30]	AT	2009	Austrian Nutrition Survey 2008	2,123	24-hour recall	19–64	37.3	14.6	12.6	8.0
Belgium [11]	BE	2005[1]	Survey 1979–1984	6,870	24-hour recall	25–75	41.5	16.5	15.0	8.5
Belgium [31]	BE	2006	Epidemiological Survey, only women	641	48-hour recall	18–39	34.3	13.7	13.1	6.0
Denmark [11]	DK	2005[1]	Survey 1995	1,352	7-day record	19–64	36.3	15.2	11.0	5.0
Finland [11]	FI	2005[1]	Survey 2002	2,007	48-hour recall	25–64	33.7	13.9	11.2	5.0
France [11]	FR	2005[1]	Survey 1994–2002	8,202	24-hour recall	35–60	38.2	15.6	14.0	5.0
Germany [32]	DE	2003	EPIC Cohort	4,021	24-hour recall	35–40	37.6	15.7	12.8	6.5
Greece [11] (a)	GR (a)	2005[1]	EPIC Cohort	20,942	FFQ	25–64	46.2	13.1	22.3	6.6
Greece [33] (Cretan) (b)	GR (b)	1999	food and nutrient intake of Cretan adults	470	validated 24-hour recall	18–64	40.3	11.8	19.8	5.1
Hungary [11]	HU	2005[1]	Survey 1992–1994	2,349	3 × 24-hour recall	18–54	37.9	14.0	15.0	4.0
Italy [11]	IT	2005[1]	Survey 1994–1996	–	7-day record	18–64	34.0	10.0	13.0	5.0
Norway [34]	NO	1998	Norwegian national nutrition surveys 1997	3,144	FFQ	19–79	31.0	12.2	10.9	5.5
Portugal [11] (a)	PT (a)	2005[1]	Surveys 1995–1998, 2001	972	FFQ	>18	30.1	9.5	12.9	5.3
Portugal [42] (b)	PT (b)	1999	assessment of food nutrient intakes	489	FFQ	>40	28.5	8.9	12.4	4.9
Spain [11] (a)	ES (a)	2005[1]	Survey 1990–1998	10,208	24-hour recalls, 3 day record FFQ	25–60	38.1	12.0	16.0	5.5
Spain [35] (Catalan) (b)	ES (b)	1999	Catalan Nutrition Survey	1,600	2 × 24-hour recall and FFQ	18–60	38.0	12.8	17.2	4.6
Sweden [11]	SE	2005[1]	National Food Survey 1997–1998	1,215	7-day record	18–74	34.0	14.5	12.5	5.0
UK [36]	UK	2003	National Diet and Nutrition Survey adults 19–64 years	1,724	7-day dietary record	19–64	33.5	12.6	11.1	6.0

TZ: SFA, MUFA and PUFA estimated and calculated from graphs. FFQ = Food frequency questionnaire.
[1] Data from the European Nutrition and Health Report 2004.

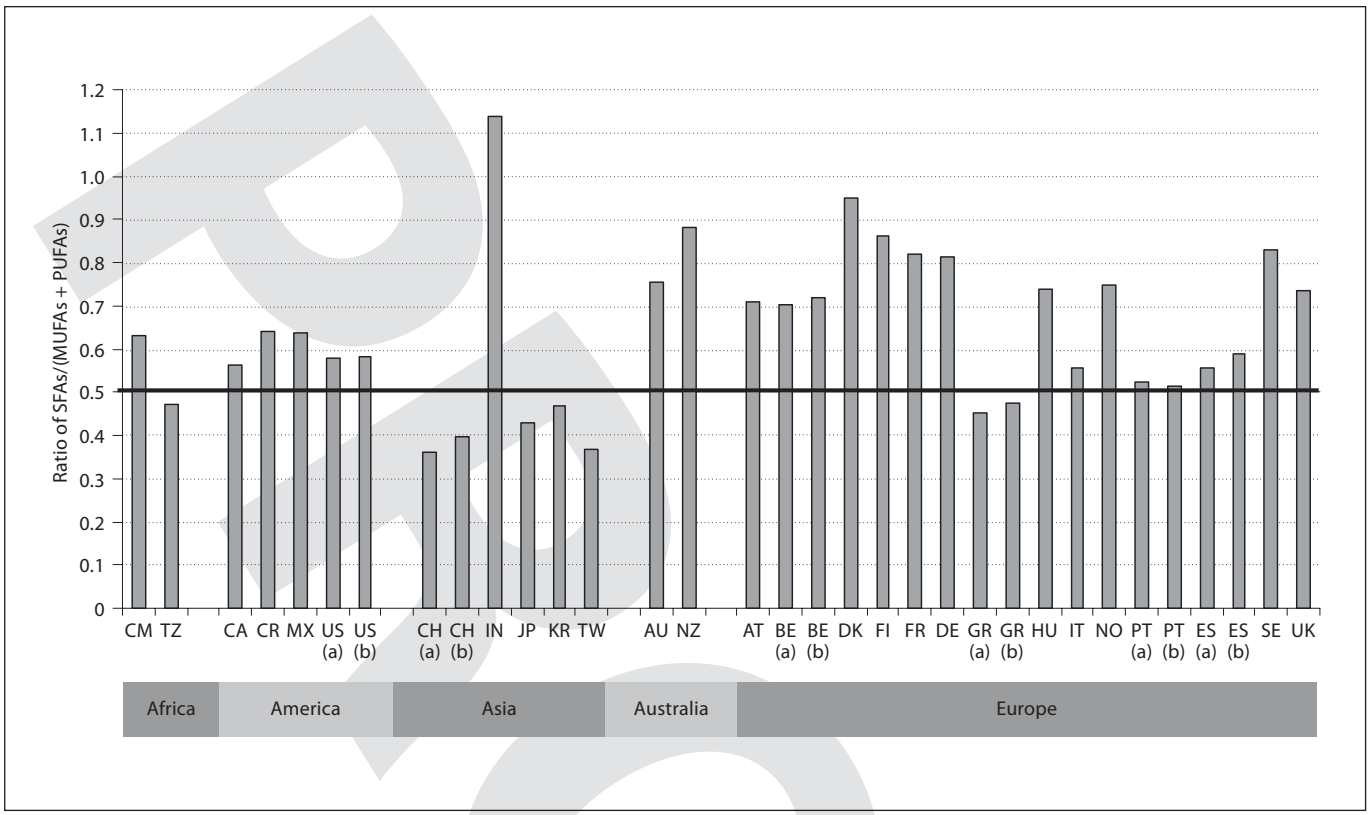

Fig. 1. Ratio of SFAs/(MUFAs + PUFAs) in the diet in different regions. For full country names and references, see table 1.

Table 2. Ranges of intake (%E) of total fat, SFA, MUFA and PUFA from different continents

Continents	Total fat	SFA	MUFA	PUFA
Africa	13.1–50.7	4.1–25.4	4.7–16.4	4.0–5.9
America	25.7–37.2	7.4–12.2	7.2–14.3	4.4–7.1
Asia	11.1–35.6	3.1–10.6	3.5–12.6	3.3–11.3
Australia	32.5–35.0	12.7–15.0	11.8–12.0	5.0
Europe	28.5–46.2	8.9–16.5	10.9–22.3	4.0–8.5

Africa (total fat and SFA: CM, NG and TZ; MUFA and PUFA: CM and TZ).

America (total fat, SFA, MUFA and PUFA: CA, CR, MX and US).

Asia (CH, IN, JP, KR and TW).

Australia (AU and NZ).

Europe (AT, BE, DK, FI, FR, DE, GR, HU, IT, NO, PT, ES, SE and UK).

The full country names and references are shown in table 1.

highest in European countries (11.8–16.5%E), with the exception of Portugal and Italy (≤10%E; table 1).

The average proportion of MUFAs was between 3.5 and 22.3%E. The mean daily intake of PUFAs in populations ranged from 3.3 (India) to 11.3%E (Taiwan). Twenty countries demonstrated mean intakes of PUFAs <6%E. The ratio of SFAs to the sum of MUFAs and PUFAs [SFAs/(MUFAs + PUFAs)] ranged from 0.36 (China) to 1.14 (India). A ratio >0.5 demonstrates that the proportion of SFAs is unfavorable, which could be observed in 21 countries (fig. 1).

Data on LA and ALA intake were limited to 14 countries (USA, Costa Rica, India, Japan, China, South Korea, Australia, Austria, Belgium, Finland, France, Germany, Sweden and the UK). Mean LA intake was between 2.7 (India) and 7.2%E (Austria). All countries demonstrated higher intakes than the 2.5%E of LA that are necessary to prevent deficiency symptoms [10], whereas 9/14 countries did not meet the WHO/FAO-recommended intake for n-6 (mainly LA) (5–8%E) [8] (fig. 2). Nine of 14 countries had mean ALA intakes of ≥0.5–1%E and five countries dem-

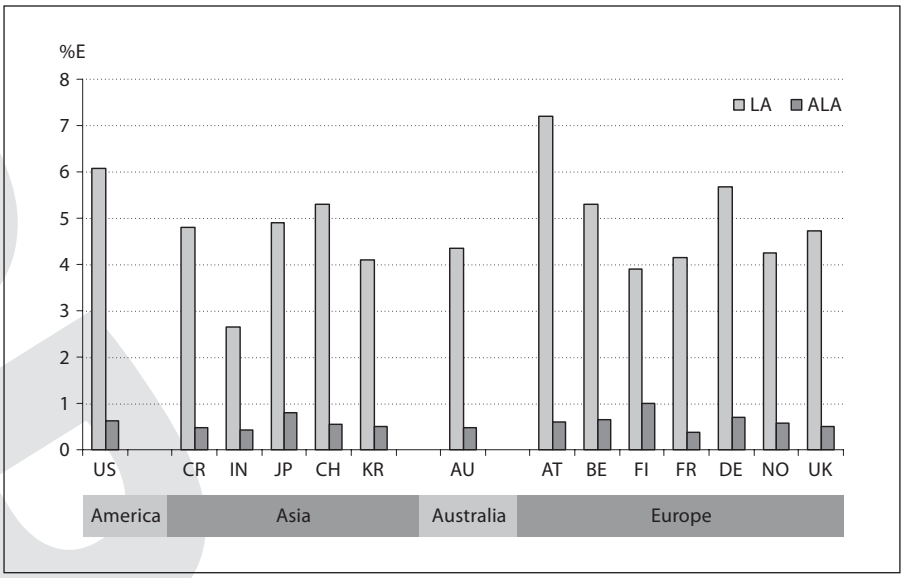

Fig. 2. Mean daily intake of LA and ALA among adults in various countries. For full country names, see table 1; US [37]; CR [19]; IN [25]; JP [23]; CH [23]; KR [26]; AU [38]; AT [30]; BE [31]; FI [39]; FR [40]; DE [32]; NO [34]; UK [41].

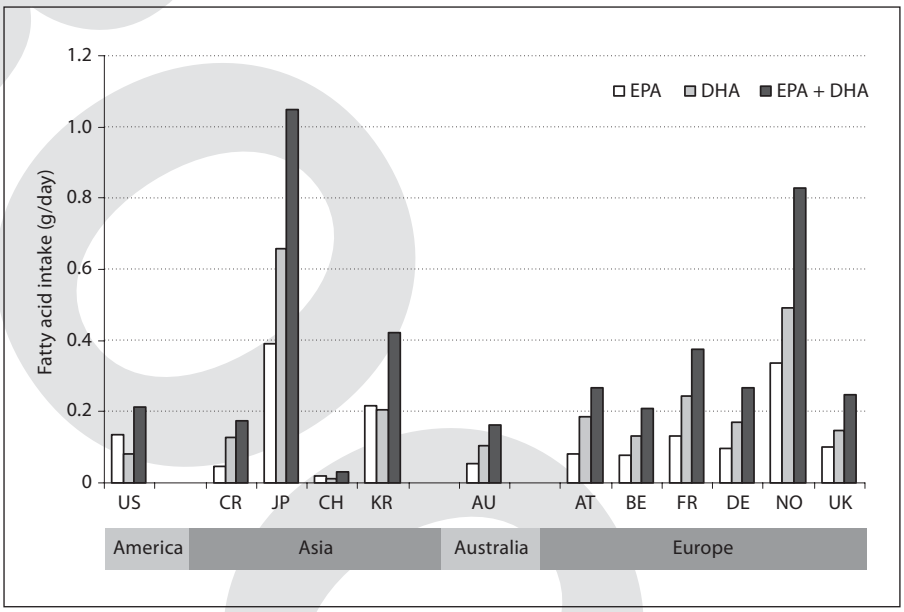

Fig. 3. Mean daily intake of EPA and DHA among adults in various countries. For full country names, see table 1; US [37]; CR [19]; JP [23]; CH [23]; KR [26]; AU [38]; AT [30]; BE [31]; FR [40]; DE [32]; NO [34]; UK [41].

onstrated very low intakes of ALA (<0.5%E), which is borderline when it comes to the prevention of deficiency symptoms [10]. The mean intake of EPA and DHA varied between 0.03 (China) and 1.05 g/day (Japan; fig. 3).

Discussion

Tremendous differences in total fat and FA intakes were observed between countries from different regions. For instance, 13 countries (Cameroon, Nigeria, US Alaska, Taiwan, Austria, Belgium, Denmark, France, Germany, Greece, Hungary, Spain and New Zealand) had total fat intakes ≥35%E, which is higher than recommended [8, 10]. Total fat intake of six countries was in agreement with the WHO/FAO nutrient intake goals (20–30%E) [8], including Mexico, China, India, Japan, South Korea and Portugal, while about nine countries were borderline (total fat intake between 30 and 35%E). It has to be emphasized that there is no uniform recommendation for this higher range of total fat intake between 30 and 35%E, especially in populations with a sedentary lifestyle [8–10,

12]. Total fat intake was even below the recommendation (≤15%E) [8] in China (Guangxi Bai Ku Yao and Han populations) and Tanzania.

The proportion of SFAs in total fat intake was higher than that of other FA groups in most countries in Europe, America (Mexico), Africa (Cameroon and Nigeria; rural dwellers), Asia (India), Australia and New Zealand. The highest intakes (≥14%E) of SFAs were reported in Cameroon, Nigeria, New Zealand, Austria, Belgium, Denmark, France, Germany, Hungary and Sweden. Only eight of 28 countries (Nigeria-urban, Tanzania, Mexico, China, Japan, South Korea, Taiwan and Portugal) had an SFA intake <10%E. SFAs, namely lauric, myristic and palmitic acids, are known to increase LDL cholesterol, which is a major risk factor for CHD [13]. Therefore, the upper level for SFA intake is set at 10%E [8].

The average percentage of MUFAs was between 3.5 and 22.3%E. The recommendation for MUFAs is calculated as total fat – (SFAs + PUFAs + TFAs) [11]. The replacement of SFAs and TFAs with cis-MUFAs and -PUFAs is negatively associated with CHD [4]. On the one hand, MUFAs are regarded as important FAs to improve the FA pattern by reducing SFAs and TFAs, but on the other hand this is not enough to change the quality of the fat intake when the total fat intake is very high (>35%E). For instance, Greece demonstrated a very high intake of MUFAs (22.3%E) and total fat intake (46.2%E; table 1), and although direct relationships between fat intake and body mass index have to be viewed with caution, a look at the data shows that the mean body mass index in Greek adults ranges from 25.4 (women, age group 25–34) to 30.3 (women, age group 55–64) [11].

All countries demonstrated higher intakes than 2.5%E of LA, which is sufficient to prevent deficiency symptoms. The majority (20) of the countries failed to reach the WHO/FAO population nutrient intake goals for PUFA intake (6–10%E) [11], which are important for the prevention of chronic diseases (table 1), especially in populations with borderline or even higher total fat intake (30–35%E). Mainly European countries, but also Australia and New Zealand, fit into this dietary pattern. Twenty countries demonstrated mean intakes of PUFAs <6%E. Due to the predominance of SFAs compared to unsaturated FAs, the calculated ratio of SFAs/(MUFAs + PUFAs) was unfavorable (>0.5) in 21 of the 28 countries. The borderline was set according to the general recommendations for fat and FAs (<10%E SFAs, 6–10%E PUFAs and the remaining from MUFAs 10–15%E) [8, 10]. Asia demonstrates a ratio <0.5 with the exception of India. Data from India are limited to women and are not representative for the whole population. Intake data for India are rare, but in 1998, Ghafoorunissa [14] reported that the fat intake in India varied considerably, which can be observed by widespread chronic energy deficiency related to low fat intake up to an increased risk of CHD in the urban middle- and high-income groups.

All countries demonstrated higher intakes than 2.5%E of LA. This level of intake is necessary to prevent deficiency symptoms [10]. In five countries, ALA intakes were well below <0.5%E, an intake level which is at the borderline to the prevention of deficiency symptoms [10], especially when the diet is lacking in n–3 long-chain PUFAs. Data on the mean intake of EPA and DHA were only available from 12 countries. The sum of both FAs varied between 0.03 (China) and 1.05 g/day (Japan; fig. 3).

Conclusion

Except for the fact that more accurate intake data are required to assess present global fat intake, available data indicate a very heterogeneous picture regarding current quantity and quality. Africa reveals a very high diversity in total fat, ranging from 13.1 to 50.1%E. In addition, these variations are not only found between countries in Africa, they are also found within a state (e.g. urban and rural dwellers in Northern Nigeria). Similar observations can be made for Asia, due to the fact that quantity and quality can differ hugely. All considered European countries mostly have high fat intakes (>35%E). Especially the intake of SFAs is high (>10%E). Therefore, the reduction in saturated fat (from animal products) would reduce both total fat and SFA intake, while the ratio of SFA to unsaturated FAs would be improved. Only Japan, South Korea and Norway demonstrate higher intakes of long-chain n–3 fatty acids (>0.4 g/day), which are recognized to have health benefits.

Disclosure Statement

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Foods with a High Fat Quality Are Essential for Healthy Diets

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Cardiovascular health · Essential fatty acids · Fat modification · Growth and development · Hydrogenation · Interesterification · Margarine · Polyunsaturated fats · Saturated fat

Abstract
Fat is generally a highly valued element of the diet to provide energy, palatability to dry foods or to serve as a cooking medium. However, some foods rich in fat have a low fat quality with respect to nutrition, i.e., a relative high content of saturated (SFA) as compared to unsaturated fatty acids, whereas others have a more desirable fat quality, i.e., a relative high content of unsaturated fatty acids as compared to SFA. High-fat dairy products and fatty meats are examples of foods with low fat quality, whereas vegetable oils (tropical oils such as palm and coconut oil excluded) are products with a generally high fat quality. The aim of this paper is to explore the nutritional impact of products made of vegetable oils, e.g. margarines and dressings, and how they can be designed to contribute to good health. Since their first industrial production, the food industry has endeavored to improve products like margarines, including their nutritional characteristics. With evolving nutrition science, margarines and cooking products, and to a lesser extent dressings, have been adapted to contain less trans fatty acids (TFA), less SFA and more essential (polyunsaturated, PUFA) fatty acids. This has been possible by using careful fat and oil selection and modification processes. By blending vegetable oils rich in the essential PUFAs α-linolenic acid (vegetable omega–3) or linoleic acid (omega–6), margarines and dressings with both essential fatty acids present in significant quantities can be realized. In addition, full hydrogenation and fat rearrangement have enabled the production of cost-effective margarines virtually devoid of TFA and low in SFA. Dietary surveys indicate that vegetable oils, soft margarines and dressings are indeed often important sources of essential fatty acids in people's diets, whilst providing negligible amounts of TFA and contributing modestly to SFA intakes. Based on empirical and epidemiological data, the public health benefit of switching from products with a low fat quality to products with a high fat quality can be predicted. For example, switching from butter or palm oil to a soft margarine shows a substantial improvement in the nutritional quality of the diet. These simple, practical dietary adaptations can be expected to contribute to the healthy growth and development of children and to reduce the burden of cardiovascular disease.

Introduction

Fat is an important part of the diet in most societies. However, the public has generally little knowledge about fats and the products containing fats. Fat is often perceived as fattening and hence has a bad perception. Consequently, the fat quality of the diet of many people is

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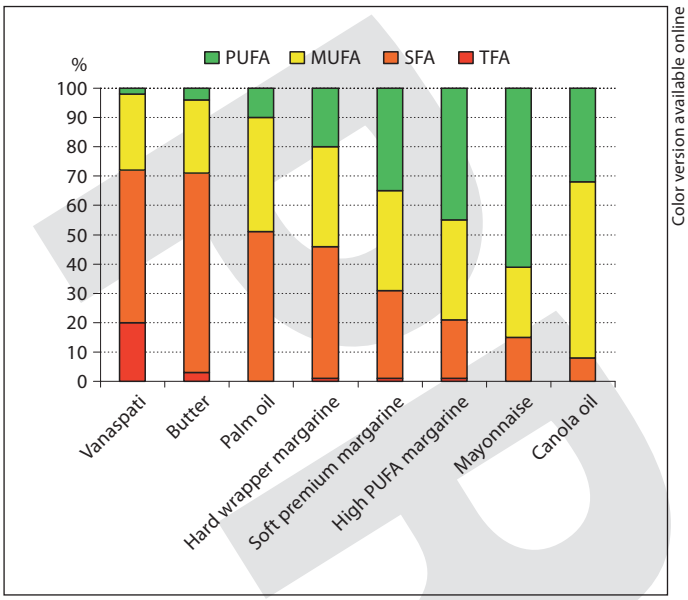

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Fig. 1. Fatty acid composition of common fat-rich products.

deviating significantly from what is recommended, which may have a negative impact on health.

The aim of this paper was to outline what the main sources of fat in our diets are, how products rich in fat are produced and what the nutritional characteristics of the main fat-rich products are. Finally, we provide examples of the positive impact that foods with a high fat quality can make on our health.

Main Dietary Sources of Fat

The main fats commonly consumed are vegetable oils and fats, dairy fat and fats derived from animals, e.g. lard, tallow and fish oil. Many food products in the world are prepared with these fats and oils. In this paper, we focus on those products that contain a significant amount of fat. Major examples are listed in the following.

Margarines and Reduced Fat Spreads. Originally, the term margarine was reserved for butter-like products with 80% fat. In this paper, we will use this term for all spreadable fat products made predominantly from vegetable oils and fats at levels ranging from 20 to 80%.

Butter and Ghee. By definition, butter is made with ~80% milk fat in most countries. Ghee is clarified butter (butterfat), used in South-Asia/Middle East. Mélanges are mixtures of vegetable fats and oils with butterfat.

Vanaspati. Vanaspati is a cooking fat usually made from partially hydrogenated vegetable oils used in South-Asia and Africa.

Cooking Fats/White Fats/Shortenings, either from Animal or Vegetable Origin. These are products made to remain stable at high temperatures as in cooking and baking.

Mayonnaise. Similar to margarine, originally with 80% vegetable oil, mayonnaise now represents products with fat levels ranging from 20–80%.

These products are often named by consumers as products high in fat: they form the majority of the so-called visible fats, as opposed to invisible fats: fats hidden in products that may not be perceived as fatty, such as cheese, milk, meats and baked goods.

As dietary recommendations often advice to reduce the saturated fat (SFA) intake and maintain or increase the intake of polyunsaturated fats (PUFA) [1], a rough indication of the foods that contribute most to the intakes of these types of fat is useful. Wide differences in common usage of foods exist all over the world: this makes it impossible and irrelevant to define a 'global average'. However, in looking at the products that are the major sources of SFA or PUFA in countries or regions around the world, often the same types of products appear. Therefore, a few general comments on foods often providing a significant contribution to the SFA intake can be made [1–5]:

- In many countries, dairy fat, either via cheese, butter or milk, is the most important source of SFA. This is particularly true for the Western World.
- Meat is again, particularly in the Western World, an important source of SFA.
- In many developing countries, baked and fried foods, high in SFA, are very common. Fatty snacks in general often provide a significant amount of this fat.
- Finally, cooking fats and oils like vanaspati and tropical oils are often significant sources of SFA.

Major contributors to the PUFA intake are less diverse: these are for most populations either vegetable oils or products made thereof, like margarines and mayonnaise. Chicken or pork can also be significant contributors but both, pork in particular, also contribute significantly to the SFA intake.

Of course, the contribution to the SFA and PUFA intake is determined by the amount of food consumed and the level of these fats in those foods. For some of the most common high-fat products, the fraction of trans fatty acid (TFA), SFA, monounsaturated fatty acid (MUFA) and PUFA of the total fat is depicted in figure 1.

A differentiation often used in the communication to consumers is that of 'good fat' and 'bad fat', the latter being SFA and TFA and the former being the unsaturated fats, i.e., PUFA and MUFA. Vanaspati and butter are very rich in 'bad fats', predominantly SFA; however, whereas butter usually contains a few percent of TFA (3–5%), vanaspati can contain much more than 20%. Both provide very little PUFA. One of the most important edible oils is palm oil. This oil is about 50/50 in 'bad' and 'good' fats. Of the various types of margarine, stick margarines or wrappers usually contain >40% SFA on fat. These products are hard and often can stand higher temperatures. Soft premium margarines, sold in the chilled cabinet, are better in composition with ~30% SFA on fat and a reasonable level of PUFA, usually >30%. The best margarines from a health perspective are high-quality soft margarines rich in PUFA: they are predominantly made of vegetable oils rich in PUFA and hence relatively low in SFA (some contain <20% on fat). It should be realized that nowadays the majority of margarines globally are almost free of TFA ('virtually trans fat free') and contain less TFA than for example butter. Mayonnaise is made from vegetable oil, such as soybean oil. This oil is low in SFA and contains >50% PUFA. Finally, the common oil lowest in SFA is rapeseed (or canola) oil.

The total global oil and fat market is a huge economic factor with a total turnover of more than 120 billion Euro, making it one of the bigger markets in the food-agricultural segment [6, 7]. With the rise of affluence in developing countries, this market is increasing and can be expected to increase further.

More important for public health is the actual consumption of oils and fats and products made thereof. Unfortunately, due to the complex nature of the worldwide oil and fat usage, clear data on consumption do not exist. On the basis of various production data on butter, margarine, spreads and some other sources, e.g. the vegetable fat and oil production data reported by the Food and Agriculture Organization of the United Nations, a rough estimate of the total consumption split out over various types of oils and fats can be attempted. It is important to stress that these data are only an indication of the consumption, providing useful insights but no hard facts.

Oil and Fat Consumption

The total fat and oil disappearance, including wastage (although this is estimated to be minor for the majority of the world population), but excluding the use as animal feed and for the chemical industry, was around 120 million tons in 2005. With a world population of 6.5 billion people in 2005, the average intake of oils and fats would be almost 20 kg per person per year. Of course there is a wide variability: intake in the Western World is estimated at around 50 kg/person/year whilst in sub-Saharan Africa this is no more than 10 kg.

Table 1. Share of fats and oils to total consumption (i.e., 120 million tons) globally in 2005

Type of fat/oil	Share
Seed and bean oils (e.g. soybean, sunflower seed, rapeseed)	33%
Tropical oils and fats (e.g. palm, coconut, palm kernel)	30%
Olive oil	3%
Margarine and spreads	6%
Butter	6%
Edible tallow	7%
Ghee	3%
Industrial lard	7%
Vanaspati	5%

Table 1 captures the estimated split over the various types of oils and fats and some of their products. It is evident that margarine and vanaspati are made from vegetable oils, which are included in tropical and seed oils, but nevertheless this representation gives a rough indication of the sizes of these segments.

The table shows that vegetable oils and fats are by far the most important for human consumption and constitute about two thirds of all fat sources. Of vegetable oils, seed and bean oils, which have generally a healthy fatty acid composition, are about half, and tropical oils with palm as its main representative the other half. But the intake of animal fat, while on the decline worldwide, is still considerable: butter, ghee, tallow and lard make up about 23% of the fat consumption. This is important for public health as these fats are generally high in SFA and low in PUFA and are thus not contributing to a healthy fat intake. Olive oil is relative small in volume and localized in Europe and the Americas. Its share of the total oil and fat market is no more than 3%.

Of the products made of vegetable oils and fats, margarine is the biggest in volume and most widespread. The margarine segment is about as big as the butter segment. Vanaspati, a replacement product for butter, is a common product in India and the surrounding countries. In India alone, the production of vanaspati is approximately 1 billion kg/year [8].

Differences in the habits of people regarding fat and oil usage are quite marked. In the Northern hemisphere, butter and margarine is widely used, with oils for cooking or cold use. Around the Mediterranean, olive oil is the main oil used. In the US, cooking with lard and shortening is fairly common. The Southern hemisphere is characterized by oil as the predominant source of visible fat. A large part of that is used as cooking medium. China is the world's biggest producer and user of lard, whereas in South-Asia and the Middle-East vanaspati and ghee are abundant. Margarine and butter is used habitually in many countries, particularly in those with bread-eating habits. The use of fish oil is small, especially since partially hydrogenated fish oil is hardly used anymore in developed countries.

Basic Technology and Production of Oils, Margarines and Cooking Products

Oil Production and Refining

Nowadays, products like table or cooking oils, margarine and mayonnaise are almost exclusively made from vegetable oils which are derived from the seeds and beans of plants, such as sunflower, rape, flax and soy, or from the flesh or kernels of tree fruits, such as palm, olive and coconut. After harvesting, the oil is pressed from the seeds and fruits. For some oil seeds, the yield of simple pressing is too low to be economically feasible, hence the remaining oil is extracted from the press cake with food grade organic solvents like hexane. After extraction, the hexane is recovered from the oil and the last residues are blown off. The oils from fruits like palm and olive are recovered by pressing followed by oil-water phase separation. Kernels are normally dried and pressed although coconut meal can also be extracted after pressing to recover the remaining oil.

The resulting crude oils are usually heavily colored by plant materials like chlorophyll and other colorants, and during the whole process from harvesting to oil production, oxidized byproducts may arise. Furthermore, the crude oils contain phospholipids (lecithin) and free fatty acids, which may have a strong undesirable taste. Finally, pesticides and other undesirable fat-soluble components taken up by the oil crop may be present in crude oils. Therefore, virtually all edible oils commercially available have been refined. Notable exceptions are virgin oils of which virgin olive oil is by far the largest in volume.

The vegetable oil refining process is usually a combination of washing with water, acid and lye followed by a treatment with bleaching clay (a natural mineral) and active coal and finally a heat treatment. The basic refining process was first applied in the early 1900s. The lecithin is removed by washing with water ('degumming'). A subsequent treatment with bleaching clay removes excessive colorants and oxidized oil components. Free fatty acids can be removed as soap with lye or alternatively in the final heat treatment with steam under vacuum, where the remaining free fatty acids and volatiles like off-flavors and possible pesticide residues are removed. The resulting oils are clear, slightly yellow and bland tasting. These can be used as table oils (labeled as sunflower seed oil or rapeseed oil for example) and as the main raw material for margarines and mayonnaise [see ref. 9 for an overview].

Margarine Making

The remainder of this part of the paper focuses on margarine. Margarine is a structured water-in-oil emulsion with particular properties like spreadability, stability and pleasant mouthfeel. Basically, this emulsion consists of little water droplets (of a few microns in diameter) dispersed in a continuous oil phase. The amount of water in the product can range from 20% (original margarine) to up to 80%. A fine network of fat crystals prevents that the water droplets coalesce or in other words grow together. The fat crystals are solidified fat: hence this fat must consist predominantly of fatty acids with a high melting point, i.e., SFA or TFA. Without this network, the margarine would not be stable and would not have the desired perception in the mouth. So, every margarine needs some higher-melting hard fat, hence SFA or TFA, both of which we want to minimize for nutritional reasons. Of course the liquid oils used also contain some SFA, varying from low levels like in rapeseed oil (from 8%) to palm oil olein with around 40%. It should be noted again that nowadays the majority of quality margarines are virtually trans free. More about this will follow later.

Traditional margarine, like butter, contains 80% fat and 20% water [10]. In the late 1970s, the first 'light' spreads were developed with only half the fat content, but with the same flavor and texture as the traditional product. Compared to full-fat margarine, lower-fat versions have more and bigger water droplets. To stabilize the water droplets, the water is thickened with starch, similar to sauces. Nowadays, spreads with even lower fat levels are available to fulfill the increasing need for lower-calorie versions.

Apart from oils, fats and water, a few components are added to margarine in small to very small amounts. Sometimes, milk proteins are added to enhance mouth-

feel and taste. Citric acid helps to provide a fresh taste. In many countries, a preference for salted margarine and butter exists, hence salt is added to margarine at 0.3–2%. However, in other countries, salt is not added and the products are very low in sodium. Emulsifiers are added for several purposes. At first, they facilitate the fabrication of a fine water-in-oil emulsion and secondly, they can improve the stability of the product. Thirdly, they also help to invert the product into a water-continuous emulsion in the mouth, thus influencing the oral sensation. Lecithin and mono- and diacylglycerols are the most commonly applied emulsifiers. Depending on country-specific legislation, vitamin A and D is added. Vitamin E is also present in margarine as liquid vegetable oils, like sunflower seed oil, are naturally rich in this vitamin. In some cases, extra vitamin E (often in the form of tocopherol acetate) is added to protect the PUFA from oxidation in the human body once consumed. Carotenoids give margarine its yellow color, and flavor is added to give margarine its taste. Finally, in low-fat spreads, a preservative like potassium sorbate is often used to prevent microbiological spoilage, particularly from molds.

Margarine making is basically a melting, blending and chilling process. Solid fat is melted and mixed with liquid vegetable oils. This is blended with the water phase to get a mix of water, oil and the added ingredients mentioned above. The mix is generally pasteurized and then gradually chilled by large heat exchangers under constant stirring. The chilling causes the fat to solidify and turn the emulsion in a thick but pourable product. This is packed in tubs (and then often called soft margarine) or in wrappers (resulting in stick or hard margarines), and in most cases stored refrigerated to keep the quality. Margarine is usually distributed chilled in most countries, though in developing countries, ambient stable products form a large part of the products sold.

Margarines are foods with a careful balance between consumer-driven qualities like stability and taste and optimal nutritional profile.

The stability of margarine is largely determined by the level of hard or solid fat in the product. This fat has typically a high melting point of above 40°C. If the level of this fat is low, the product will usually be soft and easily spreadable at refrigerator temperatures (6–10°C). This is often a differentiating factor compared to butter, which is hard straight from the refrigerator. When the margarine warms up at the table or during transportation (20–30°C), consumers want the product to remain stable and not fall apart in separate water and oil phases. Hence, a higher level of solid fats is required. Finally, the product should melt completely in the mouth, which is around 35°C, to prevent a fatty aftertaste. This means practically all solid fat is molten at 35°C. The line describing the desired relationship of the solid fat content as a function of the temperature in margarines is flat and not too high at temperatures from 6–30°C and then falling rapidly to almost zero. However, just mixing liquid oil with a minor amount of solid fat will not provide a homogeneous fat blend with a melting behavior approximating the desired melting properties. Animal fats such as butter as well as palm and coconut oils are solid both at room temperature and in the refrigerator. These fats can provide the required levels of solid material and thus firmness. However, because of the limited structuring effectiveness of their SFA, these fats do not lead to good margarines low in SFA. Therefore, technologies to change the melting behaviors of fat and oil mixtures have been developed, enabling the production of margarines with the following desired characteristics: virtually free of TFA, low in SFA and high in unsaturated vegetable oils.

Oil Modification

Before 1900, animal fats were used as sources of fat with a high content of solids in margarine production. This led to a shortage of animal fats since they were also the main feedstock for soap making. To extend the sources of hard fat and to make a wider variability in stable hard fats, the hydrogenation process was widely used on vegetable oils since the beginning of the last century. In the hydrogenation or hardening process, hydrogen reacts with oils at high temperatures under anaerobic conditions. With the help of a catalyst, double bonds of the unsaturated fatty acids, which are almost exclusively in the cis-position in vegetable oils and fats, are opened and saturated with hydrogen to form SFA. Simultaneously, part of the cis double bonds is transformed to trans double bonds, resulting in TFA. These fatty acids have melting points much higher than their cis counter parts and together with the high-melting SFA they can serve as hard fat. In nature, a biohydrogenation process occurs in the rumen of ruminants: here, cis unsaturated fatty acids are also converted into trans unsaturated fatty acids, be it of slightly varying distribution and at much lower levels. By partial hydrogenation of liquid oils, levels of up to 50% TFA were reached. Of the ruminant fats, the most common one, milk fat, of which butter is made, usually contains 3–5% TFA.

In the mid 90s, when the scientific community reached consensus that TFA was more adverse to health than SFA, the development of margarines with low levels of TFA

was turned up significantly. Various technologies that could provide low or no TFA-containing, solid fats became more attractive and were exploited widely. Three of these technologies will be described briefly, as they are the core of the current edible fat industry and have made a big positive impact on public health [11].

Fractionation

This is particularly applied for tropical oils like palm oil or palm kernel oil. The hot oil is slowly cooled down till part of the oil starts to solidify. The solids are separated by filtration to obtain two fractions: a more liquid oil fraction (called olein) and a more solid fat fraction (called stearin). The solid fraction can be used as solid fat in the margarine production, preferentially in combination with the technique described below as fat rearrangement. The liquid fraction (palmolein) is often used as liquid frying oil or as a liquid oil in the production of margarine.

Full Hydrogenation

If the hydrogenation process is continued until all double bonds, including the trans double bonds, are saturated, we call this full hydrogenation. The TFA level of such a fully hydrogenated product is very low (<1.5%); however, the product is fully saturated and therefore too hard for direct use in food products.

Fat Rearrangement or Interesterification

Simply using the solid fat separated from palm and coconut oils or fully hydrogenated fat with liquid oils will not result in high-quality margarine with a good nutritional profile as this blend does not show the required melting properties. Rearrangement or interesterification, i.e., redistribution of the fatty acids in the fat molecule, changes the melting properties of the fat. This process is basically similar to the process taking place in the gut: triglycerides are split into di- and monoglycerides and free fatty acids. These components are combined again to yield triglycerides but now with a different composition. For example when a fat consisting mainly of triglycerides rich in SFA is mixed with liquid oil with triglycerides rich in PUFA, after the rearrangement a mixture results that consists of triglycerides with no, one, two or three PUFA and three, two, one or no PUFA. This variety of triglycerides has a much better melting behavior than the original mixture. Hence, with a modest amount of SFA, a rearranged fat can be produced that allows the production of TFA-free margarines rich in PUFA and low in SFA of excellent quality and stability.

Rearrangement is either performed at higher temperatures with a catalyst or by enzymic action at 40–70°C. Rearranged fats have been used for decades in the food industry, not only for margarines and cooking fats but also in infant formulas.

These oil modification processes allow improvements in the nutritional quality of margarines (reduction in SFA, no TFA and high PUFA) beyond that what is possible with traditional oils and technologies. Hence, as will be described later in this paper, they play an important role in supplying the growing worldwide demand for healthier margarines.

Nutritional Characteristics of Oils, Margarines and Cooking Products

The nutritional quality has always played a role for margarines and cooking products. In the past, it has not been the main impetus for the edible-fat industry but yet over the years the industry increasingly addressed the nutritional needs of consumers. Nowadays, continuous improvements are achieved by

- replacing SFA by unsaturated fat and preferably PUFA;
- practically eliminating TFA;
- ensuring delivery of essential omega–3 and –6 fatty acids, the main types of PUFA;
- fortification with fat-soluble vitamins A and D;
- preserving natural beneficial minor components like vitamin E.

Dietary recommendations on fat are the basis for these improvements, and more and more consumers have been taught to look out for products that are TFA free, low in SFA and contain omega–3 and –6 essential fatty acids. Scientific acceptance that replacing SFA by PUFA decreases blood cholesterol levels emerged in the early 1960s. This was the basis for the medical community requesting the industry to market new margarines high in PUFA and low in SFA. Becel margarine (derived from blood cholesterol lowering, also known as Flora) was the first of this generation that was widely available. Later in the 1990s when the negative effects of TFA on the blood lipid profile were discovered, the margarine industry reacted by the near elimination of trans fat. The latest trend has been to increase the level of omega–3 and –6 PUFA, omega–3 levels (α-linolenic acid, ALA) in particular.

Margarine as a substitute for butter is mandatorily fortified with vitamins A and D in many countries, and by more gentle refining techniques, beneficial components

in the oil (e.g. vitamin E) are well preserved. Whereas quality margarines could be characterized by having 30–40% SFA on total fat, 20–30% TFA and only 10–20% PUFA in Western Europe in the 1960s, the major shift since the early 1990s led to products with 30–40% PUFA [often with increased level of omega–3 (ALA)], often less than 30% SFA and less than 2% TFA currently. From a nutritional point of view, the best margarines are the ones rich in PUFA. These can contain up to 50% PUFA on fat, of which 10–20% are omega–3, with only 20–25% SFA and <1% TFA.

So undoubtedly, the most striking change for better nutrition in the margarine industry that has taken place the last decades is the near removal of TFA in the 90s. The story of the change is well reported in the paper of Korver and Katan [12]. They describe how new scientific findings of the impact of TFA on blood lipids and cardiovascular disease led to a complete change in attitude in the edible-fat industry, led by Unilever, the leader in the market. Up to 1990, the scientific belief was that TFAs were similar to oleic acid in their cholesterolemic properties. In 1990, new scientific evidence emerged showing that TFAs were as bad as SFAs with respect to their effects on blood lipids and hence heart health. This change in insight caused major challenges for the industry. Unilever committed in 1994 to develop new margarines without using partial hydrogenation and hence virtually TFA free. With high investments driven by a strong commitment, in most regions of the world TFA was nearly eliminated from Unilever retail margarines in the late 1990s. Meanwhile, accumulating epidemiological and controlled trial evidence led to a consensus that TFAs are, per gram, more unfavorable for heart health than SFAs and that their consumption should be minimized. This strengthening of the evidence against TFAs vindicated the earlier decision of Unilever to eliminate this fat from retail spreads. It also brought most other European margarine manufacturers on board, and nowadays margarines are usually virtually TFA free. Significant TFA levels can still be encountered in industrial fats for food service and industrial baking and frying, but retail margarines usually contain much less TFA than butter.

Impact of Modern Fat and Oil Products on Diet and Health

The previous parts demonstrate that improvements from a nutritional point of view have been made in high-fat products like margarine, driven by scientific developments. In the following, the potential impact of modern high-fat products on public health will be discussed. This will be done via three examples:

- Oils, margarines and mayonnaise are nutrient-dense sources of essential fats (or omega–3 and –6 PUFA).
- Margarine can make a significant contribution to the required intake of vitamins A, D and E.
- Soft margarines have a relevant impact on the LDL cholesterol level and hence on the incidence of coronary heart disease (CHD).

It is evident that these examples are not relevant everywhere, and the impact of margarine on long-term health and growth and development has not been proven clinically, but the data are strong and the logic clear.

Margarines, Mayonnaise and Vegetable Oils Are Nutrient-Dense Sources of ALA

In many societies, the intake of ALA is below the recommended intake, as is shown by Elmadfa and Kornsteiner [13]. In some countries, the gap is modest, but in others, the intake is less than half of that recommended. Therefore, foods that make a significant contribution to that intake, fitting the habits of people and without providing too many calories, are nutritionally very relevant. Figure 2 shows a number of the most nutrient-dense sources of ALA, ranked in order of grams of ALA per 100 kcal.

Walnuts appear to be the most energy-dense source, but these can hardly be called common foods, consumed by many people every day. Mayonnaise, margarines and liquid oils like soybean and rapeseed oil are good sources and despite their high caloric content, they are more efficient sources of ALA than vegetables like spinach or broccoli. The amount of vegetables one needs to consume to get a significant amount of ALA is considerable. Many mayonnaises or margarines can provide 15% of the Guideline Dietary Amount (2 g/day) per daily serving of 10–20 g, as recently proposed by the Confederation of the Food and Drink Industries in the European Union [14].

The fact that margarine is a nutrient-dense source of ALA and also of vitamin D has led the Dutch Nutrition Center, a government-funded, independent organization providing nutrition advice to the Dutch population, to increase the recommendation on margarine intake for the Dutch population [15]. The Dutch, already having one of the highest intakes of margarine in the world, still have a below-recommended intake of ALA. By increasing the intake from 20 g per day to 30–35 g/day, this gap is expected to be closed.

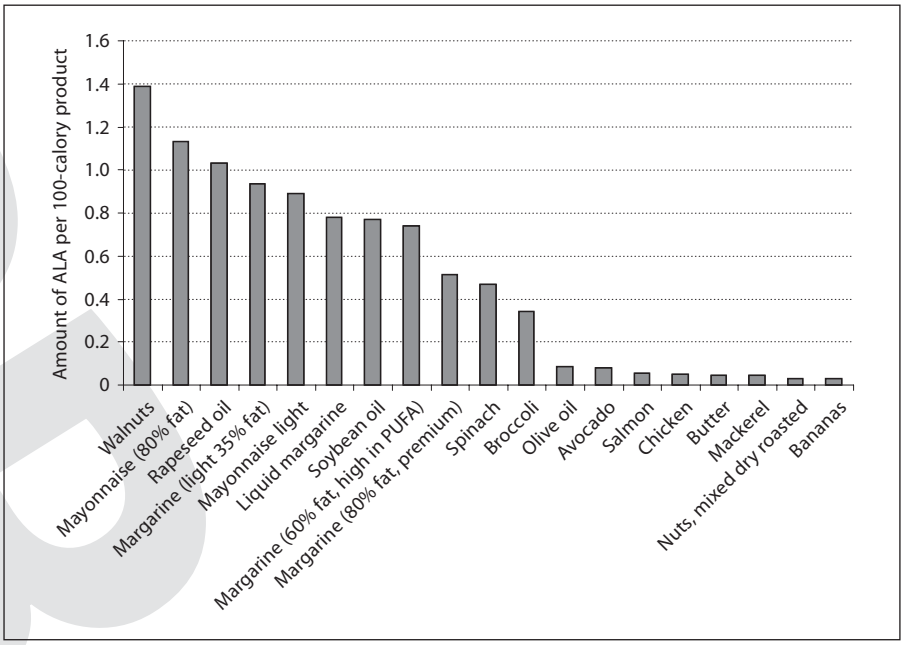

Fig. 2. ALA density for various foods.

Margarine Can Make a Significant Contribution to the Required Intake of Vitamins A, D and E

Margarine is fortified with vitamins A and D in many countries: in some countries fortification of margarine is mandatory, but in other countries not allowed. If fortified, margarine can make a significant contribution to the intake of these fat-soluble vitamins. The levels of fortification are usually around 15–30% of the recommended daily allowance for those vitamins per daily portion. A good illustration of the impact this fortification can make is a recent dietary survey in Finland: the National Findiet 2007 Survey [16]. In adult males, the group of fat spreads, oils, dressings and gravies provided 20–25% to the average daily intake of vitamins A, D and E. Particularly relevant is the contribution to the vitamin D intake as the average intake is lower than recommended in many societies [17].

Soft Margarines Have a Relevant Impact on the LDL Cholesterol Level and Hence Potentially on CHD Incidence

Undoubtedly, the best investigated effect of fatty acids is their effect on blood lipids, particularly on LDL cholesterol, with LDL cholesterol being a primary risk factor for CHD [18]. The qualification of fats into 'good' and 'bad' is mainly based on their effect on blood cholesterol levels. Already in the mid-1950s when Ancel Keys published his series of human intervention studies with mixtures of various fats, the picture began to emerge that SFA increased total cholesterol, PUFA lowered it and MUFA had a neutral effect [19]. Since then, this picture has been sharpened and extended. One of the more recent meta-analyses of good-quality intervention studies investigating the effect of fatty acids on blood lipids is the study by Mensink et al. [20]. They reported the effects of fatty acids on total cholesterol, the ratios of total/HDL and LDL/HDL cholesterol and even on triglycerides. TFA was also included in the analysis.

When compared to carbohydrates, the LDL-cholesterol-increasing effect of SFA was clear. TFA was even worse because it not only increased LDL cholesterol slightly more than SFA, it also did not increase HDL cholesterol like all other fatty acids did. PUFA was found to lower LDL cholesterol. MUFA also lowered LDL cholesterol but to a lesser extent. In the study by Mensink et al. [20], the increase in LDL cholesterol induced by SFA was almost twice as big as the decrease in LDL cholesterol by PUFA. Therefore, quantitatively, lowering SFA intake has the largest effect on LDL cholesterol.

Mensink et al. [20] described the relationship between fats and LDL cholesterol in an equation:

$$\text{Change in LDL cholesterol (mmol/l)} = (0.032 \times \Delta\text{SFA \%E}) + (-0.009 \times \Delta\text{MUFA \%E}) + (-0.019 \times \Delta\text{PUFA \%E}) + (0.040 \times \Delta\text{TFA \%E}),$$

where Δ stands for the change in fat intake in percent of energy (%E).

This equation, though describing the effect of the fatty acid composition of whole diets on LDL cholesterol, can be adapted to predict what the effect of an individual fat-containing food product would be. For example one can predict the effect the daily consumption of 20 g of margarine would have based on the assumption that the product is part of a diet providing 2,000 kcal per day and that the product/margarine is replacing calories otherwise consumed from carbohydrates. The resulting effect (in mmol/l) can be expressed as percentage lowering of LDL cholesterol by using an average LDL cholesterol level in a population. In all examples in this paper, the population average LDL cholesterol level used is 3.5 mmol/l, being representative for Western societies [21, 22]. The results of predictions for the fat-rich products described earlier in this paper are given in figure 3.

These predictions are hypothetical, but the results nevertheless are similar to those seen in intervention studies. For example when comparing the effect of consuming butter with that of consuming soft/premium margarines, differences of 4–5% in LDL cholesterol are often described [23–25]. This approach shows that products like vanaspati, butter and palm oil are predicted to increase cholesterol, whereas margarines rich in PUFA, premium mayonnaises and pure rapeseed oil are expected to lower LDL cholesterol. Replacing 20 g vanaspati and butter per day by soft margarine or liquid oils is expected to reduce LDL cholesterol on average by around 4–5%.

For an individual, a reduction in LDL cholesterol of 4–5% may not seem large, but on a population scale such an effect is significant. The relationship between LDL cholesterol lowering and a reduction in the CHD risk has been quantified in a few large-scale population studies as well as intervention studies [18]. As a conservative assessment, every 1% reduction in LDL cholesterol could lead to a 1–2% reduction in the risk of CHD. On this basis, the lowering of LDL cholesterol by 4–5% could signify a reduction in the CHD risk by around 5%. If one could reduce the number of deaths by CHD globally (according to the WHO 7.6 million in 2005) by 5%, approximately 400,000 people less would die of CHD. This reasoning is based on major assumptions, but it illustrates the potential benefit of making relatively small changes in our daily dietary choices on a global scale.

Large-scale intervention studies, e.g. the North Karelia Study described by Puska [26], have shown that major reductions in CHD mortality are achievable by diet and lifestyle changes in a population. The significant changes seen in blood lipids of the population in North Karelia were mostly ascribed to changes in fat consumption [27].

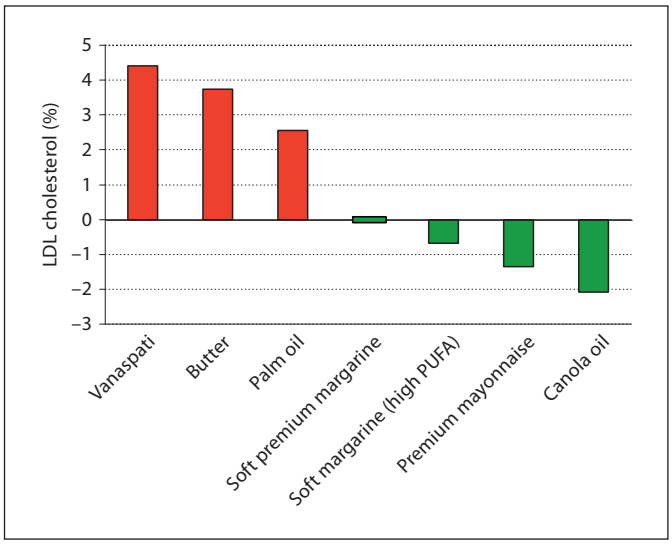

Fig. 3. Fat composition of foods influences their ability to lower or increase blood cholesterol: predicted effect of consumption of 20 g per day [adapted from ref. 20].

The cholesterol lowering was thought to be responsible to a high extent for the striking reduction observed in CHD mortality and morbidity [28].

Conclusions

Oils and fats, and products made thereof, play an important role in diets worldwide. The nutritional characteristics of these products vary widely: whereas some are low in 'bad fats' and high in 'good fats', others are not. Though good data on the intake of dietary fats are not available for large parts of the world, it is evident that despite healthier alternatives, a significant proportion of the fat consumed is too high in SFA and low in essential fats (omega–3 and –6 PUFA). On a global level, the main sources of SFA are fatty dairy products (e.g. butter, ghee, whole milk, cream and fatty cheeses), fatty meats, animal fats (e.g. lard), the vegetable fats palm, palm kernel and coconut oil and fatty snacks (like cakes, pastries and fries). Important sources of unsaturated fats are vegetable oils such as soybean, rapeseed (canola), sunflower and olive oil, fatty fish, fish oil, nuts, seeds and products made from these, e.g. soft margarines and mayonnaise, and derived products.

Over the last decades, the food industry has made significant improvements to the nutritional quality of products with a high fat content like margarines and cooking

products. This is due to the selection of healthier base materials (vegetable oils) in combination with technologies that enable the production of high-quality products with lower SFA and TFA and higher essential fatty acid content. Therefore, an easy way for many people to substantially improve the fat composition of their diets is to switch products from animal fats or cooking fats to modern soft margarines or oils.

Despite wide differences in dietary habits, modern products made from fats and oils are essential for healthy diets for children and adults worldwide. This is partly given by their contribution to the essential fatty acid intake (i.e. the essential fatty acids of the omega–3 and –6 families) and the vitamin A and D intake, which are not optimal in many societies for optimal growth and development of children, partly by an improved balance of 'bad fats' over 'good fats', which can contribute to a decreased LDL cholesterol level, which would lead to a reduced incidence and mortality of CHD.

Unfortunately, many people are not aware of the benefit of switching to these modern soft margarines and cooking products. A higher awareness followed by a greater motivation to select healthier fat choices is expected to have a significant positive impact on public health.

Disclosure Statement

All authors are employees of Unilever. Unilever markets food products, including margarines and vegetable spreads.

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Consumer Perception and Insights on Fats and Fatty Acids: Knowledge on the Quality of Diet Fat

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Key Words
Consumer knowledge · Dietary fat · Fatty acids · Healthy diets · Population attitudes

Abstract
Background: Research indicates that consumers do not understand dietary fat, either the importance of the quality or the quantity of fats needed for health. Previous consumer surveys suggest the priority placed on fat in various nutrition communications (i.e., low fat or reduction in fats) has contributed to this confusion. ***Methods:*** This consumer study was carried out in 16 countries in two waves, investigating in total 6,426 subjects. The survey was conducted by phone, internet and face-to-face interviews, depending on the acceptable method for the population. Participants, aged 18–70 years, were the main family shopper. ***Results:*** Knowledge about fat is conflicted, including which fats have health benefits; 59% of respondents think fat should be avoided, 65% think a low-fat diet is a healthy diet and 38% claim to avoid foods containing fat. Respondents were aware of different types of fats but did not know which ones were healthier. Omegas have the greatest level of recognition but at the same time many people do not realize they are fats. ***Conclusions:*** Around half of consumers do not know whether fats are good or bad, meaning they do not know what to eat.

Introduction

Research indicates that consumers do not understand basic information about dietary fat (e.g. good and bad fats) and consumer survey findings suggest the priority placed on dietary fat in various nutrition communications (i.e., low fat or reduction in fats) has contributed to misunderstandings about the inclusion of fat in a healthful eating plan. Consumers are cutting out more visible fats (often rich sources of essential fatty acids), such as margarine, mayonnaise and oil-based dressings, and are consuming a lot of hidden fats (primarily saturated fatty acids), such as high-fat dairy foods, cookies, pastries and excess meat.

Consumer surveys also show that fat consistently ranks at the top of the list of consumer nutrition concerns. The Food Marketing Institute's annual trends survey showed in 1996 that 60% of shoppers were more concerned about the fat content of foods than any other nutritional component/issue [1]. The 2008 Food and Health Survey of the International Food Information Council found that 70% of those surveyed were concerned with the amount of fat they consume, a percentage that is consistent with 2007 at 71% and 2006 at 66% [2]. A recent survey, published in the *Journal of the American Dietetic Association* and conducted for the American Heart Association by Cogent Research, found that 62% of Ameri-

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Table 1. Characteristics of the study population: wave 1, studied between November and December 2007

	B	CZ	Ger	Gre	Fr	NL	PL	Sp	Swe	UK	EU	USA	Dev	Bra	Ind	Mex	TK	SA	Emer	All
Total, n:	200	200	200	202	200	200	202	200	200	200	2,004	200	2,204	200	200	200	210	200	1,010	3,214
Survey method:	P	P+C	P	P+C	P	P	P+C	P	P	P		P+C		P+C	F2F	F2F	F2F	F2F		
Chief shopper; personally buys items from supermarkets and shops for household, %																				
Almost all the time	82	75	62	68	79	90	83	89	72	75	76	82	79	67	54	66	69	73	63	71
Half/more than half the time	18	25	38	32	20	10	17	11	28	26	24	19	21	34	46	34	31	27	37	29
Less than half the time	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Age, %																				
18–34 years	15	21	19	37	19	15	14	15	23	26	20	12	16	35	47	52	31	51	43	29
35–54 years	52	38	49	38	52	45	51	60	47	49	50	53	51	46	39	37	57	30	42	46
55+ years	31	41	33	25	27	41	35	23	28	27	30	37	33	21	13	10	11	21	15	24
Sex, %																				
Female	75	84	74	80	75	74	86	80	67	74	77	78	77	50	92	52	82	99	73	75
Marital status, %																				
Married or living with partner	75	68	70	68	67	71	75	75	61	54	68	70	68	58	72	60	87	41	65	67
Single[1]	25	33	31	32	33	29	25	25	39	45	32	30	31	42	28	39	13	59	35	33
Paid work, %																				
≥30 h/week	43	49	42	41	54	29	39	54	64	52	47	54	50	36	13	31	13	37	25	38
8–29 h/week	18	5	13	7	9	32	11	8	12	16	13	7	10	15	11	16	6	17	13	11
<8 h/week	35	42	44	36	37	36	43	37	23	30	38	37	37	49	75	33	80	46	59	48
Children living in household in any of these age groups, %																				
0–5 years	34	37	34	52	41	32	35	38	38	39	37	34	35	52	54	58	29	97	55	48
6–10 years	41	48	34	62	48	36	45	52	42	44	44	39	42	64	49	50	42	97	54	50
11–16 years	56	52	84	90	85	82	56	72	77	73	74	81	77	89	52	39	60	48	54	61
17–18 years	32	46	25	27	27	12	14	12	15	22	22	23	22	16	47	17	22	51	31	26

B = Belgium; CZ = Czech Republic; Ger = Germany; Fr = France; NL = The Netherlands; PL = Poland; Sp = Spain; Swe = Sweden; UK = United Kingdom; EU = Europe; USA = United States of America; Dev = average of developed countries; Bra = Brazil; Ind = Indonesia; Mex = Mexico; TK = Turkey; SA = South Africa; Emer = average of emerging countries; P = interview by phone; P+C = interview by phone; computer aided; F2F = face-to-face interview.

[1] Includes divorced, separated and widowed.

cans aged 18–65 years were concerned about the amount of fat they consume [3]. One change in recent surveys is an increased recognition of the role of trans fats in overall health, but the level of recognition of healthy fats continues to be low. The Soy Food Association of North America has found similar trends in terms of awareness of trans fat with 89% of those surveyed in their 2008 Consumer Attitudes about Nutrition Survey viewing trans fats as somewhat or very unhealthy [4]. Clearly, Western populations of all ages interpret recommendations to reduce dietary fat intake to mean the elimination of all higher-fat foods, which is likely to be a major obstacle in achieving recommended dietary intakes of unsaturated fatty acids.

This survey was conducted by Millward Brown to determine the degree of consumer knowledge and confusion about nutrition, with emphasis on the role of fats and the importance of fat quality, in 16 countries worldwide.

Methods

This study was carried out in 16 countries and was conducted in two periods. Details of the study populations can be found in tables 1 and 2. The first wave was conducted by phone and through face-to-face interviews, and took place between November and December 2007. During the first wave, the goal was to gather topline information so questions focused on what types of fats had people heard of, could they identify saturated fats, essential fats, the omegas, for example, and did they believe there were good and bad fats. The second wave was conducted through the internet and face-to-face questions during the months of August and September of 2008. The questions during this wave sought more information about fats by asking questions related to overall nutrition, role of fats, what foods are needed for health and what foods provide these types of fats. The two waves consisted of 160 different questions.

Study subjects were the families' main shoppers, defined as those who for more than half of the time personally buy items for their households. Sample size was approximately 200 subjects per country per wave for a total of just over 6,400 main shoppers surveyed. The samples set quotas by ages in order to reflect the overall population but ranged from 18 to 70 years of age. Gender

Table 2. Characteristics of the study population: wave 2, studied between August 2008 and September 2008

	B	CZ	Ger	Gre	Fr	NL	PL	Sp	Swe	UK	EU	USA	Dev	Bra	Ind	Mex	TK	SA	Emer	All
Total, n:	200	200	200	201	200	200	200	200	200	200	2,001	200	2,201	200	200	203	200	208	1,011	3,212
Survey method:	I	I	I	I	I	I	I	I	I	I		I		I	F2F	F2F	F2F	F2F		
Chief shopper; personally buys items from supermarkets and shops for household, %																				
Almost all the time	77	73	85	76	80	82	74	79	70	80	80	82	81	81	56	53	54	59	63	72
Half/more than half the time	24	27	15	24	20	19	26	21	30	21	20	18	19	20	44	46	46	41	37	28
Less than half the time	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Age, %																				
18–34 years	34	35	27	41	34	31	39	28	32	33	32	39	35	46	48	38	25	31	42	39
35–54 years	44	38	44	43	42	44	42	43	40	40	42	41	42	35	40	39	45	58	41	41
55+ years	23	27	29	16	24	25	20	28	28	27	26	20	23	19	12	22	30	11	17	20
Sex, %																				
Female	70	70	75	69	65	70	60	75	70	67	69	59	64	74	75	49	60	75	69	67
Marital status, %																				
Married or living with partner	67	57	66	54	71	68	46	73	64	64	64	56	60	60	78	69	49	84	70	65
Single[1]	32	43	34	39	28	32	53	27	36	36	35	45	39	40	23	31	52	16	30	35
Paid work, %																				
≥30 h/week	35	62	48	75	66	44	61	69	57	44	56	56	56	69	24	32	44	25	40	48
8–29 h/week	14	13	18	12	8	25	13	9	11	17	14	11	12	12	12	17	14	2	12	12
<8 h/week	51	25	35	13	26	31	27	23	33	40	31	34	32	19	65	51	43	73	48	40
Children living in household in any of these age groups, %																				
0–4 years	14	19	14	14	16	14	9	12	16	20	14	24	19	23	54	28	19	16	34	26
5–9 years	17	12	18	11	20	16	10	12	18	12	15	18	16	18	43	34	27	17	30	23
10–12 years	12	5	6	4	9	7	7	7	5	9	7	8	8	10	27	16	26	16	19	13
13–15 years	11	10	10	4	6	5	9	13	14	7	9	9	9	10	23	13	25	14	17	13
16–17 years	5	12	7	7	11	7	8	8	9	3	7	6	6	5	17	12	18	10	12	9

B = Belgium; CZ = Czech Republic; Ger = Germany; Fr = France; NL = The Netherlands; PL = Poland; Sp = Spain; Swe = Sweden; UK = United Kingdom; EU = Europe; USA = United States of America; Dev = average of developed countries; Bra = Brazil; Ind = Indonesia; Mex = Mexico; TK = Turkey; SA = South Africa; Emer = average of emerging countries; I = internet; F2F = face-to-face interview.

[1] Includes divorced, separated and widowed.

quotas did not reflect the gender distributions of the various countries since chief shoppers are predominantly females. The male/female distribution ranged from a low of 14% males to 100% females in the first wave and from 25% males to 75% females in the second wave. The gender ranges were also different within countries from wave 1 to wave 2.

The interview method was based on techniques most familiar to the country with face-to-face interviewing more often used in emerging countries and telephone or internet in developed countries. Data analysis was weighted to reflect population size of the countries surveyed so that when comparing countries, the numbers reflected the differences in country size (table 3). In addition, data were presented on the basis of global averages but were also clustered to allow comparison amongst developed and emerging countries.

Topic areas included the role of fat in the diet, clarity of messages about fat, health benefits of fat both in terms of quantity and quality, knowledge of types of fats including trans fats, saturated fats, omega–3 and omega–6, and other unsaturated fats, food sources of all types of fats and the connection of fat to body weight.

Results

Contradictory Information

When consumers in wave 2 (n = 3,212) were surveyed about the information provided by governments, experts, food companies and the media related to fats and their role in a healthful diet, the global average indicated that 57% of consumers were confused, and 64% reported that they felt information provided was contradictory. In comparing responses from developed versus emerging countries, the levels of confusion are high in both but the developed countries do show a lower level of confusion with 51% on average indicating confusion. The role of fats in a healthful eating plan is a message that generates much confusion in emerging countries with 63% of respondents indicating that they felt information about fats was contradictory. When looking at individual countries, the level of confusion ranges from 43% in Germany to

Table 3. Overview of weight factors: global average and cluster averages have been weighted according to population size

Global average	Weight factor, %	Cluster of developed countries	Weight factor, %	Cluster of emerging countries	Weight factor, %
Belgium	0.82	Belgium	1.63	Brazil	28.95
Brazil	14.38	Czech Republic	1.59	Indonesia	36.04
Czech Republic	0.80	France	9.80	Mexico	16.58
France	4.93	Germany	12.63	South Africa	7.45
Germany	6.36	Greece	1.71	Turkey	10.98
Greece	0.86	The Netherlands	2.52		
Indonesia	17.91	Poland	5.86		
Mexico	8.24	Spain	6.95		
The Netherlands	1.27	Sweden	1.41		
Poland	2.95	United Kingdom	9.31		
South Africa	3.70	USA	46.60		
Spain	3.49				
Sweden	0.71				
Turkey	5.46				
United Kingdom	4.68				
USA	23.44				

59% in Greece but in emerging countries the degree of confusion about fat is higher, ranging from 61% in Brazil to 73% in Turkey (table 4).

Role of Fat

Confusion about fat messaging is certainly evident but an additional concern is that on average 52% of those surveyed in wave 2 (n = 3,212) do not know which fats have health benefits. The question also reflected the differences in awareness among developed and emerging countries. A smaller percentage, 45%, in developed countries indicated lack of knowledge, but 58% of those in emerging countries expressed lack of knowledge about the health benefits of fats. One of the main areas of confusion seems to be related to whether fats belong in a healthful eating plan. The question posed to those surveyed in wave 2 was whether they agree or disagree that a low-fat diet is a healthful diet. The global average indicated that 65% of those questioned agree that low fat is healthy but 38% of those questioned claim to avoid fat. A follow-up question about what percentage of daily calories consumed were from fat showed that only 1 in 5 (22%) indicated that 15–30% of daily calories need to come from fat. In addition, 60% reported that less than 14% of daily calories were the appropriate level for fat intake.

Table 4. Percentage of people, surveyed in wave 2 (n = 3,212), agreeing with certain statements (percentages are separated for global average, for the clusters and for each country)

	Agreement with statements, %	
	Contradictory information leaves me confused about fats	Government, experts, food companies and media give contradictory messages about fats
Global average	57	64
Developed average	51	64
Emerging average	63	64
Greece	59	63
United Kingdom	57	63
Czech Republic	54	45
Belgium	54	52
United States	53	69
Spain	51	64
Sweden	50	63
France	48	56
Poland	46	61
The Netherlands	44	51
Germany	43	63
Turkey	73	78
South Africa	70	64
Indonesia	62	60
Mexico	62	61
Brazil	61	67

Table 5. Percentage of people, surveyed in wave 1 (n = 3,214), who think that certain types of fat are generally bad, neither bad or good, or good for their health (results presented for cluster of developing and emerging countries)

Type of fat	Developing average				Emerging average			
	bad	neither bad or good	good	do not know	bad	neither bad or good	good	do not know
Omega–3	3	3	77	17	2	4	63	31
Omega–6	6	4	53	37	2	2	38	57
Essential fat	15	5	56	24	5	4	16	76
Monounsaturated fat	26	6	33	34	9	5	9	76
Polyunsaturated fat	28	7	40	25	12	7	10	72
Trans fat	49	4	7	40	13	3	5	79
Saturated fat	67	6	9	17	30	7	10	54

When delving deeper into what people consider important in their eating plans, the responses from developed and emerging countries followed a similar pattern. Vitamins are mentioned as the main thing in food that people need for health followed by protein, fiber, minerals, carbohydrates, salt and then fat. The global average indicated that while 95% of respondents knew that vitamins were needed for a healthy diet, only 41% indicated fat was needed.

Types of Fat

While people are confused about the role of fat in a healthful eating plan, when it comes to recognizing different types of fats, the level of awareness shifted. In wave 1 (n = 3,214), omega–3 fatty acids had the best level of recognition, with 80% of consumers globally indicating they had heard of them, followed by saturated fats at 71%. This question, however, again pointed out the difference between developed and emerging countries in terms of awareness of the types of fats. In developed countries, 65–89% of those surveyed indicated familiarity with the different types of fats, but in emerging countries the highest level of recognition was for omega–3 fatty acids at 74%. After that, the level of recognition dropped to a range of 26% for trans fats to 53% for saturated fats.

Recognition of the types of fats is a first step in choosing healthier fats; the next step is knowing which fats are better choices. Wave 1 (table 5) showed that beyond omega–3 and saturated fat, around half of those surveyed indicated they did not know which fats were better choices, with emerging countries showing larger percentages of 'don't knows'. Recognition of whether saturated and unsaturated fats were good or bad varied by country, and developed countries once again showed higher levels of recognition than emerging countries. When asked to identify if saturated fats were good or bad, the global average found that 48% indicated saturated fats were bad but 67% of those in developed countries reported saturated fats were bad versus only 30% of those in emerging countries. Just as significant was the fact that 54% of those in emerging countries did not know whether they were good or bad. Responses for polyunsaturated fats showed a wider variation from developed countries to emerging countries with 40% of those in developed countries knowing they are good and only 10% in emerging countries, for a global average of 25%.

When asked whether essential fats are good or bad, the global average percentage in wave 1 indicated that 50% of those surveyed did not know. In developed countries only 24% did not know, but 76% of those in emerging countries did not know (table 5). In developed countries, the range of 'don't knows' for essential fats varied from 10% in the US to 61% in the Czech Republic. On a global level, 77% of those questioned in wave 1 knew that omega–3 fatty acids are good for them. Emerging countries did not have as high a level of awareness, but almost two thirds (63%) of those surveyed in emerging countries knew they were good food choices (table 5). At the same time, the global average percentage knowing that omega–6 fat is good was only 46%. While respondents in wave 1 knew omega–3 fatty acids were good choices, just over 50% of those surveyed in wave 2 knew that omega–3 and omega–6 were fats. Once again the

trend of emerging countries falling behind the developed countries in terms of knowledge held true with only 46% of respondents in emerging countries recognizing omega–3 and –6 as fats versus 61% in developed countries.

Fat in the Diet

In wave 2, respondents were also asked to identify sources of fats. Those surveyed were provided a list of foods and asked to identify those they felt were among the main providers of fat. As main sources of essential fats, respondents indicated olive oil and salmon in both the developed and emerging countries. After the first two foods, there were variations in the ranking of the foods (table 6).

Assessing the level of understanding about fat was the basis of two questions. In wave 2, the topic was approached from the angle 'what can fat do to the body?'. The question provided a list of positive functions of fat along with a list of negative associations including weight gain, clogging of arteries, raising cholesterol and cause of cancer. Since respondents could indicate positive and negative responses, the percentages do not add up to 100. Lumping all negative connections together for the global study population resulted in a 94% indication of a connection between fat and these negative outcomes. Saturated fats had a 72% association with negative factors, essential fats had a 15% connection to negative factors and omega–3 and –6 had a 7% association. When it comes to the positive associations, which ranged from 'helps cell growth' to 'keeps skin healthy', omega–3 and –6 had a 79% association and fat had only a 45% association. In wave 1, understanding was assessed by asking respondents which fatty food was better for them. The outcome showed that more than 50% believe butter is better for health than margarine. In addition, the responses from the developed and emerging countries were almost identical with 51% of those in developed countries and 56% of those in emerging countries responding positively. Finally, in wave 2, respondents were asked to what extent they agreed or disagreed with certain statements. In response to a question related to interpretation of food and nutrition messages those surveyed were asked: 'Given all of the information about food I no longer know what to eat and what to avoid' and the response was consistent in the developed and emerging countries with 43% of those in developed countries and 45% of those in emerging countries agreeing with this statement.

Table 6. Percentage of responses of the surveyed population in wave 2 on the question 'Do you know where to find essential fats?'[1]

Type of food	All respondents in wave 2 (n = 3,212)	Developed average (n = 2,201)	Emerging average (n = 1,011)
Olive oil	32	33	31
Salmon	31	31	31
Avocados	29	26	32
Walnuts	28	29	28
Sunflower oil	24	24	23
Seeds	24	22	27
Sardines	24	23	25
Soybean oil	22	25	20
Rapeseed oil	20	19	21
Cheese	16	12	20
Butter	11	10	13
Margarine	9	7	11
Chicken with skin	8	9	7
Chocolate	8	5	12
Mayonnaise	7	6	9
Biscuit	6	4	8
Bacon	5	6	4
Cakes/pastries	5	4	7

[1] Respondents were asked to indicate all foods in the list which they thought would apply.

Discussion

This study, similar to many others, supports the level of confusion that consumers have related to healthy eating and in particular fats. Outcomes of this study are similar to those of other organizations. The Soyfoods Association found in their 2008 Consumer Attitudes Study that 52% of consumers felt that information about health and nutrition is confusing [5].

Ascertaining the level of understanding of fat, both in terms of quality and quantity in the diet, is a complicated issue, so development of the survey questions was challenging, especially given that the goal was to have questions easily understood by the consumer. Another factor that complicates the outcomes of the survey is the variety of methods used for data gathering. Using the method appropriate for different countries ensures better data but comparing data from the internet, face-to-face and phone interviews can be viewed as less scientific than desired. Another limiting factor of the study is that Asia is somewhat underrepresented given its large population.

The number of people surveyed makes this study one of the largest (if not the largest) global studies published

on the topic of fat, making the information gained a good indicator of population attitudes, knowledge and behaviors associated with fat choices and consumption. The results provide a current perspective on attitudes since the survey was conducted within the last year and the most recent wave within the last 6 months. The global perspective of this survey also gives a broader picture of the overriding confusion related to fat. While the study shows differences for developed and emerging countries, the consensus is that most people do not understand the role of fats, what types of fats are healthier and how much fat is needed for health. In addition, the survey tool was designed to ensure that fats were viewed in the context of an overall eating plan so that respondents would not view fat as carrying more nutritional value or as a nutrient to avoid. To ensure accuracy of answers, questions were worded in ways that consumers would understand, so scientific terminology was avoided. Putting the questions into consumer friendly language further ensures that answers are an accurate reflection of knowledge and attitudes.

Finally, while varying data gathering techniques might be viewed as unfair for comparison of outcomes, tailoring the methods to the countries ensures better responses. Gathering information about food knowledge and preferences is a process that requires openness and comfort that the information provided will not be judged as good or bad. Utilizing face-to-face interviews, the internet or phone interviews ensured a broader sample from all of the countries. In countries where the internet was used, participants were chosen very carefully to ensure that those included were not there due to self-selection.

It is clear that people feel there is a lot of contradictory information about fats resulting in confusion about which fats are acceptable, especially when it comes to health benefits. Less than two thirds of those surveyed have heard of many of the different types of fats and one half of those questioned does not know whether a fat is good for them or not. This level of confusion generally results in consumers sticking with food choices they are comfortable with, even if they are not sure if those choices are healthful. Recognition of the types of fats is a first step in choosing healthier fats, the next step is knowing which fats are better choices, and the survey found that beyond omega–3 and saturated fat around half of those surveyed indicated they did not know which fats were better choices. In agreement with the Food and Health Survey of the International Food Information Council [2], when consumers find nutrition and health information confusing rather than trying to sort out the information, they continue using the foods they currently enjoy, no matter what the health implications. Another survey also found the same level of confusion about fat. The Soyfoods Association of North America surveyed Americans about their knowledge and attitudes towards fat and found that 36% of those surveyed felt saturated fats were healthier than trans fats and only 17% thought trans fats were better. That survey found that 66% of those questioned felt omega–3 fatty acids were somewhat or very healthy. The next closest fat was polyunsaturated fats at 29% [5].

As noted earlier, the current survey found that awareness of omegas was high but when asked to identify what omegas were, only one third of those surveyed knew they were essential fats and about one half did not realize they were fats at all. The implication of this outcome is that consumers are hearing some terms related to fat but the information being presented does not convey a usable message nor does it convey a complete message. The impact of this is failure to consume appropriate amounts of healthful fats on a regular basis.

One of the biggest outcomes of the survey was the large number of people who had a negative association with fat. More than 90% of those surveyed associated something negative with fat. This response is similar to responses in surveys conducted by other studies. The 2008 Food and Health Survey of the International Food Information Council Foundation found that the perceived healthfulness of fat ranged from a high of 37% for unsaturated fats to 4% for saturated fats [2]. Failure to connect fat in a positive way with overall health is likely an outcome of messages that have focused on fat and weight, and fat and heart disease. This survey would seem to indicate that those messages carried an all-or-none message and not a message about the proper types or amounts of fats.

While most people associated all fats with negative health implications, 72% of those surveyed did associate negative implications with saturated fats. This inability to associate fat with positive health benefits, and to view it as a nutrient to avoid, has an impact on what fats people choose, how much fat they are willing to consume and potentially on their nutritional intake, a fact supported by the number of individuals who responded that butter was healthier than margarine. Given the saturated fat content of butter, the identified failure to understand the difference between butter and margarine and how reduction of butter intake can impact overall health is a message for better public health campaigns about fats and their role in health.

For health professionals, the lack of knowledge about fat is a concern but how that lack of knowledge impacts purchasing and usage habits is a much bigger public health issue. The fact that consumers cannot recognize foods like cheese, chocolate, bacon, pastries and many other foods as contributors of fat in the diet is a very basic indication that education about healthful eating is lacking. Not only are consumers failing to make the right fat choices to consume the healthier fats, they are also potentially including foods that are high sources of fat, and in many cases saturated fat, without thinking about the impact on the overall diet.

Health care providers need to educate themselves so they can help consumers learn about fat, its role in a healthful eating plan, what types of fat to consume and how much is appropriate. If health care providers are not able to help consumers make changes in their knowledge about and consumption of healthful fats, they need to collaborate with nutrition professionals who can provide these services. Dietary guidelines worldwide focus on the inclusion of fat, identification of the types of fats needed for health and the types of fats that should be limited in order to maintain a healthy cardiovascular system. From the outcomes of this survey it appears consumers do not understand the guidelines about fat, and helping them learn more will promote their health, reduce disease risks and improve global health.

Disclosure Statement

Kim Malcolm works for Millward Brown who performed the research described in this paper on a contract base for Unilever.

As a Steering Committee member of the International Expert Meeting Connie Diekman received compensation from Unilever through an unrestricted educational grant. Her section of the paper was written without a conflict of interest.

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Fat and Heart Disease: Yes We Can Make a Change – The Case of North Karelia (Finland)

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Key Words
Cardiovascular disease · Dietary interventions · Fat · Finland · Community-based intervention

Abstract
Background/Methods: The exceptionally high mortality from cardiovascular disease (CVD) in the Finnish population in the 1970s ensued the initiation of preventive health interventions, which were first started in the Province of North Karelia and later on extended to all other regions of Finland. Their aim was to change population diets, especially with respect to the quality of fat: to reduce saturated and increase unsaturated fat intake. In addition, emphasis was placed on increased vegetable intake and salt reduction. The aim of this paper was to illustrate the effect of combined efforts of several stakeholders on CVD. This comprehensive action in Finland has involved health education programs, preventive measures in health services, actions at schools, broad collaboration with non-governmental and private sector organizations, government policies, population-based monitoring and evaluation, and international collaboration. ***Results:*** The combined efforts of all stakeholders have greatly helped people to reduce the intake of saturated fat and to replace this with unsaturated fat. This has been associated with an improved quality of the dietary fat (e.g. in 1972, over 90% of the population used butter on their bread compared to <5% at present) and a remarkable reduction in blood cholesterol levels. It has led to a 80% reduction in annual CVD mortality rates among the working aged population, to a major increase in life expectancy and to major improvements in functional capacity and health. Studies have shown that the reduction in blood cholesterol levels, explained by the target dietary changes, have had the greatest impact on these very favorable health changes. ***Conclusion:*** The Finnish experience shows both the feasibility and great potential of CVD prevention and heart health promotion through general dietary changes in the population.

Introduction

Global public health is under rapid change: chronic noncommunicable diseases have become the leading cause of death in the world and are responsible for some 60% of the deaths in the world. About half of that is due to cardiovascular diseases (CVDs; fig. 1) [1]. CVD is thus the main cause of mortality in the world, being responsible for every 3rd death. The problem is rapidly growing in the low- and middle-income countries.

This global public health transition is very much a consequence of changes in lifestyles – i.e., in dietary habits, physical activity and smoking. The particular reasons for these changes are urbanization, changes in occupations, the aging of populations and many global influ-

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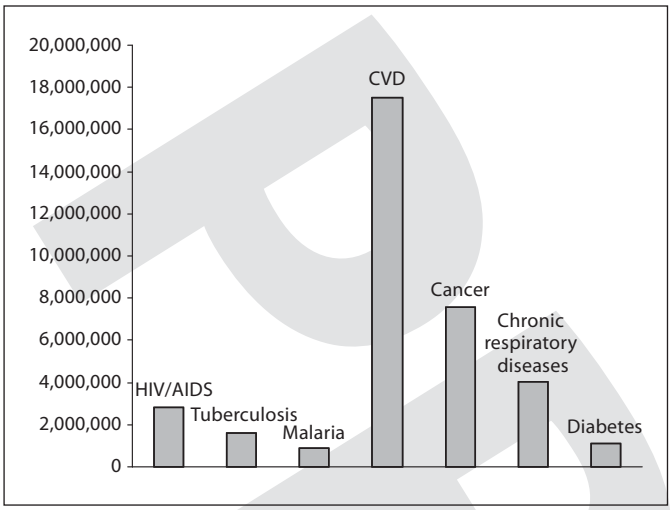


Fig. 1. Estimated global deaths by cause, all ages, 2005 [1].

ences. The risks are increasingly accumulating in lower socioeconomic groups of the population – adding greatly to the inequalities of health.

The large international study published in the World Heart Report 2002 shows how a few risk factors are responsible for much of the global mortality [2] (fig. 2). Typical for these most important global risk factors is that they are closely linked with some lifestyles: seven of the nine top determinants of mortality in the world relate to how we eat, drink, move and smoke. Thus, diet and physical activity, together with tobacco and alcohol, are key determinants of contemporary public health.

Since CVD is a leading cause of mortality, the causes of CVD are of utmost concern. The main causal risk factors for atherosclerotic CVD have been convincingly revealed decades ago. They relate much to the above-mentioned lifestyles. The role of diet, particularly the quality of fat and salt affecting blood LDL cholesterol and blood pressure, has become more and more obvious [2].

Thus, there is a firm basis for the prevention of CVD and many other noncommunicable diseases through reducing these risk factors – i.e., changing the related lifestyles. Concerning the prevention strategy, it should be emphasized that although changing the diet and other risk-related lifestyle factors among high-risk persons can bring great benefit to those individuals, population-based prevention through influencing the population's diet and other lifestyle factors is by far the most cost-effective and sustainable way for a reduction in CVD rates and promotion of heart health in the population.

North Karelia (Finland)

Finland was faced with exceptionally high mortality rates of CVD in the 1970s. Growing attention to this serious situation led to the initiation of preventive measures. The program, which was first launched in the Province of North Karelia and later was extended to all regions of Finland, concentrated heavily on changing the population's diet, especially with respect to the quality of the fat consumed: a reduction in saturated and an increase in unsaturated fat intake. In addition, emphasis was placed on an increased vegetable and a reduction in salt intake [3].

This comprehensive action in Finland has involved health education programs, preventive measures in health services, actions at schools, broad collaboration with non-governmental and private sector organizations, government policies, population-based monitoring and evaluation, and international collaboration. Collaboration with the food industry has greatly helped people to reduce the intake of saturated fat and to increase that of unsaturated fat (mainly from vegetable origin). A heart symbol is broadly used to label foods that are healthy choices in their category. The demonstration in North Karelia was heavily used in the national work.

The work in Finland has led to significant improvements in the quality of dietary fat (e.g. in 1972, over 90% of the population used butter on their bread compared to <5% at present), and to a reduction in blood pressure levels and smoking among men. The national butter consumption per capita has reduced from some 18 kg in 1965 to less than 3 kg in 2005 [4] (fig. 3). Use of vegetable oil (mainly rapeseed oil) for cooking has increased from close to 0% in 1970 to some 50%. Fruit and vegetable consumption has greatly increased and salt intake reduced. With these major dietary changes, the total fat consumption (as a percentage of energy) has reduced from close to 40% to a little over 30%, with major reductions in saturated fat and some increase in polyunsaturated fat intake [5–9] (fig. 4).

The dietary changes have also caused a remarkable reduction in blood cholesterol levels (fig. 5), with a subsequent reduction in blood pressure levels and smoking among men. A 80% reduction in the annual CVD mortality rates among the working aged population has been reported for all Finland (85% in North Karelia; fig. 6). Some 10-year increase in life expectancy and a major improvement in functional capacity and health have also been observed. Studies have shown that the reduction in blood cholesterol levels, explained by the target dietary changes, have had the greatest impact on these very favorable health changes (fig. 7).

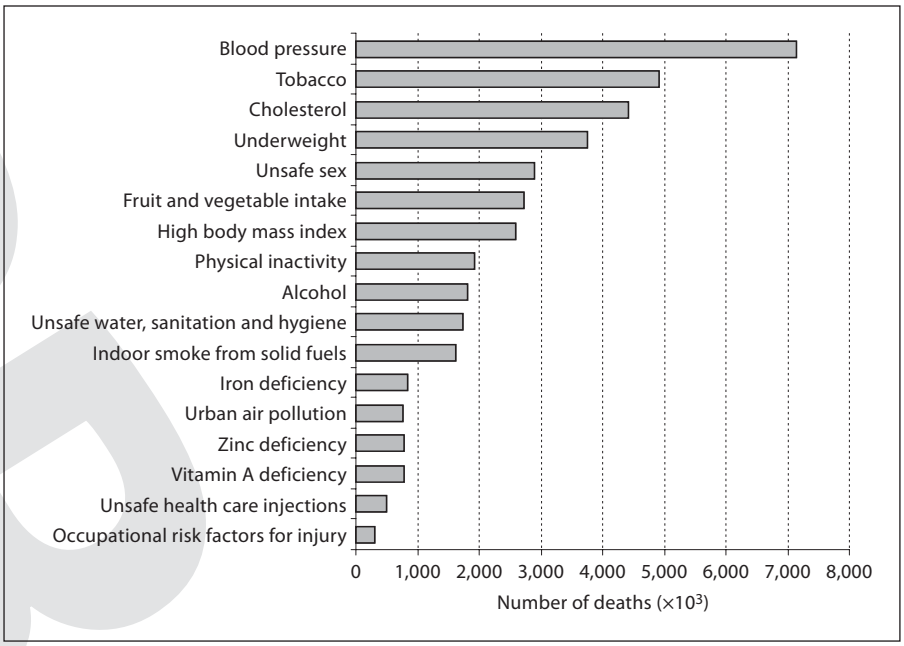
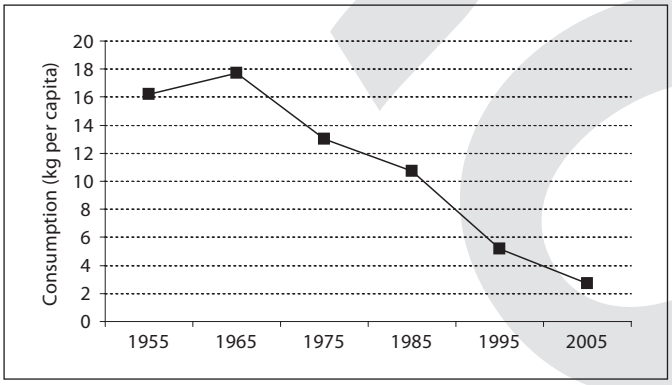


Fig. 2. Deaths in 2000 attributable to selected leading risk factors in the world [2].



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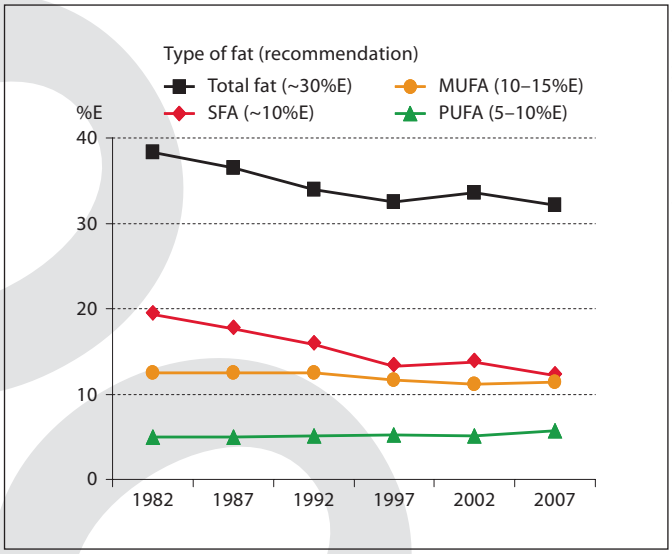

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Fig. 3. Butter consumption per capita in Finland [4].
Fig. 4. Total fat intake, and intake of saturated (SFA), monounsaturated (MUFA) and polyunsaturated (PUFA) fatty acids in Finland from 1982 to 2007 [5–9]. %E = % of energy.

The theory and practice of the work in North Karelia and Finland as well as the results are presented in a recent summary report [10].

Discussion

The experiences and results from the North Karelia Project and Finland strongly support the principles of the WHO Global Strategy on Diet, Physical Activity and Health and to its scientific background document – the Expert Group Report on 'Nutrition and Prevention of Chronic Diseases' of the WHO/Food and Agriculture Organization of the United Nations [11, 12]. The comprehensive community-based intervention in North Karelia and the consequent national application of the principles and of its demonstration effect have led to a remarkable reduction in CVD mortality and therefore improved the public health of the nation.

The intervention in the North Karelia Project was based on a population approach, i.e., on changing the dietary habits of the whole population through broad ac-

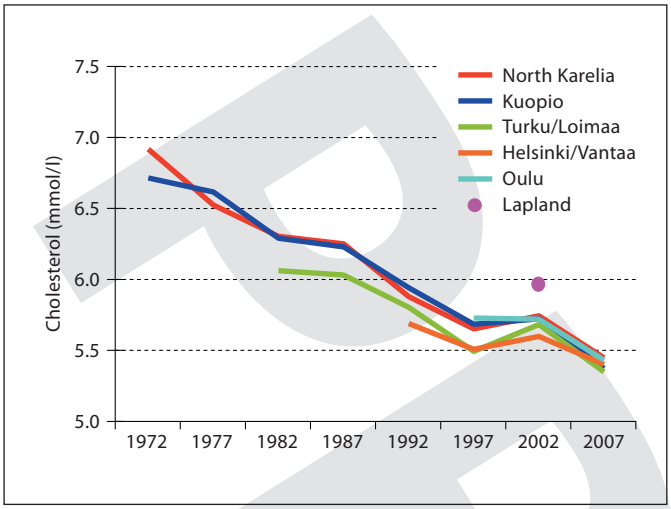

Fig. 5. Serum cholesterol in men aged 30–59 years.

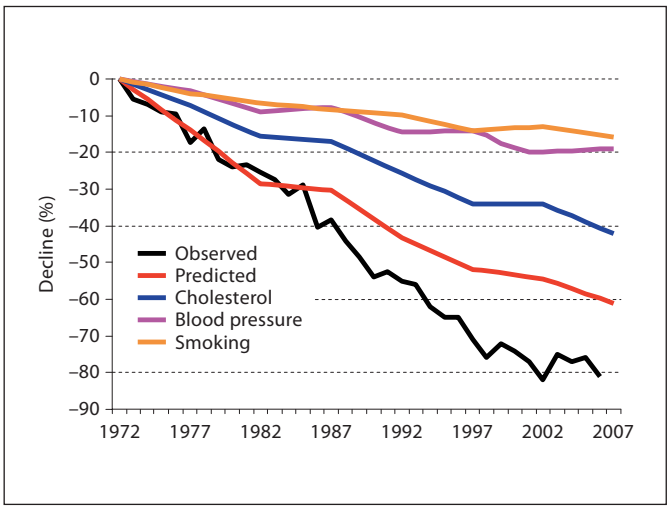

Fig. 7. Observed and predicted declines in coronary mortality in males in Eastern Finland.

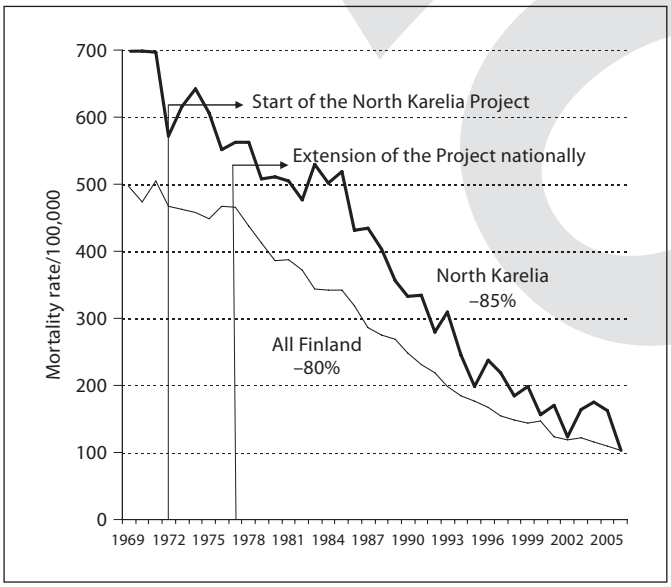

Fig. 6. Mortality rate per 100,000 population (age standardized to the European population).

tions in the community. Thus, the target was to change the community as a social and physical organization, since people's dietary habits and other lifestyles are deeply enrooted in and determined by the environment. Obviously, within this work, the local health services also assessed risk factors (like blood cholesterol) and identified persons at high risk to take steps to reduce their risk. The high-risk approach and the population approach support each other, but both theoretical considerations and practical experience show that the population approach applied in Finland is by far the most cost-effective way to influence CVD mortality rates and to promote public health.

The most important component of the successful action in Finland is often asked for. There is no 'magic bullet'. Comprehensive action is needed, using a correct and relevant theoretical frame leading to a practical, flexible intervention. Regarding theory, both correct epidemiological/medical and behavioral/social frameworks are needed. The former means that we must target the strongest risk factors and risk-related behaviors (in North Karelia blood cholesterol and the quality of fat). The latter means that in changing behaviors/lifestyles, relevant frameworks must be observed (in North Karelia aspects of persuasion, teaching practical skills, and providing social and environmental support).

At the same time it is important to notice that a correct theory alone is not enough. There must be enough practical work for the implementation, i.e., the intervention must reach people in many ways in their everyday living conditions. One could argue that currently there are plenty of good strategies and program plans, but the implementation is weak. Thus the 'implementation gap' is one of the main challenges (fig. 8).

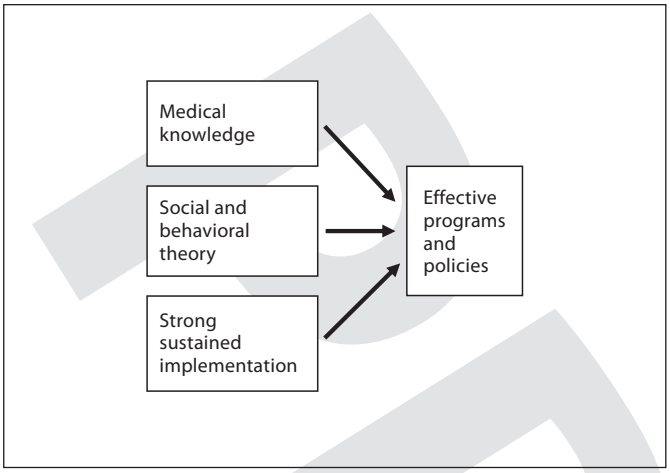

Fig. 8. Theory and action for effective programs and policies.

Briefly, the main elements of the Finnish action (from North Karelia to national actions) can be listed as follows:
- research (domestic and international collaboration)
- health services (especially primary health care)
- North Karelia Project and other demonstration programs
- health promotion programs (coalitions, non-governmental organizations, collaboration with the media)
- schools, educational institutions
- industry, private sector collaboration
- policy decisions, intersectoral collaboration, legislation
- monitoring systems: health behaviors, risk factors, nutrition, diseases, mortality
- international collaboration.

All these have contributed to the success in an interrelated way.

It has also often been asked, what the main factors behind the success in North Karelia are. The following list provides some suggestions of the project team:
- appropriate epidemiological and behavioral framework
- restricted, well-defined targets
- good monitoring of immediate targets (behaviors, processes)
- flexible intervention
- emphasis on changing environment and social norms
- working closely with the community
- positive feedback, work with media
- international collaboration, WHO support
- close interaction with the national health policy/integration with the National Public Health Institute
- long-term, dedicated leadership.

Based on the experiences and results of the work in Finland, presented here briefly and more broadly in the recent summary book [10], we can conclude that the Finnish experience has shown that:
- prevention of CVD is possible and profitable
- population-based prevention is the most cost-effective and sustainable public health approach to CVD control
- prevention calls for simple changes in some lifestyles (individual, family, community, national and global level action)
- influencing diet and especially quality of fat is a key issue
- many results of prevention occur surprisingly quickly (CVD/diabetes) and also at relatively late age
- comprehensive action, broad collaboration with dedicated leadership and strong government policy support.

Conclusion

There is strong medical evidence that CVD (like many other chronic diseases) is preventable or could be delayed to a more advanced age. A population-based prevention campaign is the most cost-effective way and in many cases the only affordable option for major public health improvements. To prevent CVD and to promote heart health, dietary changes are crucial, especially the change in the quality of fat. These changes can have a major impact in relatively short time and can lead to dramatic improvements in public health in the long run.

Disclosure Statement

The authors have no conflicts of interest to declare.

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Summary Statement of the International Expert Meeting: Health Significance of Fat Quality of the Diet

Barcelona, Spain, February 1–2, 2009

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Dietary Recommendations

- The goal of dietary recommendations is to meet nutritional needs and at the same time prevent development of chronic disease and support optimal health and well-being.
- The quantity of fat is an important factor determining energy intake, which should be balanced with energy expenditure, to achieve and maintain healthy weight.
- The quality of fat in the diet is important for normal growth and development, and it has a marked impact on blood cholesterol and the occurrence of coronary heart disease and stroke.
- In line with authoritative international health bodies and current evidence, the following recommendations on the quality of fat in the diet are made for optimal health across the life course worldwide, from an age of about 2 years onwards:
  - Fat may provide up to 30–35% of the daily energy intake;
  - Saturated fat should provide no more than 10% of the daily energy intake;
  - Essential polyunsaturated (omega–6 and omega–3) fats should contribute 6–10% of the daily energy intake;
  - The intake of trans fats should be less than 1% of the daily energy intake;
  - The remainder of the energy from fat can be provided by monounsaturated fats.

Foods

- On a global level, the main sources of saturated fats are fatty dairy products (like butter, ghee, whole milk, cream and fatty cheeses), fatty meats, animal fats (such as lard) and the vegetable fats palm, palm kernel and coconut oil and fatty snacks (e.g. cakes, pastries and fries).
- The main modifiable sources of trans fats are partially hydrogenated oils. Beef, pork, lamb, butter, milk and other milk products have naturally occurring trans fats.
- Important sources of unsaturated fats are: vegetable oils such as soybean oil, rapeseed (canola) oil, sunflower oil, olive oil, fatty fish, fish oil, nuts, seeds and products made from these, e.g. soft margarines and mayonnaise and derived products.
- Many food manufacturers have significantly reduced the content of saturated and trans fats in foods. Efforts

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to further decrease the saturated and trans fat contents in products are needed, where appropriate with a concomitant increase in the proportion of unsaturated fats.
- Substantial benefits can be achieved when simple dietary changes are made like exchanging full-fat dairy products with low-fat choices, fatty meats with lean meats and fish, and the use of vegetable rather than saturated animal fats in food preparation and food products. This will improve the fat composition of the diet and can contribute significantly to reducing the population risk of cardiovascular disease.

Consumer Knowledge and Behavior

- People are generally not aware of the importance of the fat quality of the diet and the sources of different fats. The general focus is on quantity of fat to control weight. Both are reflected in patterns of consumption for most people, which are not in line with current recommendations for optimal health. Dietary surveys indicate that many populations around the world (both in developed and developing countries) consume excess saturated and trans fats and a low proportion of essential polyunsaturated fats.

Call to Action

- People should be advised how to decrease their saturated fat intake and increase the proportion of unsaturated and essential polyunsaturated fats and oils in a practical, sustainable and actionable way in order to be healthy today and tomorrow.
- One of the most effective options is the provision of concrete examples of replacing foods in a diet generally high in saturated and trans fats (e.g. butter, fatty cheeses, fatty meats, products fried in unhealthy fats) with products with lower content of saturated and trans fats, and preferably use of foods high in unsaturated and essential polyunsaturated fats (e.g. sunflower oil, soybean oil, rapeseed oil, olive oil and products made from these such as soft margarines and mayonnaise).
- An additional option is to provide people with important information on the content of food products on pack in a clear, usable, understandable way, including energy content per portion size and fat quality.
- Use simple language when communicating with the public, e.g. good/healthy fats and bad/unhealthy fats, and use consistent, scientific and coherent language when communicating with health experts.
- The food and food service industry should collaborate with health and nutrition experts to ensure appropriate messaging based on current recommendations, to eliminate trans fats, reduce saturated fats and provide accurate information to enable people to make healthier choices.
- Nutrition and health experts should provide consistent evidence-based information supporting public health goals and become nutrition communicators. They also should continue to seek collaboration with the food industry, governments and non-governmental organizations.
- Health care professionals should take responsibility for ensuring that patients receive the right information and support on current dietary recommendations. They should provide their patients with advice on the selection of dietary fats as they do on other preventive actions and if necessary, seek training to be able to provide proper advice or to refer them to nutrition specialists.
- The International Expert Meeting calls on scientists, health care professionals, governments, the food industry, health authorities and media around the world to advocate consistent, simple and effective messages to improve the fat quality of the diet of people everywhere and promote such changes for the prevention of chronic disease and to achieve optimal health.

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