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Foods with a High Fat Quality Are Essential for Healthy Diets

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Key Words

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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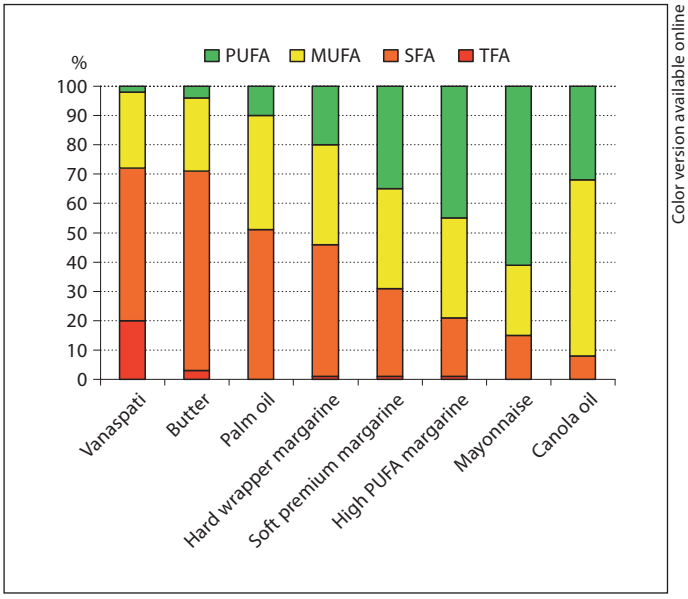

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Fig. 1. Fatty acid composition of common fat-rich products.

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.

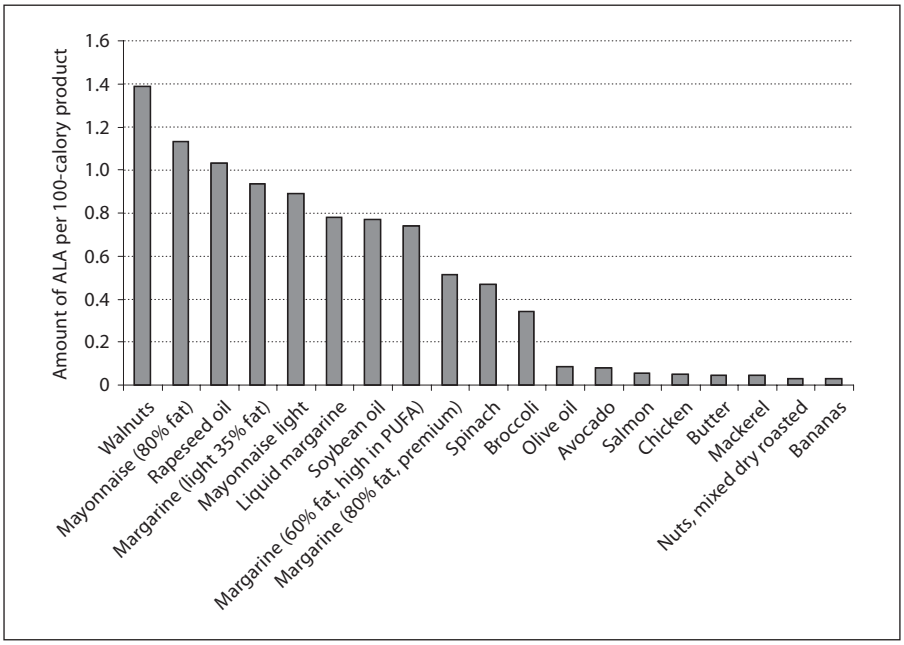


Fig. 2. ALA density for various foods.

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:

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

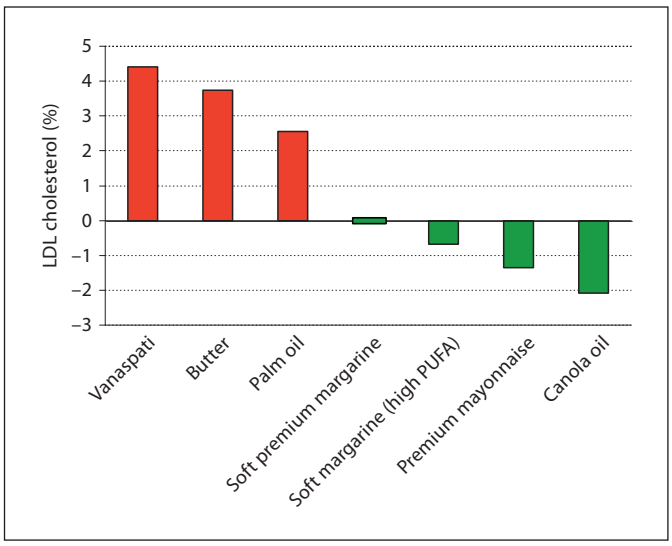
where Δ stands for the change in fat intake in percent of energy (%E).

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].



Color version available online

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.

References

1 WHO: Diet, nutrition and the prevention of chronic diseases. WHO Technical Report Series 916. Geneva, WHO, 2003.
2 Lloyd-Williams F, O'Flaherty M, Mwatsama M, Birt C, Ireland R, Capewell S: Estimating the cardiovascular mortality burden attributable to the European Common Agricultural Policy on dietary saturated fats. Bull World Health Organ 2008;86:535–541A.
3 Lichtenstein AH, et al: Diet and lifestyle recommendations revision 2006: a scientific statement from the American Heart Association Nutrition Committee. Circulation 2006;114:82–96.
4 Shapouri S, Rosen T: Global diet compositions: factors behind the changes and implications of the new trends. Food Security Assessment 2007;GFA-19:28–36.
5 Shetty PS: Nutrition transition in India. Public Health Nutr 2002:5:175–182.
6 FAO: Oilseeds, oils and oilmeals: FAO Food Outlook – No.4, Dec 2005, pp 22–25. http://www.fao.org/docrep/008/j6801e/j6801e08.htm (accessed April 23, 2009).
7 United States Department of Agriculture: Oilseeds: world markets and trade: Circular Series June 2008, FOP 6-08. http://ffas.usda.gov/oilseeds/circular/2008/June/oilseedsfull0608.pdf (accessed April 23, 2009).
8 Jeyarani T, Reddy SY: Physicochemical evaluation of vanaspati marketed in India. J Food Lipids 2005;12:232–242.
9 Bockisch M: Refining; in Bockisch M (ed): Fats and Oils Handbook. Campaign, AOCS Press, 1998, pp 613–718.
10 Flöter E, Bot A: Developing products with modified fats; in Williams C, Buttriss J (eds): Improving the Fat Content of Foods. Boca Raton, CRD Press, 2006, pp 411–427.
11 Bockisch M: Modification of fats and oils; in Bockisch M (ed): Fats and Oils Handbook. Campaign, AOCS Press, 1998, pp 446–612.
12 Korver O, Katan MB: The elimination of trans fats from spreads: how science helped to turn an industry around. Nutr Rev 2006; 64:275–279.
13 Elmadfa I, Kornsteiner M: Dietary fat intake – a global perspective. Ann Nutr Metab 2009;54(suppl 1):8–14.
14 Confederation of the Food and Drink Industries in Europe: CIAA agreed reference values for GDAs. http://gda.ciaa.eu/asp/about_gdas/ciaa_agreed_values.asp (accessed April 23, 2009).
15 Health Council in The Netherlands: Richtlijnen goede voedselkeuze. www.voedingscentrum.nl (accessed March 27, 2009).
16 Paturi M, Tapanainen H, Reinivuo H, Pietinen P (eds): The National FINDIET 2007 Survey. http://www.ktl.fi/attachments/suomi/julkaisut/julkaisusarja_b/2008/2008b23.pdf (accessed April 27, 2009).
17 Holick MF, Chen TC: Vitamin D deficiency: a worldwide problem with health consequences. Am J Clin Nutr 2008;87(suppl): 1080S–1086S.
18 Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults: Executive Summary of the Third Report of the National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III). JAMA 2001;285:2486–2497.
19 Keys A, Anderson JT, Grande F: Prediction of serum cholesterol responses of man to changes in fats in the diet. Lancet 1957;ii: 959.
20 Mensink RP, Zock PL, Kester ADM, Katan MB: Effects of dietary fatty acids and carbohydrates on the ratio of serum total to HDL cholesterol and on serum lipids and apolipoproteins: a meta-analysis of 60 controlled trials. Am J Clin Nutr 2003;77:1146–1155.
21 Allender S, Peto V, Scarborough P, Boxer A, Rayner M: Coronary Heart Disease Statistics. London, British Heart Foundation, 2007.
22 Carroll MD, Lacher DA, Sorlie PD, Cleeman JI, Gordon DJ, Wolz M, et al: Trends in serum lipids and lipoproteins of adults, 1960–2002. JAMA 2005;294:1773–1781.
23 Judd JT, Baer DJ, Clevidence BA, Muesing RA, Chen SC, Weststrate JA, et al: Effects of margarine compared with those of butter on blood lipid profiles related to cardiovascular disease risk factors in normolipemic adults fed controlled diets. Am J Clin Nutr 1998;68: 768–777.
24 Hendriks HFJ, Weststrate JA, van Vliet T, Meijer GW: Spreads enriched with three different levels of vegetable oil sterols and the degree of cholesterol lowering in normocholesterolaemic and mildly hypercholesterolaemic subjects. Eur J Clin Nutr 1999;53:319–327.
25 Cleghorn CL, Skeaff CM, Mann J, Chisholm A: Plant sterol-enriched spread enhances the cholesterol-lowering potential of a fat-reduced diet. Eur J Clin Nutr 2003;57:170–176.
26 Puska P: Fat and heart disease: yes we can make a change – the case of North Karelia (Finland). Ann Nutr Metab 2009;54(suppl 1):33–38.
27 Pietinen P, Vartiainen E, Seppänen R, Aro A, Puska P: Changes in diet in Finland from 1972 to 1992: impact on coronary heart disease risk. Prev Med 1996;25:243–250.
28 Vartiainen E, Puska P, Pekkanen J, Tuomilehto J, Jousilahti P: Changes in risk factors explain changes in mortality from ischaemic heart disease in Finland. Br Med J 1994;309:23–27.