CHEMISTRY AND HEALTH IMPACTS OF TRANS FATTY ACIDS

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ABSTRACT

Fatty acids are the main constituents of oils and fats. They are not synthesized in the human body. Dietary trans fatty acids (TFAs) are derived mainly from hydrogenated vegetable oils. The consumption and utilization of dietary TFAs has been increased due to their preservative effect providing increase of various foods shelf-life. However, excess usage of these TFAs as food by people have shown different health effects such as coronary heart and cardiovascular disease, strokes, blood pressure increase, breast cancer, diabetes, fetuses problems, and obesity. Low Density Lipoprotein (LDL) and High Density Lipoprotein (HDL) cholesterol have also other effects on blood levels. TFAs are a risk factor for the initiation and progression of atherosclerosis. All these effects are due to the chemical and physical properties, as well as to the stereochemical conformational structure of TFA. These properties and chemistry of TFA have been well studied by several analytical techniques. GC, GC-MS, HPLC, ATR-FTIR and UV are among the most versatile one among them. These are very important to identify, determine and quantify the level of TFA found in foods. Therefore, in this review paper the chemistry and health impact of TFAs on the human organism are critically compiled and discussed.

Keywords: trans fatty acids, coronary health disease, cardiovascular disease, GC-MS.

INTRODUCTION

Consumption of foods that have a high amount of trans fatty acid (TFA) have shown health impact on cardiovascular diseases (CVD). Nowadays this situation is a major concern due to its harmful effects on plasma lipoproteins. The studies reveal a correlation between TFA intake and a change in blood lipid profile [1]. Within the body, these TFA tend to enhance the stage of Low-Density Lipoproteins (LDL) called “bad cholesterol” and decrease the stage of High Density Lipoproteins (HDL) called “good cholesterol” [2]. A vast majority of fats contain partly hydrogenated rapeseed oil [3]. The total and LDL cholesterol appear to show a linear increment increase with intake of this TFA. Lipoprotein is also higher on diets high in TFA as compared to other sources of fat. This situation will contribute in boosting of LDL/HDL ratio which is considered as an important marker or pointer of the risk of CVD [4].

While mono or polysaturated fats are significant for heart health reducing CVD, saturated and trans fats in contrast are not good and they aggravate the risk of CVD. Even though the research reveals healthy oils are pertinent for heart disease prevention, it is difficult to avoid “bad fats” altogether [5]. Because this scenario is a critical issue, it makes the Food, Agricultural, and the World Health Organization to suggest the amount of fats for human consumption to be less than 4 % of the total fats in a trans form [6]. The American Heart Association (AHA) also suggests the saturated fat should be below 7 % of total calories [2]. The concentration of most common dietary monounsaturated TFA (with 18 carbon atoms) in the adipose tissue of healthy persons is 0.5 - 2.5 %. In addition, public health experts support such percent limitation in respect to TFA taking and regulation through public policy approaches aiming to
encourage the reduction of TFA consumption [8].

Hence, this review paper generally focuses on the formation of TFA, their chemical and biological properties, the main sources in human diet, their daily intake to prevent diseases encountered by high TFA content, as well as the regulatory approach to control the content of TFAs.

**TRANS FATTY ACIDS (TFA)**

Fatty acids (FA) are important compounds for human health care, in food preparation and lipids synthesis. There are two kinds of FA that differ in their stereo configuration, *cis* and *trans*. They can be found as oil and fat in human diet. The Food and Drug Administration (FDA) defines TFA as unsaturated fatty acids that contain one or more double bond(s) with a *trans* configuration of the hydrogen atoms attached to sp² carbons. Unsaturated FAs whose double bond(s) contain hydrogen atoms attached to sp² carbons in the same configuration are called *cis* FA. A group of TFA that have only one unsaturated bond are called monounsaturated TFA (MUTFA). On the other hand, polyunsaturated TFA (PUTFA) has two or more unsaturated bonds (Table 1) [4, 9].

FAs having no double bonds are called saturated FA (SFA). They are in a solid form. SFA are obtained through hydrogenation. It is a process of hydrogen atoms addition to a mono or polyunsaturated fatty acids. The hydrogenation process converts liquid oils to a semi-solid form which enhances the shelf-life maintaining the corresponding flavor and textural properties [9].

Table 1. Major TFAs and their food source.

<table>
<thead>
<tr>
<th>Major TFAs</th>
<th>Class of TFA</th>
<th>Food source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elaidic acids</td>
<td>18:1, <em>trans</em>-9</td>
<td>Major source in hydrogenated vegetable oils, and processed foods</td>
</tr>
<tr>
<td></td>
<td>18:1, <em>trans</em>-8, 10, 11</td>
<td>Present in varying amounts in hydrogenated oil products and in small amounts of dairy and beef</td>
</tr>
<tr>
<td><em>(E)</em>-octadec-7-enoic acid</td>
<td>18:1, <em>trans</em>-7</td>
<td></td>
</tr>
<tr>
<td><em>(E)</em>-octadec-12-enoic acid</td>
<td>18:1, <em>trans</em>-12</td>
<td>Present in varying amounts in hydrogenated oils</td>
</tr>
<tr>
<td><em>(E)</em>-octadec-13-enoic acid</td>
<td>18:1, <em>trans</em>-13</td>
<td></td>
</tr>
<tr>
<td><em>(E)</em>-octadec-14-enoic acid</td>
<td>18:1, <em>trans</em>-14</td>
<td></td>
</tr>
<tr>
<td><em>(9E,12Z)</em>-octadeca-9,12-dienoic acid</td>
<td>18:2, <em>trans</em>-9, <em>cis</em>-12</td>
<td>Produced in small amounts with hydrogenation of vegetable oils</td>
</tr>
<tr>
<td><em>(9Z,12E)</em>-octadeca-9,12-dienoic acid</td>
<td>18:2, <em>trans</em>-12, <em>cis</em>-9</td>
<td></td>
</tr>
<tr>
<td>Hexadecenoic acid (palmitelaidic)</td>
<td>16:1, <em>trans</em>-9</td>
<td>Present in dairy fats and meats</td>
</tr>
<tr>
<td>Vaccenic acid</td>
<td>18:1, <em>trans</em>-11</td>
<td>Relatively abundant in dairy fats and meats</td>
</tr>
<tr>
<td>Conjugated Linoleic acid</td>
<td>18:2, <em>cis</em>-9, <em>trans</em>-11</td>
<td>Present in greater amounts in dairy fats and meat than in processed foods</td>
</tr>
<tr>
<td></td>
<td>18:2, <em>trans</em>-10, <em>cis</em>-12</td>
<td></td>
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</tbody>
</table>
Sources of TFA

The two most important sources of TFAs are ruminant animal’s products such as milk, beef and lamb meat, technologically processed foods [10]. From the two kinds of sources most of the TFA are obtained from partially hydrogenated vegetable oils, some bakery products, fried and processed foods. Moreover, hydrogenation of vegetable oils is important for the production of margarines. Fast food in most countries still contains unacceptably high levels of industrially processed TFAs. Therefore, the biggest sources of TFA are commercial products like cakes, cookies, pies, breads, margarine and animal products [11].

Level of TFA in foods

Gas–liquid chromatography with long polar capillary columns is used to separate cis and trans isomeric compounds. This technique provides to determine the level of TFA existing in food. The studies carried out show that the percentage of TFA in foods can be ranged between 0 and 34 % (Table 3). The variation of TFA content in different kinds of food implies the differences of fat and oils levels used in the manufacturing or preparation process [13]. Besides, margarine products and baked foods such as cakes, cookies, chips, and muffins are known to contain partially hydrogenated oils in their formulation [14].

The percentage level of total fat, saturated fat, and TFAs of 12 main groups of food products is presented in Fig. 2 in accordance with the description provided by Fu et al. It is evident that margarine, among the products studied, has the highest level of total fat (ca 80 %) and saturated fats (ca 33 %). The sauce examined is the next in the line. However, the highest contents of TFAs are

Table 2. Food groups and the TFA intake contributed to them [12].

<table>
<thead>
<tr>
<th>Food group</th>
<th>Examples of foods contributing to TFA intake (in 2000/1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cereal products</td>
<td>Biscuits (9%), buns, cakes and pastries (retail) (8%) made using partially hydrogenated fats and oils.</td>
</tr>
<tr>
<td>Meat and meat products</td>
<td>Burgers, kebabs, meat pies and pastries. Naturally present in beef and lamb meat at low levels.</td>
</tr>
<tr>
<td>Fat spreads</td>
<td>Butter, margarines and spreads made using partially hydrogenated oils.</td>
</tr>
<tr>
<td>Milk and milk products</td>
<td>Naturally present in milk and milk products at low levels.</td>
</tr>
<tr>
<td>Potatoes and savoury snacks</td>
<td>Chips (retail) (4%), some savoury snacks (1%).</td>
</tr>
</tbody>
</table>
found in wafer and pie products. Both contain TFAs in larger amount than those of the margarine group [14].

**Analytical methods for determination of TFA isomers**

Several analytical methods are reported for TFA determination and quantification in different foods. They are generally used for lipid analysis. Gas chromatography (GC), thin layer chromatography (TLC) impregnated with silver nitrate (Ag-TLC), reversed-phase liquid chromatography (LC) and liquid chromatography impregnated with silver nitrate (Ag-LC) are among them. Lipids detection and determination can be also carried out by infrared spectroscopy (IR), Fourier Transformed infrared (FTIR), flame ionisation detection (FID) and mass spectrometry (MS) [52].

A method for separation, identification and quantification of FAs and TFAs by GC using the combination of lipid extraction and derivatization with a method based on a catalyst and trimethylsilyl-diazomethane (TMS-DM) is developed. This method reveals sensitive and accurate determination of a wide range of different types of FAs including TFA isomers [53]. More recently, another a quick routine analysis is also advanced for quantitative determination of thirteen individual C18 TFA in both pressed and solvent extracted non-hydrogenated edible vegetable oils. It uses GC-MS equipped with HP-88 capillary column. Its application follows the potassium hydroxide/methanol (KOH/MeOH) methylation proceeding [54].

Another research reports the development of a

<table>
<thead>
<tr>
<th>Product</th>
<th>Main isomer</th>
<th>% content of C18:1 isomers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milk products</td>
<td>trans-11 C18:1 vaccenic acid</td>
<td>1.0–6.3</td>
</tr>
<tr>
<td>Beef meat</td>
<td>trans-11 C18:1</td>
<td>1.4–2.4</td>
</tr>
<tr>
<td>light margarine</td>
<td>trans-9 C18:1 elaidic acid</td>
<td>0.1–23</td>
</tr>
<tr>
<td>Hard margarine</td>
<td>trans-9 C18:1</td>
<td>0.1–30.9</td>
</tr>
<tr>
<td>Soups, sauces</td>
<td>trans-9 C18:1</td>
<td>2.3–34</td>
</tr>
<tr>
<td>Sweets</td>
<td>trans-9 C18:1</td>
<td>0.2–15.5</td>
</tr>
</tbody>
</table>

Fig. 2. Comparison of the fat, saturated fat, and total TFA contents in different categories of food products [14].
rapid method to determine TFAs whose content is < 1 % in edible oils (palm, peanut, soybean and sunflower) and oils/fat samples extracted from finished products. It uses Attenuated Total Reflection-Fourier Transform Infrared Spectroscopy (ATR-FTIR). The latter is in good agreement with the GC/FID in case of extracted oils/fat content study [55]. A more recent investigation shows that a new transmission-based FTIR spectroscopy is developed to determine TFA content in edible oils using disposable polyethylene (PE) film as a spectral acquisition accessory. Results are simple and rapid. The method can be effectively used as an alternative to GC and mass spectrometry methods [56].

An alternative method for TFA analysis with direct UV detection using capillary zone electrophoresis (CZE-UV) is proposed. However, the statistical comparison between CZE-UV and the classical GC method does not present significant differences within the 95 % confidence interval [57].

Health impacts of TFA
A high intake of TFA is correlated with non transmissible diseases like coronary heart disease (CHD) and metabolic syndrome. Taking TFA results in LDL increase and HDL decrease as compared to the effect of SFA [15]. The importance of unsaturated FA such as monounsaturated fatty acids (MUFAs) and polyunsaturated fatty acids (PUFAs) refers to the decrease of plasma cholesterol concentrations [16 - 18]. An investigation is carried out aiming to study the effect of TFA on the development of orofacial dyskinesia (OD) and locomotor activity. The results reveal that a long-term intake of TFA causes a small but significant accumulation of TFA in the brain, which favors development of movement disorder [19]. The effect of TFA isomers from ruminant sources is followed on CVD between the ages of 25 and 65 years of a body mass index between 20 and 38 kg/m². The study suggests that ruminant TFA and industrially produced TFA have differential effects on disease risk. Results from a crossover study referring to a high intake of TFA (10.2 g/2500 kcal, 3.7 % energy) show that the effect of ruminant products containing TFA (rTFA) on CVD risk factors is comparable to that of industrially-produced TFA (iTFA) [9]. Moreover, the study is conducted to investigate the accumulation of dietary TFAs in the hippocampus and its effects on the growth and aversion of the spatial memories of young rats. The research reveals that TFAs are incorporated in small amounts in the hippocampus and do not affect aversive memory. However, spatial memory is modified in young rats fed with a diet rich in TFAs. These findings suggest that it is important to consider the provision of essential fatty acids and the ω-6/ω-3 ratio in addition to the TFA content of the diet provided [20].

Cardiovascular Disease
Current dietary guidelines recommend restricting TF intake to reduce cardiovascular risk. Even though industrial TF increase the risk of cardiovascular disease, the effect of natural TF particularly ruminant fats is less clear. The research evidence suggests that natural TF (rTFA) have a different bioactivity and a beneficial effect on cardiovascular health [21]. This is because ruminant animals biohydrogenate the ruminant TFA via bacterial enzymes [20]. But high doses of ruminant TFA, which are not attainable by diet, may have similar effects as industrial TFA. Generally, the consumption of TFA will increase the total cholesterol and decreases HDL cholesterol. This effect is associated with increasing the risk of CVD. Large-scale epidemiological study on TFA suggests that the risk of CVD increases with consuming of TFAs. The experience of different countries shows that the removal of TFA is a cost effective and feasible public health intervention [22].

Blood Pressure Effect
In order to circulate the blood in a smooth and healthy manner, the arteries must be healthy. This is because they transport the blood. Any effect on them affects its flowing. One of the factors that affects this situation is TF. TFA have the capacity to damage the lining of the arteries, which in turn results in their hardening and blood pressure increase [25].

Coronary Heart Disease
As explained above and based on the given reason, TFAs increase the risk of coronary heart disease (CHD) [26]. The rising of CHD will increase LDL-cholesterol and decrease HDL-cholesterol. This implies that CVD will be aggravated if TFA are consumed in high amounts [27, 28]. Epidemiological studies are carried out to scrutinize the association of dietary TFA and CHD. The results recommend reducing the consumption of TFA (from vegetable fats) as it has a strong relation with the risk of CHD [29, 30].
An investigation is undertaken to show the aggravating effects of TFA upon CVD. The result reveal that 2% increase in energy intake through TFA is corroborated with a 23% increase in the incidence of CHD [31]. Moreover, it is predicted that approximately 30,000 premature CHD deaths on an annual basis can be attributed to consumption of TFA [26]. It is concluded that taking TFA and SFA has an effect on CHD. To alleviate these problems, the American Heart Association, governmental and nongovernmental organizations have recommend decrease of dietary SFA and increase of n-6 PUFA [32].

Stroke Effect

The effects of stroke vary from person to person based on the type, severity, location, and number of strokes. The brain is very complex. Each area of the brain is responsible for a special function or ability. When an area of the brain is damaged from a stroke, the loss of normal function of a part of the body may occur. This may result in a disability. The excess intake of TFA exposes human beings to health risks like strokes. According to Stender and Dyerberg [23], TFAs are at least five times more harmful than saturated fats. A recent study of women taking higher amounts of TF shows that it is associated with a greater risk of stroke [24].

Breast cancer effect

Breast cancer is one of the most common diagnosed cancer and it is the leading cause of women mortality around the world [33]. Dietary patterns and food components are considered as main modifiable risk factors connected with the occurrence of breast cancer [34, 35]. Several studies show that dietary macro and micronutrients as well as various food groups including fruits and vegetables, phytochemical-rich foods, dairy and meat products are expected to cause breast cancer [36, 37].

The relationship between the level of TFA in European population adipose tissue as well as its effect on the occurrence of breast cancer, prostate and large intestine is investigated. It is found that there is a correlation between TFA intake and the incidence of those types of cancer [38, 39]. A study referring to the relationship between the incidence of breast-cancer and linoleic acid shows that n-6 fatty acids are not significantly associated with breast, colon or prostate cancer. Breast and colon cancers are not affected by cis-MUFA, but are positively associated with TFA [38].

Advantages of conjugated linoleic acid isomers

In vivo study [58] is performed aiming to identify the effect of purified Conjugated Linoleic Acid (CLA) on tumorigenesis and the growth of tumor cell lines. It shows that the incidence of rat mammary tumors is decreased by c9, t11-CLA and by t10, c12-CLA. These two isomers decrease also the incidence of fore stomach tumors induced by benzo(a)pyrene in mice. Both isomers reduce as well breast and fore stomach tumorigenesis. The c9, t11-CLA isomer does not affect the development of spontaneous tumors of the intestine or mammary gland, whereas t10, c12-CLA increase the development of genetically induced mammary and intestinal tumors. In vitro, t10, c12-CLA inhibit the growth of mammary, colon, colorectal, gastric, prostate, and hepatoma cell lines. The author of this research concludes finally that these two CLA isomers may regulate tumor growth through different mechanisms because they have markedly different effects on lipid metabolism and regulation of oncogenes.

The relationship between the dietary fat intake and cancer has been somewhat controversial. However, the analysis of specific food components such as different fatty acids shows that not all fats of an animal origin are disease promoters. In vitro evidence [59] indicates that long chain n-3 FA inhibit cancer promotion and progression.

Long-chain (n-3) PUFA are predominantly obtained from fish. In vitro analysis reveals that it inhibits the proliferation of breast cancer cells and reduces the initiation and progression of breast tumors in laboratory animals. A further study [60] is carried out to examine whether the intake of these marine fatty acids is associated with an improved prognosis in a cohort of women who have been diagnosed and treated for early stage breast cancer. The results show that women with higher intakes of marine fatty acids have a dose-dependent reduced risk of all-cause mortality. However, it is concluded that marine fatty acids intake from fish oil supplements is not associated with breast cancer outcome.

Diabetes Effect

The effects of TFAs do not refer only to those pointed above. They are also known to affect diabetes. A study [40] on the relation between the consumption of dietary fat and the risk of type-2 diabetes is conducted. This study concludes that the intake of saturated and
monounsaturated fatty acids is not associated with the risk of type-2 diabetes in women. However, while TFA increase, polyunsaturated fatty acids decrease the risk.

**Fetus Effect**

As TFAs have adverse effects, it is important to determine those on pregnancy and fetal development. Generally, it is believed that the inhibited synthesis of polyunsaturated fatty acids in the presence of TFA is one of the factors that determines the birth weight, the duration of pregnancy, and the development of the nervous system during intrauterine life and after birth. Pregnant women who are consuming significant amounts of TFA are at risk [41] of pregnancy-induced hypertension, pre-eclampsia, and insulin resistance.

The partially hydrogenated fats and oils in industry, particularly those used in preparation of baked and processed foods, are widely consumed by women and children. This consumption exposes them to the adverse effects of TFA especially in respect to blood lipids and inflammatory markers in adults. In addition, the high exposure to TFA is consistently related to lower levels of DHA (docosa hexaenoic acid), a fatty acid that is crucial for normal neural development and function. TFA are transported across the placenta and secreted in human milk in amounts that depend on the maternal dietary intake [42].

Existing evidence show that when TF are consumed by pregnant mothers on a daily basis, they will be incorporated in the baby’s brain cells. This situation will alter the behavior and emotional responses. A recent study reveals that in case pregnant mothers are supplemented with TF throughout pregnancy and lactation, the offspring becomes hyperactive. It is also associated [43] with bipolar disorder and psychiatric problems. The intake of TFA by pregnant women causes also oxidative damage in the brain cells of the babies [44]. All studies pointed above conclude that women should eat fish oil during pregnancy and lactation to protect baby’s brain from oxidative damage, memory impairment, emotionality and manic behavior.

**Obesity Effect**

Epidemiologic and ecologic analyses provide a strong evidence that dietary fat plays a role in the development and treatment of obesity. TF are also associated with increasing the risk of obesity. A reduction of fat intake reduces the gap between total energy intake and total energy expenditure. Thus, it is an effective strategy for reducing the present epidemic of obesity worldwide. There must be an increase in energy expenditure to decrease the prevalence of obesity, which in turn means that a reduction in total energy intake or both [45] has to be undertaken.

A more recent study is carried out aiming to outline the relation between TFA consumption and weight gain small increase. The long-term and well-controlled investigation verifies the greater adipogenic effect of TFA than that of cis MUFA. The size of the effect is similar to that reported in studies concerning human behavior [46].

**Nature of TFA and Metabolic Pathways of Dietary Linoleic and α-Linolenic Acids**

Dietary fats are composed of FA and glycerol. Their properties depend on FA composition. The unsaturated fatty acid molecule can exist in cis and trans configuration depending on the arrangement of the two hydrogen atoms. The trans arrangement is favorable for fats to form a packed structure increasing thus their melting and boiling point. The cis arrangement is not favorable to form a packed structure because the hydrocarbons around the double bond would bent the structure so that the compound would exist as a liquid. In general, fats containing saturated fatty acids are solid at room temperature, whereas unsaturated fatty acids are usually liquid at room temperature [13, 47].

TFAs are unsaturated fatty acids that contain at least one double bond in a trans configuration and are formed in the course of the process of converting liquid oils into solid fats such as partial hydrogenation used for margarine production. The process considered increases the shelf life and flavor stability of the fats considered ‘artificially’ or ‘industrially’ produced [48].

Hydrogenated oils have a higher TFA content than oils that do not contain hydrogenated fats. In the partially hydrogenated soybean oil, which is the major source of TFAs worldwide, the main isomer is trans-10 C18:1 [47]. Partial hydrogenation of unsaturated oils will result in the isomerisation of the double bonds, the increase the TFA content and the hardening of the fat. It is shown that foods that contain hydrogenated oils tend to have a higher TFA content than those that do not contain hydrogenated oils [7, 49, 50].

Syntheses of ω-3 and ω-6 polyunsaturated fatty
Acids (PUFAs) are illustrated by Scheme 1. There are two families of essential fatty acids that are metabolized in the body. In animal tissues the desaturation of synthesized saturated fatty acids stops with the formation of n-9 series MUFA. This conversion is performed by Δ9 desaturase, which is a very active desaturase enzyme in mammalian tissues introducing double bonds at the 9-10 position of the fatty acid chain. Oleic acid (18:1Δ9 or 18:1n-9) is the main product. The products of de novo synthesis are esterified with glycerol. In liver the esterified glycerol is included into circulation. In adipose tissue it is stored as lipid droplets. If a low-fat, high carbohydrate diet is eaten consistently the adipose tissue consists mostly of 16:0, 18:0 and 18:1n-9, which are the main products of de novo synthesis. Individuals eating large amounts of LA deposit this fatty acid in the adipose tissue. In the absence of dietary LA and other PUFA, 18:1n-9 is further desaturated and this step is followed immediately by elongation to form the n-9 family of PUFA [51].

**CONCLUSIONS**

The trans configurations have an effect on the functional and physiochemical properties of fatty acids. They affect their metabolism in humans. Trans unsaturated fatty acids are mainly found in processed oils and fats and are rare in nature. These fatty acids are not considered as essential fatty acids and their biological effects are questioned. The major sources of TFA in the diet refer to the commercially produced hydrogenated oils found in many processed foods as they provide these foods with a desirable texture and a longer shelf-life.

The high levels of TFA are a public health concern. Consuming TF increases LDL cholesterol. This effect contributes to the increase of CHD, CVD, obesity, breast cancer, blood pressure, stroke and death. To alleviate those problems, it is desirable to minimize the intake of TFA, which are not indispensable to humans. These led the World Health Organization and any nations governments to recommend reduced intake of trans fat.

The reduction of artificial trans fat intake can be achieved as follows:

- Consumers should cook their food using polyunsaturated or monounsaturated spray oils from canola, sunflower, soybean, olive, sesame and peanut or measure out the oil mentioned with a teaspoon.
- A good way to avoid TA is to eat a balanced diet rich in fruits, vegetables, whole grains, lean sources of protein, and low-fat or fat-free dairy products.
- The nutrition facts label and the ingredient list are to be read. One gas to:
  - Choose products with 0 grams TF;
  - Check the ingredient list to see any partially hydrogenated oil in the product;
  - Look for foods with 5% of the daily value or less;
  - Use the oil that is 100% free of “partially hydrogenated oil” and “shortening”.
- Deep fried foods and fatty take-away foods have to be limited to no more than once a week.
- Fatty snacks such as crisps, cakes, pastries, biscuits and chocolate have to be limited to once a week.
- Lean meat has to be selected. All visible fat has to be trimmed prior cooking.

Even with the emphasis on reducing TFAs, it is important that consumers must focus on the overall

![Scheme 1. Metabolic pathways of conversion of dietary linoleic and α-linolenic acids to their long chain polyunsaturated fatty acids.](image-url)
nutrient quality of their diets by moderating total fat and
 calories and limiting saturated and trans fats. The most
 prudent approach to lowering TFA intake is to choose
 more nutrient dense foods such as fruits, vegetables,
 whole grains, lean protein sources and low-fat dairy
 products, whether eating at home or away from home.

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