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# Impact of trans fatty acids on human health

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**Abstract.** The detrimental impact of trans fatty acids (TFAs) on human health has been extensively studied. This comprehensive review provides a critical analysis of the significant adverse effects of TFAs on human health. Moreover, a comprehensive evaluation of methods to reduce trans fatty acid consumption and enhance public health is provided. The paper emphasizes successful interventions performed at many levels, offering useful insights into viable strategies for tackling the urgent problem of harm caused by TFA. The compilation of evidence emphasizes the pressing need to reduce TFA intake in order to improve human health outcomes. This extensive analysis provides a significant source of information for politicians, healthcare professionals, and individuals who want to understand and tackle the various harmful effects of TFAs on human health. By increasing knowledge and offering scientifically supported suggestions, it enables individuals involved to make well-informed decisions in order to decrease trans fatty acid consumption and protect public well-being.

**Keywords:** Trans fatty acids, cardiovascular health, inflammation, chronic diseases, interventions.

## 1. Introduction

Edible oils are essential components of the human diet, offering functional, nutritional, and sensory benefits to food products. Trans fatty acids (TFAs) have attracted considerable attention from health experts and the public because of their detrimental impact on health [1]. Unsaturated fatty acids exist in two geometric forms: cis and trans. Cis fatty acids are considered beneficial for human health, while trans fatty acids are harmful (Figure 1).

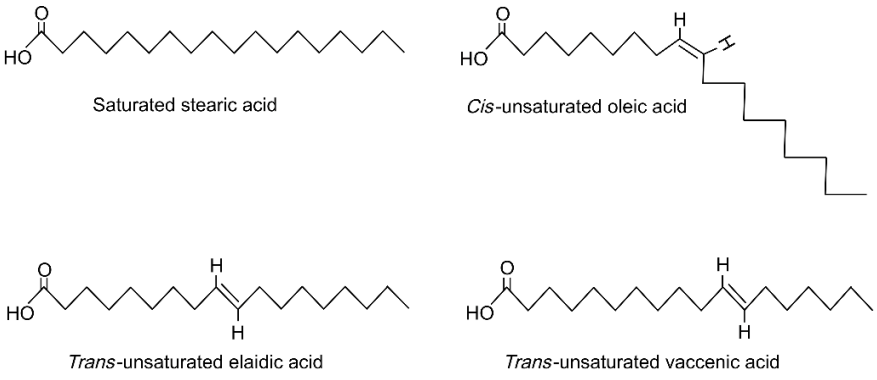


**Figure 1.** Structure of different types of fatty acid [2]

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An abundance of studies has proven that the intake of TFAs has adverse impacts on human well-being, specifically concerning cardiovascular health, inflammation, and chronic illnesses. The following sections of this review will provide a more in-depth analysis of the precise impacts of TFAs on cardiovascular health, inflammation, and chronic illnesses. Additionally, preventive measures to mitigate the risks associated with TFAs will be explored.

## 2. Literature Review

### *2.1. Sources of trans fatty acid*

The sources of trans fats are divided into two main categories: natural and industrial. In terms of Industrial Sources of TFAs, partially hydrogenated oils serve as a significant industrial origin of trans fatty acids [3]. They are frequently employed in food production procedures to prolong shelf life, increase texture, and stabilize flavor. Typical instances encompass margarine, shortening, and some cooking oils. Besides, Deep-fried fast foods like French fries, fried chicken, and doughnuts frequently contain trans fats. Restaurants and fast-food restaurants often utilize partly hydrogenated oils for frying since they are inexpensive and can endure high temperatures. Regarding natural sources of TFAs, it should be noted that Trans fatty acids are present in minimal quantities in the meat and dairy products obtained from ruminant animals such as cows, sheep, and goats [4]. These animals produce trans fats through the biohydrogenation process that occurs in their digestive systems [3].

### *2.2. Health Effects of TFAs*

*2.2.1. Impact on Cardiovascular Health.* There is a clear and significant association between the intake of TFAs and an increased likelihood of developing coronary heart disease (CHD). These fats possess the capacity to elevate levels of low-density lipoprotein (LDL) cholesterol in the bloodstream while concurrently decreasing levels of high-density lipoprotein (HDL) cholesterol. Furthermore, trans fatty acids have been found to promote inflammation and oxidative stress, both of which contribute to the development of atherosclerosis and other cardiovascular conditions.

In an experiment conducted on 6-week-old male LDL receptor-deficient mice, the mice were divided randomly into three groups. One group was fed a diet containing 0.5% cholesterol (Control group, $n = 10$), another group was fed a diet containing 0.5% cholesterol and 5% elaidic acid ($C18:1$, 9-trans) (Trans group, $n = 13$), and a third group was fed a diet containing 0.5% cholesterol and 5% oleic acid ($C18:1$, 9-cis) (Cis group, $n = 12$). After eight weeks of feeding, it was observed that the area of atherosclerotic lesions was significantly larger in the trans group compared to both the control and cis groups [5].

*2.2.2. Influence on Inflammation and Chronic Diseases.* TFAs have been found to influence the development of chronic diseases through various mechanisms. TFAs have been demonstrated to facilitate weight gain and elevate central adiposity, characterized by the buildup of fat in the waist and abdominal region. Such fat distribution is linked to a higher likelihood of obesity [6]. These findings emphasize the impact of TFAs in facilitating weight gain and the accumulation of fat around the abdomen, which contributes to the onset of obesity and associated health hazards. To offset these negative effects on the distribution of fat tissue and overall metabolic health, it is advisable to restrict the intake of TFAs. Furthermore, TFAs have been discovered to interfere with lipid metabolism and have a detrimental effect on insulin sensitivity, resulting in heightened fat accumulation and diminished fat burning. These effects contribute to an increase in body weight and the development of conditions such as obesity, diabetes, and metabolic syndrome.

A study conducted on Wistar rats found that the gastrointestinal apparent absorption rate of a test oil containing TFA was notably reduced when compared to a control oil. The experimental oil led to increased liver weight, hepatic triglyceride content, and serum non-HDL-cholesterol ratio compared to

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the control oil. These findings indicate that consuming TFAs in our diet leads to increased accumulation of body fat and hampers the process of energy metabolism [7].

Third, TFAs have been shown to promote inflammation in the body, which is closely associated with chronic diseases. Chronic inflammation can contribute to insulin resistance, metabolic dysfunction, and increased fat storage. A study comparing different dietary oils in mice showed that a high-palm oil diet resulted in significant inflammation, as indicated by increased IL-6 levels in plasma and higher expression of inflammatory markers in adipose tissue [8]. These findings demonstrate the pro-inflammatory effects of TFAs in various cellular and animal models. The consumption of trans fatty acids can contribute to chronic inflammation, which is implicated in the development of metabolic disorders and cardiovascular diseases. Limiting the intake of TFAs is crucial for mitigating inflammation and preserving general well-being.

*2.2.3. Effect on Reproductive Health.* Consuming TFAs has been linked to adverse impacts on reproductive health. Higher consumption of TFA has been associated with an elevated likelihood of experiencing infertility, hormonal disruptions, and reduced semen quality in males.

Studies have demonstrated that elevated consumption of TFA can have an adverse impact on male fertility, specifically in terms of male reproductive health. TFAs have been linked to a decrease in the number of sperm, a decrease in the ability of sperm to move, and an increase in DNA damage in sperm cells. These consequences can potentially lead to male infertility and disruptions in hormonal equilibrium. A study involved two groups of mature male mice: a control group (CON) and a group fed a high-fat diet (FD) containing trans and saturated fatty acids. The FD group had reduced sperm concentration, total motility, and progressive motility compared to the control group ($p < 0.01$) after being fed the high-fat diet for sixty days [9]. These studies collectively indicate that higher intake of trans-fatty acids is associated with adverse effects on sperm concentration, motility, and fertility rates in both human and animal models. Limiting the consumption of trans fats may be beneficial for male reproductive health.

Furthermore, the effects of TFAs on female reproductive health are not well recognized. Nevertheless, initial investigations indicate that consuming high amounts of TFA could disturb the equilibrium of hormones and perhaps impact the regularity of menstrual cycles and fertility. A study conducted by Sohrabi et al. examined the effects of a high-fat diet (HFD) on female mice. Forty mice were divided into two groups: (a) the CON group, which received a regulated diet, and (b) the HFD group, which received an HFD for a duration of twelve weeks. The researchers performed histological examinations on ovarian sections, counting follicles and corpora lutea. The results showed that an HFD negatively affects in vitro maturation and fertilization rates, oocyte quality, and folliculogenesis in the primordial and Graafian phases [10]. TFAs have been shown to have detrimental effects on reproductive health, impacting both male and potentially female fertility. Raising awareness about the risks associated with TFA consumption and promoting healthier dietary choices can support reproductive health outcomes. Further research is needed to explore the mechanisms and long-term consequences of TFAs on reproductive health.

### *2.3. Strategies for Reducing TFA Consumption*

TFAs have been linked to adverse health effects. Reducing TFA consumption is a crucial public health goal.

*2.3.1. Government Regulations.* Various government and non-government groups worldwide have implemented regulatory efforts to address the detrimental impact of trans fats. In 2003, Denmark implemented stringent legislation that prohibited the utilization of partly hydrogenated oils, a significant contributor to trans fats [1]. In the United States, the FDA implemented laws in the same year that mandated food manufacturers to provide information about the presence of trans fats on product labels [11]. In 2018, the World Health Organization (WHO) launched the “REPLACE” action plan, aiming to eliminate trans fats from the global food industry by 2023. Following the announcement of REPLACE,

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many countries have implemented stringent regulations and guidelines to restrict the availability of trans fats in various food products. Nevertheless, several countries still exhibit a deficiency in implementing stringent laws and regulations concerning the permissible levels of trans fat in processed food products. These regulatory measures exemplify the worldwide dedication to diminishing the intake of trans fats and safeguarding public health. Countries strive to mitigate the hazards linked to trans-fat consumption and encourage healthier dietary choices for their citizens by implementing these steps.

*2.3.2. Industry Initiatives.* Mozaffarian, D., in their research, identified a total of 83 reformulated products between 1993 and 2006 (58 from supermarkets and 25 from restaurants) and between 2008 and 2009. They found that 95% of the supermarket products and 80% of the restaurant products had reduced their trans fat levels to less than 0.5g per serving. On average, there was an absolute reduction of 1.8g per serving in supermarket products and 3.3g per serving in restaurant products. Additionally, 90% of the restaurant items and 65% of the supermarket items either reduced, maintained, or slightly increased their saturated fat content (less than 0.5g per serving) after reformulation. The slight increase in average saturated fat content observed in one-third of the supermarket products was due to minor changes in some food items [12]. These findings suggest a favorable advancement in the reduction of trans fat intake and the modification of dietary products to decrease trans-fat content. Several nations have effectively implemented strategies to lessen the utilization of industrial trans fats in diverse food products, resulting in enhanced public health and diminished hazards linked to trans-fat consumption. Sustained endeavors are imperative to further diminish global trans-fat intake and advocate for healthier dietary choices among populations worldwide.

## 3. Discussion

### *3.1. Trans fatty acids need to be completely eliminated*

Thorough investigation has uncovered that TFAs have harmful impacts on the human body, surpassing any possible advantages. TFAs, once ingested, are difficult to metabolize and have a tendency to build up in the body, resulting in the development of numerous ailments. The legislation targeting the reduction of trans fats in processed food has failed to tackle the underlying cause of the issue. Given the progress made by society, it is imperative to redirect our attention from only preventing the presence of trans fatty acids in processed food to completely eradicating them.

While WHO outlined its plan to achieve trans fat elimination by 2023, progress varies across countries, with some making minimal improvements. According to a recent WHO status report, five billion people worldwide are still exposed to dangerous levels of trans fats, increasing their risk of heart disease and premature death. While 2.8 billion individuals in 43 countries are now protected under best-practice standards, the goal of eliminating trans fats globally by 2023 remains elusive [13]. It is imperative to implement a comprehensive global prohibition on trans fatty acids in order to minimize their detrimental effects on populations globally, hence lessening the healthcare burden on both governments and individuals. This resolute action will ultimately contribute to improved well-being for individuals worldwide.

### *3.2. Eliminate trans fatty acids by optimizing hydrogenation*

The reduction or elimination of TFAs in oils used by the industry presents a challenge due to the need for oils that are easy to transport and have long storage times. However, advancements have been made in developing new hydrogenation processes to address this issue. An investigation was conducted to examine the manufacturing process of low trans-fat margarine utilizing a microwave plasma hydrogenation technique. This method entails the partial hydrogenation of palm olein under conditions of low temperature and low pressure, eliminating the requirement for a catalyst. The optimal conditions encompassed precise hydrogen flow rate, microwave power, temperature, voltage, and reaction time. The iodine value shown a notable decrease, leading to a diminished level of TFA concentration in comparison to conventional catalytic hydrogenation techniques. This eco-friendly method has the

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potential to produce low-TFA margarine without a requirement for catalysts [14]. In another study, heterogeneous catalysts, including palladium and platinum, were investigated for their ability to selectively hydrogenate sunflower oil. The Pd catalysts showed higher activity and selectivity compared to traditional Ni catalysts. The Pt catalyst also exhibited lower levels of trans fatty acids despite being less active than Pd catalysts. By adjusting reaction conditions, such as lowering temperature and increasing pressure, further reductions in trans fat content were achieved. These findings demonstrate the potential of using alternative catalysts to mitigate the harmful effects of TFAs [15]. While these methods have demonstrated feasibility in scientific research, their integration into practical applications and industry has not yet been generally embraced. Nevertheless, advocating and fostering the utilization of these approaches can be a progressive measure in mitigating the adverse impacts of trans fatty acids on human well-being.

### *3.3. Counteracting the harm posed by trans fats through interventions*

TFAs provide difficulties for the body's metabolic processes, and their previous ingestion has resulted in the buildup of trans fats within our bodies, hence heightening the likelihood of developing numerous ailments. Nevertheless, there are several strategies to mitigate the correlated health hazards, like participating in consistent physical activity and consuming specific nutrients. Physical activity has a vital role in reducing the negative consequences of a diet high in fat. An experiment conducted on mice exposed to a diet rich in fats and a routine of physical activity demonstrated favorable results. The combination of physical exercise with a low-fat diet resulted in a decrease in the production of inflammatory markers, an improvement in hepatic steatosis (fatty liver), and a reduction in insulin resistance. The effects of adiposity, hepatic steatosis, and adipose inflammation were reduced much more when exercise was prolonged beyond six weeks [16].

Studies conducted on mice have shown advantageous benefits in the context of vitamin supplementation. The administration of vitamins C and E to mice led to a decrease in blood total cholesterol and triglyceride levels, as well as a reduction in apo B-48-containing lipoproteins. In addition, these vitamins enhanced the structure of HDL particles, heightened antioxidant activity, and decreased the development of atherosclerosis, resulting in a longer lifetime in mice [17]. These therapies offer tactics to mitigate the detrimental impact of trans fats and enhance health outcomes.

## 4. Conclusion

This study thoroughly investigates the adverse impacts of TFAs. A compilation of measures has been outlined to mitigate the detrimental impacts of TFAs and decrease their consumption. The World Health Organization (WHO) has an objective to eliminate TFAs within a period of five years, commencing in 2018. Nevertheless, this purpose remains unfulfilled at present.

The primary aim of this paper is to raise awareness about the dangers of consuming TFAs and improve understanding of their adverse impacts on human health. By disseminating knowledge about the harm associated with TFAs, the study intends to empower individuals to make informed choices and minimize their TFA intake. In addition, the paper provides helpful suggestions on government policies that might have beneficial effects on the market and ensure the well-being of consumers. Regarding limitations, the paper is deficient in extensive analysis of experimental data, which should be further explored in future research.

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