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REVIEW ARTICLE

Trans fats—sources, health risks and alternative approach - A review

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Abstract Trans fatty acids have the presence of one or more double bonds in the trans configuration instead of the usual cis configuration. They are desired by Vanaspati industry as they impart firmness to margarines and plasticity as well as emulsion stability to shortenings. Research has proved the direct connection of trans fatty acids with cardiovascular diseases, breast cancer, shortening of pregnancy period, risks of preeclampsia, disorders of nervous system and vision in infants, colon cancer, diabetes, obesity and allergy. In light of these new findings trans fatty intake should be zero and new technology of hydrogenation of oils is to be developed which produce zero trans fatty acids at the same time preserve the desirable properties contributed by trans fatty acids to the hydrogenated oils. Presently in India there is no system to monitor and regulate the amount of trans fats in processed foods and hence a stringent food law is immediately required.

Keywords Trans fatty acids · Hydrogenation · Interesterification · Trait-enhanced oils · Low density lipoproteins

Introduction

Fat intake excess of 35% of daily calorie requirements are associated with both total increased saturated fat and calorie intakes. Trans fat increases low density lipoproteins (LDL), triglycerides and insulin levels and reduces beneficial high density lipoproteins (HDL). The overall picture of trans fatty acids (TFA) implies a detrimental effect of TFA on health. However, due to the potential isomer specific effects of TFA, a blanket statement cannot be applied to the wide variety of TFA. Processed food industry has an important role in decreasing trans fatty acid content of the food supply by using the alternatives sources of fat with zero TFA level in the processed foods.

All natural fats and oils are a combination of monounsaturated, polyunsaturated and saturated fatty acids. Trans fatty acids (TFAs) are unsaturated fatty acids that contain at least one double bond in the trans configuration (Fig. 1). Trans fatty acids are formed during industrial partial hydrogenation of vegetable oil, a process widely commercialized to produce solid fats. The TFA content of partially hydrogenated vegetable oils (PHVO) depends on the variables of the hydrogenation process i.e. time, catalyst, temperature, and hydrogen pressure; the types and proportions of oils and composition of monounsaturated fatty acids (MUFA) and poly unsaturated fatty acids (PUFA) (Ghafoorunissa 2008).

Sources of trans fatty acids

Dietary fatty acids with trans double bonds come primarily from Industrial sources i.e. by partial hydrogenation of edible oils containing unsaturated fatty acids to saturated fats and secondly from bacterial transformation of unsaturated fatty acids in the rumen of ruminants. Ruminant and industrial fats contain the same TFA isomers, but the proportions differ (Weiland et al. 1999). The primary dietary TFA are vaccenic acid and elaidic acid. Vaccenic acid (18:1, trans-11) is the major ruminant TFA, whereas elaidic acid (18:1, trans-9) is the main TFA isomer in industrial hydrogenation (Mensink 2005; Weiland et al. 1999). The trans fatty acid content of industrially hydrogenated fats varies widely and may account for up to 60% of the fatty acid content, whereas the trans fatty acid content of beef and dairy products is considerably

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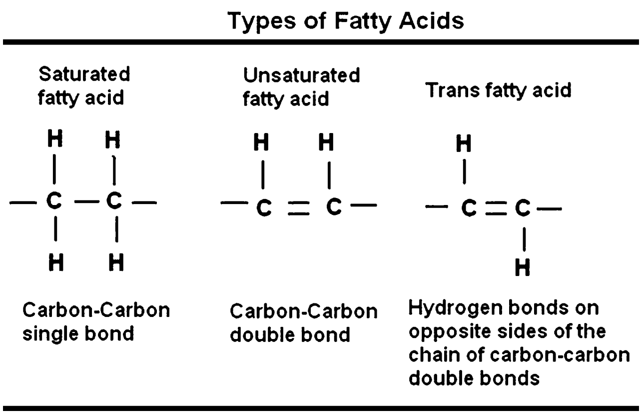

Fig. 1 Types of fatty acids showing trans configuration

lower and accounts for 2%–5% of the fatty acid content (Weggemans et al. 2004). In the case of special dietary choices, this allows for a daily intake of up to 10 times more industrially produced trans fatty acids than trans fatty acids from ruminants. Processed foods and oils provide approximately 80% of trans fats in the diet, compared to 20% that occur naturally in food from animal sources. The dietary intake of trans fats in some countries is depicted in Table 1. The major dietary sources of trans fats are cakes, cookies, crackers, animal products, margarine, fried potatoes, potato chips, popcorn and household shortening (Table 2). Limited consumption of foods made with processed sources of trans fats provides the most effective means of reducing intake of trans fats. To meet the recommended dietary intake for fat i.e. amount corresponding to 20 to 35% of calories, most dietary fats should come from sources of polyunsaturated and monounsaturated fatty acids. Plant sources of polyunsaturated

Table 1 Intake of industrially produced trans-fatty acids in different countries

Country	Ruminant (%)	Industrially produced TFA (%)			Mixed (%)	% Total energy
		Total	Fast foods	Spreads		
Australia	60	24	8–24	16		0.6
NZ	41	46	3–16		13	0.7
Canada	19	81	22	37		2.2
Denmark	50	50				1
US	21	79	–	17		2.6
Europe						0.9
Europe						1–2
UK				18		1.2
Iran						4.2
India[a]						0.9–1.35

[a] Risk Assessment Report on TFAs in Indian Diets submitted by National Institute of Nutrition, Hyderabad in October, 2009

Source: Skeaff 2009

Table 2 Contribution of various foods to trans fat intake in the diet

Food group	Contribution (per cent of total trans fats consumed)
Cakes, cookies, crackers, bread etc.	40
Animal products	21
Margarine	7
Fried potatoes	8
Potato chips, corn chips, popcorn	5
Household shortening	4
Breakfast cereals and candy etc.	5

fatty acids are vegetable oils, including soybean oil, corn oil, canola oil, walnuts, flaxseed and safflower oil. Eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) are omega 3 fatty acids that are contained in fish and shellfish. Plant sources that are rich in monounsaturated fatty acids include canola oil, olive oil, high oleic safflower oil, and sunflower oil and nuts.

Trans fats are not formed during frying process. Tsuzuki (2010) has reported that an ordinary frying process using unhydrogenated oils has little impact on TFAs intake from edible oils. No trans fatty acids were formed in unhydrogenated and hydrogenated soyabean oil during heating at 160, 180 or 200 °C for 24 h, implying that trans fatty acid can only be formed under drastic heating conditions i.e. heating the oil at high temperatures or reusing the oil many times (Liu et al. 2007).

Health risks of trans fatty acids

A low intake of fats and oils (less than amount corresponding to 20% of daily calorie intake) increases the risk of inadequate intakes of vitamin E and of essential fatty acids and may contribute to unfavourable changes in HDL and triglycerides. Following risks are reported to be associated with the intake of trans fatty acids on human health.

Cardiovascular diseases Many years of epidemiological research have shown that populations consuming diets high in saturated fatty acids show relatively high levels of serum cholesterol and carry a high prevalence of coronary heart disease (Caggiula and Mustad 1997; Kromhout and Lezenne 1984; Keys 1980). Based on the evidence of various studies conducted, it is generally accepted that high levels of serum cholesterol, particularly LDL, promote the development of atherosclerosis or coronary heart disease. Mensink and Katan (1990) suggested that trans fats increased LDL and decreased the beneficial HDL resulting in a less desirable LDL/HDL ratio. Invariably, it was established that TFA could be worse than the saturated fatty acids. The concept has become widely accepted that lowering LDL cholesterol by any means will reduce the risk of coronary heart disease (Gould et al. 1998). It has been estimated that dietary TFAs from partially hydrogenated oils may be responsible for 30,000–100,000 premature coronary deaths per year in the United States.

TFA has unique effects on serum lipid levels. Mozaffarian et al. (2006) reported that saturated fat and TFA had similar effects on LDL on a calorie for—calorie basis. However, when compared with either saturated or unsaturated fat, TFA reduced HDL and increased the ratio of total cholesterol to HDL. TFA consumption also increased serum triglyceride and lipoprotein levels and reduced LDL particle size in controlled trials indicating higher risk of coronary heart disease. These adverse effects of trans fatty acids have been confirmed by subsequent metabolic studies (Aro et al. 1997; Judd et al. 1994; Lichtenstein et al. 1999; Zock et al. 1995). Williams et al. (1998) established an association between TFA and incidence of non-fatal myocardial infarction from coronary heart disease. Relative risk for cardiovascular disease was increased by 27% as a result of consumption of TFA (Ascherio et al. 1994). Although it is established that TFAs increase LDL levels and decrease HDL levels (markers of coronary heart disease), little is known about the mechanisms by which TFAs actually work at the cellular level. It is unknown what levels of TFAs are clinically significant and it is not clear how TFAs are associated with cardiac arrhythmias or sudden cardiac arrest. It was hypothesized that TFAs affect membrane structure, thus altering enzymatic pathways that may subsequently induce cardiac arrhythmias and sudden death. Moreover observational studies by Mozaffarian et al. (2009) showed that a higher CHD risk is related to TFA from industrial sources. Because ruminant fat contains low levels of TFA (<6% of fatty acids), the amounts of ruminant TFA consumed are low in most countries studied (generally <1 energy%). Thus, even when the total ruminant fat intake is relatively high, the potential amount of TFA from this source is still quite modest. In the amounts actually consumed, ruminant TFA is not a contributor to CHD risk.

Breast cancer There is conflicting evidence concerning the possible role of TFA in breast cancer. Kohlmeier et al. (1997) investigated the relationship between TFA and postmenopausal breast cancer in European populations differing greatly in their dietary fat intakes. The adipose concentration of TFA showed a positive association with breast cancer, not attributable to differences in age, body mass index, exogenous hormone use, or socio-economic status. These findings suggested an association of adipose stores of TFA with postmenopausal breast cancer in European women, but require confirmation in other populations, with concomitant consideration of the potential roles of dietary saturated and monounsaturated fats.

The analysis of trans and cis fatty acids levels in blood serum of women showed that breast cancer risk increased with the increase in trans fatty acid level, reflecting processed food consumption. It was reported that women with elevated serum levels of trans fatty acid have double the risk of developing breast cancer as compared to women with the lower levels.

Pregnancy Based on results from animal studies, it was previously assumed that trans fatty acids do not cross the placenta, and that the foetus is therefore protected against trans fatty acids (Stender et al. 1994). However more recent studies on humans have shown that trans fatty acids are transferred to the foetus, as they were found in the same levels in the blood of newborn infants as in that of mothers (Berghaus et al. 1998; Elias and Innis 2001). In animal experiments, a high intake of industrially produced trans fatty acids inhibits the formation of long-chain polyunsaturated fatty acids (LCPUFAs) from their precursors (Pax et al. 1992). Theoretically, something similar may apply in humans (Koletzko 1992). LCPUFAs are important for both growth and the development of vision and the central nervous system in foetus. Elias and Innis (2001) showed that trans fatty acid levels including conjugated linoleic acid (CLA) in the umbilical blood of neonates reflected the mother's levels of trans fatty acids in the blood and thus the mother's trans fatty acid intake. The pregnancy period was also found to be shorter in mothers with higher trans fatty acid level in the infant's blood. n-3 fatty acids from fish oils prolonged pregnancy (Olsen et al. 1992) while trans fatty acids appear to shorten it. n-3 fatty acids inhibit the contraction in uterine cells by virtue of an effect on the ion channels of these cells, thus prolonging pregnancy. Trans fatty acids may have the opposite effect. Mother's intake of trans fatty acids is negatively associated with levels of polyunsaturated fatty acids in the blood of newborn infants, it is advisable to minimise the intake of trans fatty acids during pregnancy (Hornstra 2000). Another surprising observation was the finding of an association between a high intake of trans fatty acids and the risk of preeclampsia (pregnancy induced hypertension) (Yli-Jama et al. 2002). In this study, trans fatty acid intake was estimated by the trans fatty acid content of the cell walls of red blood cells. It was noticed that women who developed preeclampsia had approximately 30% higher trans fatty acid levels in red blood cells than women who did not develop this disorder.

Interference with essential fatty acids Essential fatty acids (EFA) are transformed in the body by a series of reactions into long chain polyunsaturated fatty acids essential for development of the nervous system and eyesight (Sugano and Ikeda 1996). TFA compete with EFA for the enzyme systems involved in these reactions. High intakes of TFA have been shown to influence the metabolism of EFA in experimental animals when the EFA intake was low. Deficiency of EFA is found only in abnormal circumstances in human adults. However, new-born infants, and especially if premature, show borderline deficiency in EFA, and their TFA intake from the mother's milk is related to her TFA intake.

Colon cancer Slattery et al. (2001) reported that the men and women above age of 67 years those did not use non steroidal anti-inflammatory drugs (NSAIDs) were at a 50% greater risk of developing colon cancer when they consumed high levels of trans-fatty acids. Women who were estrogen negative i.e. not taking hormone replace therapy after menopause, had a twofold increase in risk from high levels of trans-fatty acids in the diet, while women who were estrogen positive did not experience an increased risk of colon cancer, regardless of level of trans-fatty acids consumed. It has been hypothesized that trans-fatty acids could increase risk of cancer through alteration of immune response, cell wall integrity, and prostaglandin synthesis.

Diabetes Analysis of the Nurses' Health Study after 14 years observation showed that the risk of the development of type-II diabetes was associated with trans fatty acid intake (Salmeron et al. 2001). It was observed that as the intake of industrially produced trans fatty acids in the USA is on average 3% energy, a reduction in trans fatty acid intake of 2% energy could reduce the incidence of type-II diabetes by 40% if the fats containing the trans fatty acids were consumed in their original unhydrogenated form. It was not possible, however, to find such an association in either the Iowa Women Study (Meyer et al. 2001) or the Health Professional's Study (Wahle and James 1993). Studies carried out at National Institute of Nutrition (NIN), Hyderbad, India to evaluate the effects of TFA from vanaspati in rats showed that both saturated fatty acids (SFA) (5 g/100 g,10% energy) and TFA (3% energy) increased insulin resistance (decreased insulin sensitivity). However, the effects of TFA were greater than SFA in increasing insulin resistance. Increasing dietary linoleic acid did not prevented TFA induced increase in insulin resistance; it becomes necessary to reduce the absolute intake of TFA (Ghafoorunissa 2008).

Obesity Research indicates that trans fat may increase weight gain and abdominal fat deposits, despite a similar caloric intake. Industrially produced trans fatty acids and trans fatty acids from ruminants contain calories in the same quantities as other edible fats. A Swedish study indicates that certain conjugated linoleic acid isomers that are present only in very low levels in ruminant fat increase the insulin resistance of men with abdominal obesity (Ricerus et al. 2002). A six year study revealed that monkeys fed on a trans fat diet gained 7.2% of their body weight, as compared to 1.8% for monkeys on a monounsaturated fat diet (Kavanagh et al. 2007).

Allergy The incidence of asthma, allergic cold and asthmatic eczema in children aged 13–14 years was investigated in selected centres around the world (Weiland et al. 1999). A positive association was found between the intake of trans fatty acids and these diseases. Such an association was not observed for the intake of monounsaturated and polyunsaturated fatty acids (Willett et al. 1993).

Alternative approach to trans fats

Increased consumer awareness of the health implications of TFAs, has resulted in local and state efforts to limit or ban their use by restaurants and foodservice establishments. Food manufacturers are using or developing basically four technological options to reduce or eliminate TFA in their products. These options include:

Modification of the hydrogenation process Hydrogenation i.e. saturating some double bonds and converting others to the trans configuration is a common technique to provide firmness and plasticity to shortenings, thus, enabling the production of solid and semi solid fats. Modifying the conditions of hydrogenation (e.g. pressure, temperature, and catalyst) affects the FA composition of the resulting oil, including the amount of TFA formed, and properties such as melting point and solid fat content of the oil. It is possible to make equivalently performing low-trans fats by increasing the degree of hydrogenation, which reduces the level of TFA but increases the level of saturated fatty acids. Modification of the hydrogenation process can be used to prepare low-trans baking shortenings. Low or zero-trans baking fats may have increased levels of stearic acid from the hydrogenation of α-linolenic, linoleic, and oleic acids, and also significant levels of palmitic acid for functionality.

Use of interesterification The interesterification process rearranges the distribution of the fatty acids either chemically or enzymatically within and between the triglycerides thus the fatty acid distribution is altered but the fatty acid composition remains same. Interesterification modifies the melting and crystallization behaviour of the fat, thus producing fats with the desirable physical properties of trans fats but without TFA. One current application of this process is in the production of trans-free or low-trans fats spreads, margarine, and shortening. Several human studies have shown no significant effects of interesterified fats on blood lipid parameters (Hunter 2001; Meijer and Weststrate 1997; Nestel et al. 1995).

Use of fractions high in solids from natural oils Fractions high in solids derived from natural oils, namely coconut, palm, and palm kernel oils, are not new to the food industry and have been components of functional ingredients for years. If fat is melted and cooled slowly to below its melting point, the triglycerides with a higher melting point than the tempering temperature will eventually form crystalline material, which can be relatively easily centrifuged or filtered off from the liquid part. Many commercially available fractions come from palm and palm kernel oils. They can be used successfully either as single fractions or in combination with other fractions to meet specific needs.

Use of trait-enhanced oils Trait-enhanced oils generally fall into three categories: high-oleic acid oils, such as high-oleic sunflower and canola oils, mid-range oleic acid oils, such as mid-oleic sunflower and soybean oils, and low-linolenic acid oils, such as low-linolenic canola and soybean oils. (The term "low linolenic" commonly refers to oil containing about 1–3% α-linolenic acid. Soybean oil typically contains about 7%, and canola oil, about 10% α-linolenic acid.) These types of oils are derived through traditional plant breeding or biotechnological methods. All of these trait-enhanced oils have good oxidative stability making them suitable for frying, spraying, and some bakery applications. These modification techniques offer the chance to minimise and control the trans content of oil blends, and can be used to successfully formulate trans-free hardstocks. However, the combination of these techniques, leads to a greater variety of hardstocks with a wider range of physical properties such as solid fat phase and melting point behaviour.

Recent trends have indicated that many frying fats in the fast-food industry have been replaced by medium- and high-stability vegetable oils, resulting in a virtual elimination of trans fats in products fried in these fats and a significant reduction of saturated fats as well (usually by more than 50%). The possible evolution of these changes is shown in Table 3 (Skeaff 2009).

Analysis of trans fatty acids in food products

There are two official methods for the quantification of trans fatty acid accepted by the American Oil Chemists' Society (AOCS) and the Association of Official Analytical Chemists (AOAC) namely, capillary gas chromatography (GC) and Fourier transform infrared (FTIR) spectroscopy in conjunction with the attenuated total reflectance (ATR) cell. The technique of Fourier transform infrared (FTIR) spectroscopy is capable of the determination of isolated trans-double bonds in commercial fat and oils samples with greater ease and accuracy, since it is no longer necessary to derivatize or to dissolve in solvents prior to the analysis; automation of sample handling and data collection is also possible.

Labelling of trans fat

The Food and Drug Administration (FDA) requires that the Nutrition Facts panel list the amount of trans fat in a serving of food if a serving contains 0.5 g or more of trans fatty acids, this is listed on the line below the listing of saturated fat. For nutrition labeling purposes, trans fats are defined as the sum of all unsaturated fatty acids that contain one or more isolated, non conjugated, double bonds in a trans geometric configuration. Conjugated fatty acids with a trans double bond, including conjugated linoleic acid (commonly known as CLA) isomers, are excluded from this definition of trans fats. There is no Daily Value for trans fat. Instead, the Institute of Medicine recommends we keep our intake of trans fats to as near zero as possible. The World Health Organization (WHO) recommended that governments around the world phase out partially hydrogenated oils if trans-fat labelling alone does not spur significant reductions.

Trans fats in Indian food

Saturated fats were supposed to be the main cause of heart disease over years, but now from various studies it has been observed that trans fats are the main culprits. In India, trans fats are consumed a lot in the form of vanaspati i.e. hydrogenated vegetable oil. Vanaspati is the cheaper source

Table 3 Evolution of deep-frying fats

Time	Type of fat used	Trans	Saturated
Traditional practice	Partially hydrogenated oils	30%–40%	20%
Present	Blends of palm olein, cottonseed, sunflower seed, canola, and so on	Zero	30%–40%
Future	High-oleic forms of sunflower, soybean, canola, and so on	Zero	<20%

Skeaff 2009

of fat and improves taste as well. WHO has recommended that TFA intake as a% of energy should not exceed 1%. The total fat intake as a% of energy should not be less than 15% and should not exceed 30%. The intake of Saturated Fat (SFA) as a% of energy should not exceed 10% (7% for cardiac patients). Food preparations enjoyed frequently by Indian people are prepared in vanaspati thus contributing trans fat in diet (Table 4). Trans fat is also present in sweets, chocolates, spreads, soups, salad dressings and snacks. In rural and urban India the fat consumption is around 20 and 30 g/day, respectively, according to diet studies (National Consumption Survey data by NIN 2009) (FSSA 2010). If 10% TFA is permitted in vanaspati, a person consuming 2,000 Kcal derived from food which contains 20 and 30 g vanaspati/day will derive 0.9 and 1.35% energy from the TFA. (This shows that even at 10% TFA level there is health risk at 30 g of vanaspati consumption per day (which exceeds the 1% energy, which is the limit for TFA recommended by WHO). The trend of eating out in the urban population and consumption of food in hotels and restaurants add to criticality as the food prepared there is very high in trans fats. According to the latest recommendations, trans fat in oil should not exceed 2% of the total fat. However, the laboratory tests conducted by Delhi based Centre for Science and Environment (CSE) found trans fat levels to be as high as 23% in some vanaspati brands liberally consumed in India. Trans fats levels were, however, lower in *desi* ghee, butter and the refined oils. The World Health Organization has predicted that deaths due to circulatory system diseases will double between 1985 and 2015 in India.

To regulate the TFAs in partially hydrogenated vegetable oils, the issue was considered in the Third meeting of the Food Authority held on 26th November, 2009 where it was recommended to fix a limit of not more than 10% trans-fatty acids in partially hydrogenated vegetable oils. It was also recommended that a national consultation may also be organized to obtain feedback from consumers and industry and the scientific community for implementation of the regulation. Hence, National Institute of Nutrition, Hyderabad conducted a national consultation by inviting participants representing all stakeholders on 29.01.2010. Considering the

Table 4 Trans fat in some commonly consumed Indian foods (g/100 g)

Some Indian food	Energy (calories)	Fat (gm)	Total trans fat (gm)	TFA as fat%	TFA en%
Common Indian sweets					
Barfi (Heat dried milk, ghee and sugar)	409.0	19.7	8.4	42.5	18.4
Sweet biscuits	349.0	10.2	4.8	47.1	12.4
Butter biscuits	482.0	17.3	0.0	0.0	0.0
Plain cake	492.0	27.7	0.0	0.0	0.0
Pinni (roasted flour, heat dried milk, sugar and ghee)	492.0	17.4	0.3	1.9	0.6
Gulab-jamun (deep-fried heat dried milk in sugar syrup)	387.0	11.4	6.1	53.0	14.1
Halwa (fried flour, sugar syrup, ghee and nuts)	263.0	12.3	6.3	51.3	21.6
Jalebi (fried fermented flour, in sugar syrup)	494.0	34.8	17.7	50.8	32.2
Churi (roasted flour mashed with ghee, powered sugar and nuts)	454.0	22.6	0.4	1.9	0.9
Kheer (creamy rice pudding)	141.0	7.7	0.0	0.0	0.0
Shakarpara (fried flour with shortening, dipped in sugar syrup)	403.0	6.9	3.1	45.4	7.0
Indian snacks/savories					
Indian bread (leavened baked flour)	275.0	5.0	1.9	38.0	6.2
Potato kachori (deep-fried pastry filled with potatoes)	603.0	10.5	5.6	53.0	30.3
Chewra (deep-fried flaked rice, sugar and nuts)	420.0	25.9	10.6	41.0	22.7
Paapri (deep-fried white flour with shortening)	444.0	19.5	10.2	52.2	20.6
Plain khichri (steamed cooked rice pulse and ghee)	168	7.4	4.0	54.1	21.4
Vegetable biryani (rice, ghee, meat, fish or vegetable)	148.0	6.0	3.1	51.7	18.9
Mathri (fried flour with shortenings, rolled flat)	495.0	30.8	16.3	53.0	29.7
Samosa (a triangular deep-fried pastry containing vegetable or meat)	256.0	13.0	3.3	25.4	11.6
Potato puri (deep-fried unleavened wheat bread filled with potato)	247.0	9.5	4.8	50.9	17.6

Aggarwal et al. 2008

recommendations of the national consultation meet FSSAI has proposed the following the following with regard to TFA limits:-

- The TFA level in PHVO should be below 10% and brought down to 5% in 3 years. A phasing in period may be given to industry after the date of notification.
- Existing melting point regulation which is 31°–41 °C for partially hydrogenated vegetable oils, bakery shortening and margarines, interesterified vegetable fat and other fats made using vegetable oils be raised only to the extent that would facilitate bringing down the TFA level to the above limits.
- There is need to look into the feasibility for laying down the limits of Saturated Fatty Acids (SFA) in vanaspati and other fats. This is being thought of because if the melting point is raised, it will lead to increase in saturation of partially hydrogenated vegetable oils. WHO had recommended that not more than 1% and not more than 10% of energy in diet be derived from TFAs and SFAs, respectively.
- Palm Stearin content may be permitted only in interesterified fat and not approved for blending of oils or to be used as such.
- There should be mandatory labelling of TFA & SFA content on vanaspati packs, edible oils or any other product containing TFA from vanaspati sources.
- Enzymatic esterification for production of vanaspati for regulating trans fatty acids can be considered. But it being a costly alternative, may take time for implementation.
- There is currently a limit on blending of more than two oils and a minimum requirement of 20% for each oil used for blending. These limits have been imposed to facilitate detection of adulteration. There is a demand for reviewing this restriction to facilitate greater use of other oils by industry and facilitate balance in SFA : MUFA : PUFA components.

Conclusions

Trans fatty acids have several beneficial aspects for processed foods owing to their characteristic structures. These very characteristic structures, in turn, have been suspected to be associated with the possibility that trans fatty acids affect the development of several health problems, including coronary heart disease, and foetal and infant neurodevelopment and growth, and childhood allergies etc. There is considerable interest in zero- and low-trans fats among food manufacturers, and current use of such products is increasing. But banning all TFA from the diet would be detrimental as this would include banning trans fats that could be positive for health, such as vaccenic acid. Ruminant animal products, such as meat and dairy are rich in essential nutrients, such as protein, calcium, and iron, which are difficult to obtain from plants or other sources. To ban these foods would have detrimental effects on the population at large, with the most potentially serious ramifications for infants, who require a variety of fatty acids for growth and development. Four independent strategies are needed to limit trans fat intake i.e. health care providers should advise their patients about how to minimize the intake of trans fats. Consumers should learn to recognize and avoid products containing trans fats. Restaurants and food manufacturers should use alternative fats in food production and preparation and local, state, and national government agencies should aid these efforts by enforcing legislation that limit trans fat use. These steps should help reduce the consumption of trans fatty acids, likely resulting in substantial health benefits. In addition, development of new TFA free products requires more research to determine the health-related effects, as it would be impractical to replace TFA with products that may be just as detrimental, or even worse.

References

Aggarwal A, Gupta R, Varma K, Mathur B (2008) High trans fatty acid content in common Indian fast foods. Nutr Food Sci 38(6):564–569

Aro A, Jauhiainen M, Partanen R, Salminen I, Mutanen M (1997) Stearic acid, trans fatty acids, and dairy fat: effects on serum and lipoprotein lipids, apolipoproteins, lipoprotein (a), and lipid transfer proteins in health subjects. Am J Clin Nutr 65:1419–1426

Ascherio A, Hennekens CH, Buring JE, Master C, Stampfer MJ, Willett WC (1994) Trans fatty acid intake and risk of myocardial infarction. Circulation 89:94–101

Berghaus TM, Demmelmair H, Koletzko B (1998) Fatty acid composition of lipid classes in maternal and cord Plasma at birth. Eur J Pediatr 157:763–768

Caggiula AW, Mustad VA (1997) Effects of dietary fat and fatty acids on coronary artery disease risk and total and lipoprotein cholesterol concentrations: epidemiologic studies. Am J Clin Nutr 65:1597S–1610S

Elias SL, Innis SM (2001) Infant plasma trans, n-6, and n-3 fatty acids and conjugated linoleic acids are related to maternal plasma fatty acids, length of gestation, and birth weight and length. Am J Clin Nutr 73:807–814

FSSA (2010) Food Safety and Standards Authority of India Proposes Regulation of Trans Fatty Acids (TFAs) in Partially Hydrogenated Vegetable Oils (PHVOs) http://www.fssai.gov.in/Website/LinkClick.aspx?fileticket=SvU1nfLZRrc%3D&tabid=94. Accessed 10 November 2010

Ghafoorunissa G (2008) Role of trans fatty acids in health and challenges to their reduction in Indian foods. Asia Pac J Clin Nutr 17:212–215

Gould AL, Rossouw JE, Santanello NC, Heyse FJ, Furberg CD (1998) Cholesterol reduction yields clinical benefit: impact of stain trials. Circulation 97:946–952

Hornstra G (2000) Essential fatty acids in mothers and their neonates. Am J Clin Nutr 71:1262S–1269S

Hunter JE (2001) Studies on effects of dietary fatty acids as related to their position on triglycerides. Lipids 36:655–668

Judd JT, Clevidence BA, Muesing RA, Wittes J, Sunkin ME, Podczasy JJ (1994) Dietary trans fatty acids: effects of plasma lipids and lipoproteins on healthy men and women. Am J Clin Nutr 59:861–868

Kavanagh K, Jones KL, Sawyer J, Kelley K, Carr JJ, Wagner JD, Rudel LL (2007) Trans fat diet induces abdominal obesity and changes in insulin sensitivity in monkeys. Obes Res 15:1675–1684

Keys A (1980) Coronary heart disease, serum cholesterol, and the diet. Acta Med Scand 207:153–160

Kohlmeier L, Simonsen N, Van't Veer P et al (1997) Adipose tissue trans fatty acids and breast cancer in the European community multicenter study on antioxidants, myocardial infarction, and breast cancer. Cancer Epidemiol Biomark Prev 6(9):705–710

Koletzko B (1992) Trans fatty acids may impair biosynthesis of long-chain polyunsaturates and growth in man. Acta Paediatr 81:302–306

Kromhout D, Lezenne CC (1984) Diet, prevalence and 10-year mortality from coronary heart disease in 871 middle-aged men Zutphen Study. Am J Epidemiol 119:733–741

Lichtenstein AH, Ausman LM, Jalbert SM, Schaefer EJ (1999) Effects of different forms of dietary hydrogenated fats on serum lipoprotein cholesterol levels. N Engl J Med 340:1933–1940

Liu WH, Stephen Inbaraj B, Chen BH (2007) Analysis and formation of trans fatty acids in hydrogenated soyabean oil during heating. Food Chem 104(4):1740–1749

Meijer GW, Weststrate JA (1997) Interesterification of fats in margarine: effect on blood lipids, blood enzymes, and hemostasis parameters. Eur J Clin Nutr 51:527–534

Mensink RP (2005) Metabolic and health effects of isomeric fatty acids. Curr Opin Lipidol 16:27–30

Mensink RP, Katan MB (1990) Effect of dietary trans fatty acids on high-density and low density lipoprotein cholesterol levels in healthy subjects. N Engl J Med 323:439–445

Meyer KA, Kushi LH, Jacobs DR, Folsom AR (2001) Dietary fat and incidence of type II diabetes in older Iowa women. Diabetes Care 24:1528–1535

Mozaffarian D, Katan MB, Ascherio A, Stampfer MJ, Willett WC (2006) Trans fatty acids and cardiovascular disease. N Engl J Med 354:1601–1613

Mozaffarian D, Aro A, Willett WC (2009) Health effects of trans-fatty acids: experimental and observational evidence. Eur J Clin Nutr 63(2):S5–S21

Nestel PJ, Noakes M, Belling GB, McArthur R, Clifton PM (1995) Effect on plasma lipids of interesterifying a mix of edible oils. Am J Clin Nutr 62:950–955

Olsen SF, Sørensen JD, Secher NJ, Hedegaard M, Henriksen TB, Hansen HS, Grant A (1992) Randomised controlled trial of effect of fish-oil supplementation on pregnancy duration. Lancet 339:1003–1007

Pax J, Douglass L, Sampugna J (1992) Effects of linolenic and trans-fattyadics on neonatal survival of C57BL/6 Mice. J Nutr Biochem 3(7):342–348

Ricerus U, Arner P, Brismar K, Vessby B (2002) Treatment with dietary trans10- cis12 conjugated linoleic acid causes isomer-specific insulin resistance in obese men with the metabolic syndrome. Diabetes Care 25:1516–1521

Salmeron J, Hu FB, Manson JE, Stampfer MJ, Colditz GA, Rimm EB, Willett WC (2001) Dietary fat intake and risk of type II diabetes in women. Am J Clin Nutr 73:1019–1026

Skeaff CM (2009) Feasibility of recommending certain replacement or alternative fats. Eur J Clin Nutr 63:S34–S49

Slattery ML, Benson J, Ma KN, Schaffer D, Potter JD (2001) Trans-fatty acids and colon cancer. Nutr Cancer 39(2):170–175

Stender S, Dyerberg J, Hølmer G, Ovesen L, Sandström B (1994) Transfedtsyrers betydning for sundheden. A report from the Danish Nutrition Council. Publ No. 2. Copenhagen 1994

Sugano M, Ikeda I (1996) Metabolic interactions between essential and trans-fatty acids. Curr Opin Lipidol 7:38–42

Tsuzuki W (2010) Cis–trans isomerization of carbon double bonds in monounsaturated triacylglycerols via generation of free radicals. Chem Phys Lipids 163:741–745

Wahle KWJ, James WPT (1993) Isomeric fatty acids and human health. Eur J Clin Nutr 47:828–839

Weggemans RM, Rudrum M, Trautwein EA (2004) Intake of ruminant versus industrial trans fatty acids and risk of coronary heart disease—what is the evidence? Eur J Lipid Sci Technol 106:390–397

Weiland SK, von Mutius E, Hüsing A, Asher MI (1999) On behalf of the ISAAC Steering Committee. Intake of trans fatty acids and prevalence of childhood asthma and allergies in Europe. Lancet 353:2040–2041

Willett WC, Stampfer MJ, Manson JE, Colditz GA, Speizer FE, Rosner BA, Sampson LA, Hennekens CH (1993) Intake of trans fatty acids and risk of coronary heart disease among women. Lancet 341:581–585

Williams MA, King IB, Sorensen TK, Zingheim RW, Troyer BL, Zebelman AM, Luthy DA (1998) Risk of preeclampsia in relation to elaidic acid (Trans Fatty Acid) in maternal erythrocytes. Gynecol Obstet Investig 46:84–87

Yli-Jama P, Meyer HE, Ringstad J, Pedersen JI (2002) Serum free fatty acid pattern and risk of myocardial infarction: a case-control study. J Intern Med 251:19–28

Zock PL, Vries JHM, Fouw NJ, Katan MB (1995) Positional distribution of fatty acids in dietary triglycerides: effects on fasting blood lipoprotein concentrations in humans. Am J Clin Nutr 61:48–55