Chapter

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Transfatty Acids and Cardiovascular Disease

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INTRODUCTION

"Man is a product of nature and nurture"

The dietary fat available from different fats and oils in foods is digested, metabolised and absorbed variably in the body. In nature, both dietary fat as well as the lipids in the body are made up of basic units called fatty acids. These fatty acids are usually long chain chemical compounds made up of hydrogen and carbon and their chemical make up determines their ultimate fate and function in the body. There are specific enzymes in the body which synthesize and break down these fatty acids and this releases energy to perform the different functions of the human body.

The fatty acids can be classified as:

1. Saturated fatty acids (SFA) that increase the LDL cholesterol thereby increasing the risk of coronary heart disease (CHD).
2. Unsaturated fatty acids which are of two types:
   a. Polyunsaturated fatty acids (PUFA).
   b. Monounsaturated fatty acids (MUFA).

   PUFAs can be further classified as – Linoleic acid (n 6) and alpha-Linolenic acid (n 3).

   Linoleic acid or n 6 (also known was Omega 6) reduces LDL only upto 12% of energy after which it starts reducing HDL. Alpha linolenic acid or n 3 (also known as omega 3) reduces Triglycerides (TGs). MUFAs which when substituted for SFAs, reduce LDL with no increases in VLDL and reduce TGs and also give a good glycemic control in a diabetic.
3. Transfatty Acids increase LDL, reduce HDL and are most atherogenic and hence increase the risk of CHD more than SFAs[1].

Table 1: Fatty acid recommendations in diet

Total fat	*15-30% of energy*
SFA	< 10% and < 7% with elevated lipids
PUFA	< 10% (n6: n3 ratio 5-10)
MUFA	12-15%
Cholesterol	<300 mgm

The ideal ratio of n 6 and n 3 should be between 5 and 10 to achieve the beneficial results and therefore it is essential that mixed oil strategy in the diet be used[2]. It is not feasible to acquire oil that fulfills all the above mentioned requisites. The fatty acid recommendations in the diet are in Table 1.

What are Transfatty Acids?

Since it was known that the SFAs found in high levels in the coconut oil, palm oil, butter, lard that are used for cocking the commercial foods by the manufacturers, increase the LDL cholesterol leading to atherosclerosis, the manufacturers started to use healthier vegetable oils in their food production. A the liquid vegetable oils are not stable to heat and can go rancid easily, scientists began to partially "hydrogenate" liquid oils so that they can withstand the food production process better and provide a better shelf-life and desirable taste, shape and texture. As a result of this partial hydrogenation, trans fatty acids (or trans fat) are formed. Fully hydrogenated oil does not contain transfatty acids; it contains more SFAs (mainly stearic acid).

The majority of transfat can be found in shortenings, stick (or hard) margarine, cookies, crackers, snack food, fried foods (including fried fast foods), doughnuts, pasteries, baked goods and other processed foods made

Table 2: Fats in different types of foods

SFA-rich	*MUFA-rich*	*PUFA-rich*	*Transfatty rich*
Animals foods	*Plant oil*	*Plant oils*	*Transfatty rich*
• Beef	• Canola oil	• Cotton seed oil	• Vanaspati
• Lamb	• Olive oil	• Canola	• Ghee
• Pork. lard	• Groundnut oil	• Sunflower	• Butter
• Poultry fat	• Sesame oil	• Safflower	• Margarine (Stick)
• Egg yolk	• Rice bran oil	• Soyabean	• Whole milk
• Butter	• Palm oil	• Sesame	• Beef meat
• Cream		• Rice bran oil	• Hydrogenerated fish oil
• Milk (whole)		• Fish oils	• Common Commercial
• Cheese		• Legumes	• α packaged foods
• Ghee		• Pulses	• Fried, Fast foods
• Plants:		• Fenugreek seeds	
• Coconut oil		• Green leafy vegetable	
• Palm oil			
• Palm kernel oil			
• Cocoa butter			

with or fried in hydrogenated oils (Vanaspati). Transfat is also found in beef meat and dairy products like butter, whole milk, cream and ghee (See Table 2).

Most packaged foods and snacks such as microwaved popcorn and commercially fried foods such as French fries are rich in transfat. Frozen pastry, cake, pizza, etc. are other foods rich in transfat.

Foods high in SFAs include fatty beef, ghee, cream, milk, cheese and other dairy products made from whole milk. Foods from plants high in SFAs include coconut oil, palm oil, and Cocoa butter and vanaspati. The animal foods are also rich in dietary cholesterol.

PUFAs are found primarily in oils from plants including safflower, sunflower, sesame, corn and soyabean, many nuts as well as fish oils (fatty fish).

MUFAs are found mainly in canola, olive oil, ground nut, Mustard oil and in rice bran oil.

CHEMICAL NATURE OF CIS AND TRANSFATTY ACIDS

Transfatty acids contain at least one double bond in the transconfiguration. The carbon/carbon double bonds of fatty acids can exist in either the Cis or trans configuration. When the two hydrogen atoms are on the same side of the double bond, the configuration is termed Cis., when the two hydrogen atoms are on the opposite sides of the double bond, the configuration is termed trans. Lack of rotational mobility precludes interconversion of configurations under normal circumstances. The bond angle is larger for a trans than Cis double bond. Therefore, the presence of a trans relative to Cis double bond results in acyl chains that can pack together more tightly[3].

Trans double bonds occur in nature as such. They are the result of anaerobic bacterial fermentation in ruminant animals and are thereby introduced into the food chain. Humans cossume them in the form of meat and dairy products. Trans double bonds are also formed during the hydrogenation of either vegetable or fish oils which increases their plasticity and chemical stability, hence their potential use in foods. It is important to note that hydrogenation results in a number of changes in the acyl chain of the fatty acid moiety, all of which can have impact on physiological parameters: conversion of Cis to trans double bonds, saturation of double bonds and migration of double bonds along the acyl chain resulting in multiple positional isomers.

HEALTH EFFECTS OF TRANSFATS

Concerns have been raised that the consumption of transfatty acids might have contributed to the 20th century epidemic of (CHD). Metabolic studies have shown that trans fats have adverse effects on blood lipid levels they increase the LDL cholesterol while decreasing HDL cholesterol. The combined effect on the ratio of LDL, HDL cholesterol is double that of SFAs.

Transfats have also been associated with an increased risk of CHD in epidermiological studies. Based on the available metabolic studies, it is estimated that approximately 30,000 premature CHD deaths annually could be attributable to consumption of transfatty acids. Two independent methods of estimation, based on metabolic as well as epidermiological studies indicate that the adverse effect of transfat is stronger than that of saturated fat. By a very conservative estimate in US, replacement of partially hydrogenated fat in diet with natural unhydrogenated vegetable oils would prevent approximately 30,000 premature coronary deaths per year and this number could be far higher.

EFFECTS OF TRANSFAT ON LIPID AND CHD RISK

Substantial evidence from RCTs indicates that transfatty acids raise LDL cholesterol levels to a similar degree as SFAs. These studies also show that when transfatty acids are substituted for SFAs, HDL cholesterol levels are lower with a dose response effect observed. Recent data show that the use of liquid vegetable oils results in the most favorable total and LDL cholesterol levels and ratios of total cholesterol to HDL cholesterol whereas the use of butter or margarine (stick) results in the worst lipid levels. In addition, evidence from some epidermiological cohort studies suggests that higher intake of transfatty acids are associated with higher risk of CHD. Whether this association is due to adverse effects of transfatty acids on lipoproteins, to other adverse actions or to confounding variables is uncertain[1,3,4].

Overall, transfatty acids increase LDL cholesterol similarly to SFAs but unlike SFAs they also decrease HDL cholesterol. As a result, the net effect of trans fat on LDL / HDL cholesterol ratio is double that of SFAs, according to several studies that allowed a direct comparison of transfat and saturated fat[3,6].

In addition to the increasing the LDL / HDL cholesterol ratio, transfatty acids increase lipoprotein (a)- Lp (a)- when substituted for SFs as shown in the majority of trials[3,5]. High blood levels of Lp (a) have been associated with increased risk of CHD, independently or LDL of HDL cholesterol concentrations. However, diet induced modification in Lp (a) concentrations are modest relative to the genetic differences and their quantitative impact on risk of CHD remains to be established.

Another effect of transfatty acids on blood lipids is that on fasting triglyceride (Tg) levels. In several recent studies that directly compared transfatty acids with Cis unsaturated fatty acids, the Tg-raising effect was consistently observed.

However the relation between triglycerides and the risk of CHD is still uncertain and therefore the resulting benefit is modest even if the transfatty acids are eliminated from the diet to lower the Tg levels.

Potential effects of transfat on LDL oxidation[3] and coagulation have also been investigated but sofar there is no conclusive evidence of adverse effects.

EPIDEMIOLOGICAL STUDIES

One of the most influential studies on diet and CHD was the work of keys[7] who related the in a device of heart disease in 16 defined populations in seven countries to their intake of fat and cholesterol. Subsequent investigations have shown that whereas SF intake was strongly correlated to CHD mortality, and a similar positive correlation was found between CHD mortality and transfat intake[6].

The strongest epidemiological evidence relating to intake of transfatty acids and the risk of CHD comes from 3 large cohort studies: Health professionals follow-up study. (HPFS)[8], The Alpha – Tocopherol Beta – Carotene study (ATBC)[9] and the Nurses Health study (NHS)[10]. In these studies the transfat consumption was assessed using detailed food frequency questionnaire (FFQ). The relative risk of CHD for a 2% increase in transfatty acids intake was 1.36 in HPFS, 1.14 in ATBC and 1.93 in NHS. In all these cohorts, the relatives risks were considerably higher than those for saturated fat. In the Framingham Cohort also a positive relation between margarine intake and the risk of CHD was reported[11].

Cross-sectional or case control studies have shown a strong and significant positive association between trans fat intake and risk of acute myocardial infarction (MI) in several studies[12]. However in the large EURAMIC study[13] which included 671 men with acute MI in eight European countries, the overall analysis revealed no association between transfat intake and the risk of acute MI. Interpretation of EURAMIC results has been controversial for various reasons and hence did not provide a strong evidence against the hypothesis that transfatty acids increase the risk of CHD.

In summary, prospective studies provide strong evidence that transfatty acid consumption increases substantially the risk of CHD. In a recent updated analysis of the transfat-heart disease link, Harvard School of Public Health researchers have found that removing transfat from the industrial food supply could

prevent tens of thousands of heart attacks and cardiac deaths each year in the U.S[14].

QUANTITATIVE ESTIMATES OF RISK

Independent estimates of the effects of transfat can be obtained by combining the effects of transfat on blood lipids and the relationship between the lipids and CHD risk or from the results of cohort studies. Metabolic studies have shown that the adverse effects of transfatty acids are entirely mediated by their effects on blood levels of LDL and HDL. Epidemiological studies suggest that the increase in the risk of CHD caused by transfat is higher than that predicted by effects on blood lipids alone. Ignoring this possibility could cause a substantial under estimation of the adverse effects of transfat.

Data on individual fatty acids suggest an association between risk of CHD and 16:1 trans which comes to a great extent from animal sources and not 18:1 trans which comes to a great extent from hydrogenated fat. There conflicting data have added confusion to draw any definite conclusion at this time[15].

NCEP ATP III evidence statement summarises that the transfatty acids raise serum LDL cholesterol levels (evidence level A2) and that through this mechanism higher intake of transfatty acids should increase the risk of CHD[1]. Prospective studies support an association between higher intakes of transfatty acids and CHD incidence (level C2). However, transfatty acids are not classified as SFAs, nor are they included in the quantitative recommendations for SFA intake of < 7% of calories of therapeutic lifestyle changes. Therefore, the recommendation by NCEPATP III is that the intake of transfatty acids should be kept low at the use of liquid vegetable oil, soft margarine and transfatty acids – free margarine are encouraged instead of butter, stick margarine and shortenings and fast foods like French fries cookies, etc.

SUMMARY AND CONCLUSION

Five years ago evidence was strong that transfat had deleterious impacts on blood lipids. Ensuing studies have confirmed these metabolic findings and strengthened epidemiological support for an important adverse link on the risk of CHD. Because partially hydrogenated fats can be eliminated from the food supply by changes in processing that do not require major efforts in education and behavioral modification, these changes would be an extremely efficient and rapid method for substantially reducing the rates of CHD.

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