Trans Fatty Acids in Milk Fat and Hydrogenated Oils

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The presence of *trans* unsaturated fatty acids in milk fat and hydrogenated oils are of greater concern nowadays because of health-related issues. *Trans* fatty acids in milk fat are the result of incomplete biohydrogenation of the unsaturated dietary lipids in the rumen. Partial hydrogenation process of vegetable oils also produces *trans* type fatty acids for use in semi-solid fat products, such as margarine and confectionery to increase the shelf life of the product. Processed foods and oils provide approximately 80 % of trans fats in the diet, compared to 20 % that occur naturally in food from animal sources. These fatty acids have attracted attention because of their adverse nutritional effect on health. As suggested by observational studies and clinical trials artificial *trans* fats may increase the risk of heart disease by significantly varying the ratio of lipoproteins LDL and HDL levels in the blood. The American Heart Association recommends that less than 25 to 30 % of daily calories come from total fats and *trans* fats should be less than 1 %. An average 2,000 Calorie daily diet should include less than 2 grams of *trans* fats. This article presents the detailed chemistry of *trans* fatty acids, their composition, status, and health effects, which are sourced from milk fat and hydrogenated vegetable oils.

Cis and *trans* fatty acids

All fats and oils are the esters of fatty acids and glycerol, which are chemically named as triacylglycerol, the major type of fats or oils. Fatty acid composition of fats and oils differ w.r.t the ratio of saturated and unsaturated carbon atoms, denoted by the absence or presence of double bonds, respectively. Unsaturated fatty acids exhibit two different geometric isomeric forms namely '*cis*' and '*trans*'. The *trans* fats or *trans*-fatty acids (TFA) in foods come from two major sources either naturally (ruminant animals) or artificially (industrial/processed/ hydrogenated oil).

An important structural difference between *cis*- and *trans*-unsaturated fatty acids is that the *cis* configuration of the double bond puts a significant ''kink or bend'' in the hydrocarbon chain, whereas the *trans* configuration causes only a slight distortion (Fig 1). This difference has a major impact on the way in which triacylglycerols pack in crystal lattices when they solidify (Fox and McSweeney, 2006).

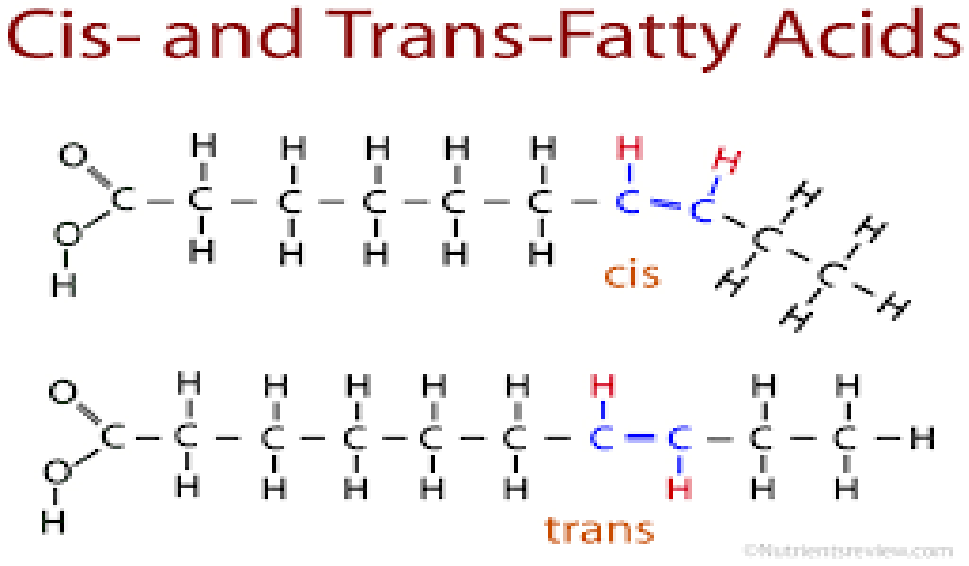

Fig. 1: Structure of '*cis*' and '*trans*' unsaturated fatty acids

Trans fats in Ruminant milk fat and hydrogenated vegetable oils

The primary dietary *trans* fatty acids (TFA) are vaccenic acid and elaidic acid. Vaccenic acid (C18:1, trans-11) is the major ruminant TFA, whereas elaidic acid (C18:1, trans-9) is the main TFA isomer in

industrial hydrogenation. The TFA content of industrially hydrogenated fats varies widely and may account for up to 60 % of the fatty acid content, whereas the TFA content of beef and dairy products is considerably lower and accounts for 2–5 % of the fatty acid content. In the case of special dietary choices, this allows for a daily intake of up to 10 times more industrially produced TFA than from ruminants (Mensink, 2005).

In milk fat, unsaturated fatty acids having single double bond (C18:1) and two double bonds (C18:2) may exist both in *cis* and *trans* forms. Vaccenic acid (11t-C18:1) is the most important *trans* isomer having *trans* double bond at 11th carbon atom of the fatty acid from carboxyl end, with values ranging from about 30 to 60 % of the total *trans*-C18:1. The concentration of *trans*-C 18:1 varies considerably from about 2.0 to 6.0 %, with mean values for milk fats from several European countries in the range 3.3 to 4.4 %. The higher values are for milk fat samples that were obtained from cows fed on summer pasture, whereas the lower values were associated with the feeding of concentrates and silage to cows in the winter. The feeding of fresh grass to cows appears to reduce the efficiency of the biohydrogenation reactions in the rumen, which leads to higher amounts of trans fatty acids (Precht and Molkentin, 2000).

The best-known ruminant *trans*-fat is conjugated linoleic acid (CLA), which is found in dairy foods, butter, lamb and beef. C-18:2 (9c, 11t) is the principal isomer of the CLA in bovine milk fat, accounting for about 80–90 % of the total. The term CLA refers to a mixture of positional and geometric isomers of octadecadienoic acid (C18:2) with conjugated double bonds (e.g., 10t, 12c-C18:2, 10t, 12t-C18:2). The CLA content of milk fat is derived from two related sources. First, C18:2 (9c, 11t) is an intermediate product of the biohydrogenation of fatty acids in the rumen. In addition, 11t-18:1 can be converted to 9c, 11t-18:2 in the mammary gland by the enzyme stearoyl-CoA desaturase (SCD), which normally catalyses the conversion of 18:0 to 9c-18:1. The concentration of C18:2 unsaturated fatty acids (linoleic acid) in milk fat, which contain *trans* form fatty acids are given in the Table 1 (Precht and Molkentin, 1997).

Table 1: Concentration of trans-octadecadienoic acids in bovine milk fat

***Trans*-C18:2 isomers**	**Mean (n)**	**Range**
C18:2(9c,11t); Conjugated linoleic acid; CLA	0.85 (100)	0.25-1.95
C18:2 (9c, 12t)	0.10 (100)	0.05-0.16
C18:2 (9t, 12c)	0.07 (100)	0.02-0.48
C18:2 (9c, 13t) and C18:2 (8t, 12c)	0.11 (11)	0.07-0.16
C18:2 (11t,15c)	0.33 (100)	0.04-0.68
C18:2 (9t, 12t)	0.09 (11)	0.06-0.12

Conjugated linoleic acid (CLA) isomers are excluded from definition of trans fats for labelling purpose. Some food manufacturers are fortifying foods with extra CLA and marketing them as functional foods. The health implications of CLA have widened to include inhibition of carcinogenesis, atherosclerosis, diabetes, and weight loss induced by immune stimulation; and increase in the percentage of lean body mass (Parodi, 1999). These studies have shown that CLA can be regarded as unique, because it appears to provide numerous positive health effects unlike other *trans* fatty acids (Fox and McSweeney, 2006).

However, artificial *trans* fats (industrial trans fats or partially hydrogenated fats) are proven hazardous to health. These fats occur when vegetable oils are chemically altered to stay solid at room temperature, which gives them a much longer shelf life. Partially hydrogenated vegetable oils were the

largest source of artificial *trans* fats in the diet because they were used in many foods such as crackers, cookies, snack cakes and other snack foods. Very commonly found processed foods in the marker which are rich in *trans* fats are microwave popcorn, French fries, cheese burger, pies, chicken nuggets, vanaspati, donuts etc. The major sources of *trans* fats that are found in several modern processed diet is presented in Table 2 (Vandana *et al,* 2011).

Table 2. Contribution of several foods in the diet as *trans* fat

Food groups	**Contribution (% of *trans* fat consumed)**
Cakes, Cookies, Crackers, Bread	40
Animal products	21
Margarine	7
Fried potatoes	8
Potato chips, Corn chips, Popcorn	5
Household shortening	4
Breakfast cereals etc	5

Health risks

TFA has unique effects on serum lipid levels. Clinical trials have shown that *trans*-octadecenoic acids (C18:1), relative to the *cis* isomer, can increase the LDL (bad cholesterol) and decrease the HDL (good cholesterol), thus producing an unfavourable effect on the LDL: HDL ratio (Mensink and Katan, 1993). Mozaffarian *et al.* (2006) reported that saturated fat and TFA had similar effects on LDL on a 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. Consumption of excess artificial *trans* fats in the diet are similarly linked to other illnesses such as long-term inflammation, insulin resistance, and even some kind of cancer (breast cancer), especially for people with obesity or excess weight (Joe, 2023).

The Food and Drug Administration (FDA) banned the use of partially hydrogenated oil in most processed foods in the US in 2018. Intake of these fats has declined in recent years can be related to consumer awareness and action of legal regulatory bodies. In India, Food Safety and Standards Authority (FSSA) also has reduced the levels of *trans* fatty acids (TFA) in oils and fats to 3 % for 2021 and 2 % by 2022 from 5 % limit. Commercial fat and oils samples can be analysed with advanced technology methods using Fourier transform infrared (FTIR) spectroscopy technique, which can determine *trans*-fats with greater accuracy as compared to Gas Chromatography.

Conclusion

Fats and oils are required in the diet (min. 20 % of daily calorie intake) as a source of essential fatty acids and vitamin E. Avoiding fats and oils in the diet is not a fair option to reduce *trans*-fat consumption. Industrial production of processed foods which contain hydrogenated oils should be discouraged and consumer awareness regarding the ill effects on health can bring down the use of *trans* fats in the diet.

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