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ORIGINAL PAPER

Properties and Health Effect of Trans Fatty Acids

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INTRODUCTION

Trans fatty acids (TFA) are geometric isomers of monounsaturated and polyunsaturated fatty acids with hydrogen atoms on opposite sides of at least one carbon-carbon double bond (trans configuration). The intake of TFAs raised the risk of cardiovascular disease (CVD). TFA raises the ratio of LDL cholesterol to HDL cholesterol, which increases the risk of CVD (Iqbal, 2014). Intake of industrially manufactured trans-fatty acids is responsible for approximately 540,000 deaths per year. As per WHO (2018), Trans fat consumption raises the risk of death from any cause by 34%, coronary heart disease deaths by 28%, and coronary heart disease deaths by 21%. This is possibly due to the impact on lipid levels: while lowering HDL ("good") cholesterol levels, trans fat raises LDL ("bad") cholesterol levels. Trans fat doesn't have any known health benefits.

Most of the solid fat content of trans fatty acids, however, is formed by part hydrogenation of oils, which allows some double bonds to be isomerized and moved, giving the fat more solidity and increasing its trans fatty acid content. Stick margarine contains a lot of trans fatty acids, and cookies, pastries, doughnuts, and French fries also have a lot of them (Litin and Sacks, 1993). In Western Europe, the contribution of trans fatty acid intake to overall energy intake varies from 0.5 % to 2.1 %, 2 % in the US (Ascherio et al., 1999) and 1 % to 2 % in the Netherlands (Oomen et al., 2001).

PROPERTIES OF TRANS FATTY ACIDS

Melting points

Heating of vegetable oil at high temperatures for long periods of time, as in the frying process at fast food restaurants, allows fatty acid double bonds to equilibrate,

resulting in high levels of trans fatty acids in old frying oil. Fats are applied to a wide range of processed foods to give a satisfying firm texture and flavour.

From table 1 the melting points of the two series are very with the *trans* isomers having the higher melting points (Hagemann *et al*., 1975). It can be seen that the higher melting activity of trans fatty acids that made them so attractive in commerce. Because of these melting characteristics, hydrogenation of cottonseed oil was able to achieve the desired properties for a plastic shortening (and subsequently of other oils, e.g. soya bean oil). The different shapes of trans fatty acids relative to the cis isomers are responsible for the melting point differences. In Fig. 1, the trans isomer elaidic acid has a straight chain that scarcely alters the overall form as opposed to a saturated acid, stearic acid, as seen in Fig. 2. The cis double bond in Fig. 3, on the other hand, produces a bend in the chain, allowing the molecules to pack together less tightly (Hagemann *et al*., 1972; Jackson and Callen, 1951; Markley, 1947).

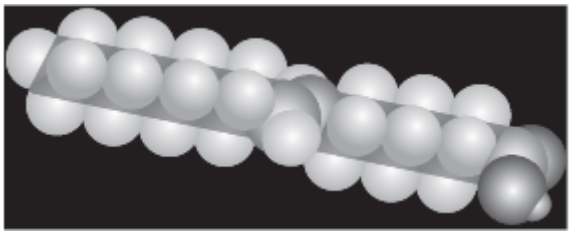

Fig. 1

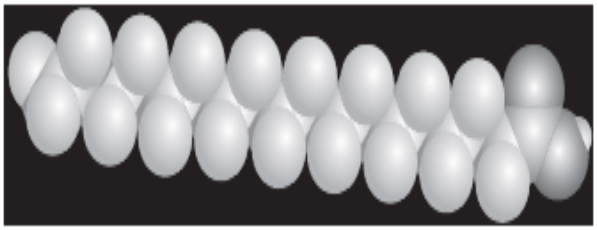

Fig. 2

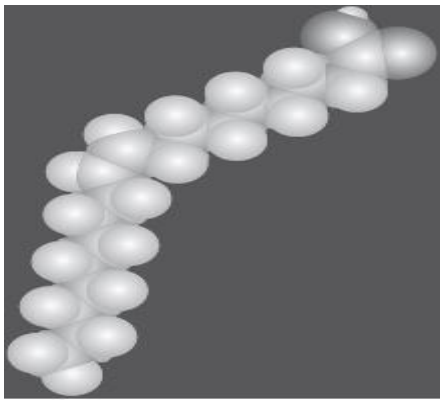

Fig. 3

Three-dimensional representations of Fig.1. elaidic acid, Fig.2. stearic acid and Fig.3. oleic acid

Ultraviolet spectra

Ultraviolet (UV) spectra are not used for the determination of the major fatty acids, because the UV λ- maximum for the *trans* double bond at 187 nm and for the *cis* unsaturated group at 176 nm. The UV spectrum is much more informative when conjugated double bonds are present in the fatty acid (Hamilton and Cast, 1999). In cyclohexane, α-eleostearic acid, 9*c*,11*t*,13*t*-octadecatrienoic acid, has λ_{max} 262, 272 and 283 nm, as shown in Fig. 4, whilst β-eleostearic acid, 9*t*,11*t*,13*t*-octadecatrienoic acid, has very similar absorption maxima at λ_{max} 259, 270 and 281 nm.

Table 1. Melting points of monoacid triacylglycerols

Position of the double bond	**Cis isomers**	**Trans isomers**
4	34	53
5	14	41
6	28	52
7	7	39
8	24	49
9	5	41
10	27	49
11	10	43
12	32	51
13	26	44
14	44	58
15	43	56

Infrared spectra

The infrared spectra are maximum for the trans double bonds at 1680–1670 and 980–865/cm, and for the cis double bonds are at 1660–1630 and 730–650/cm. Trans conjugated bonds are obtained at 990–980 and 968–950/cm when the double bonds are in conjugation, whereas trans, trans double bonds are at 990–984/cm. For tri unsaturated acids, it is maximum at 989/cm for cis, cis, trans conjugated, at 991/cm for cis, trans, trans conjugated and at 994/cm for trans, trans, trans conjugated (Chapman, 1965). A typical spectrum for trielaidin is shown in Fig. 5, with the characteristic band at 980/cm, in contrast with the spectrum for triolein.

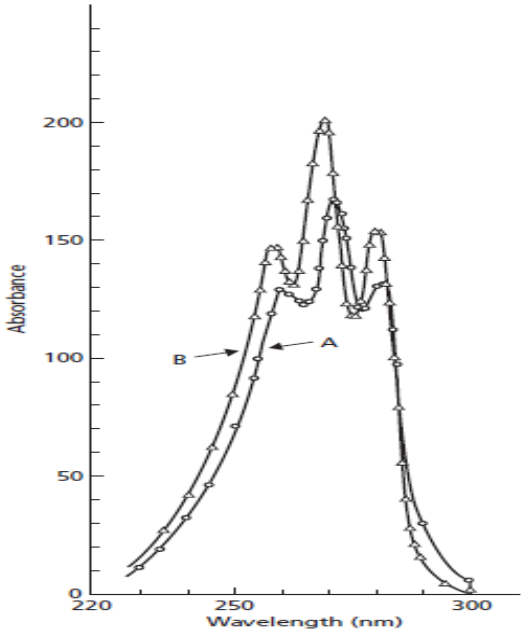

Fig. 4. UV absorption spectra of (A) α-eleostearic acid and (B) β-eleostearic acid

EFFECT OF TRANS FATTY ACIDS ON HUMAN HEALTH

However, TFA stack together just like saturated fats, sabotaging the flexible and porous functionality needed by the body. High TFA intake has been related to a number of negative metabolic effects, according to studies. Low fat and oil consumption (less than 20% of daily calories) raises the risk of vitamin E deficiency and essential fatty acid deficiency, which may lead to adverse changes in HDL and triglycerides. The following threats have been related to trans fatty acid consumption and human health.

Cardiovascular diseases

Many years of epidemiological studies have shown that people who consume saturated fatty acid-rich diets have relatively high serum cholesterol levels and a high risk of coronary heart disease. TFA increases the levels of lipoprotein and decreases the size of LDL-c particles, raising the risk of CHD (Mozaffarian *et al*.,2006). High levels of serum cholesterol, particularly LDL, are thought to promote the development of atherosclerosis or coronary heart disease, according to evidence from numerous studies. According to Mensink and Katan (1990), Trans fats increased LDL while decreasing beneficial HDL, resulting in a less favourable LDL/HDL ratio. The concept that lowering LDL cholesterol in some way decreases the risk of coronary heart disease has become generally accepted (Gould et al. 1998). Dietary TFAs from partially hydrogenated oils are thought to be responsible for 30,000–100,000 premature coronary deaths in the United States per year.

TFA, on the other hand, decreased HDL and increased the ratio of total cholesterol to HDL as compared to either saturated or unsaturated fat. In controlled trials, TFA intake increased serum triglyceride and lipoprotein levels and decreased LDL particle size, suggesting a higher risk of coronary heart disease. Subsequent metabolic studies have confirmed the detrimental effects of trans fatty acids (Lichtenstein et al. 1999; Zock et al. 1995).

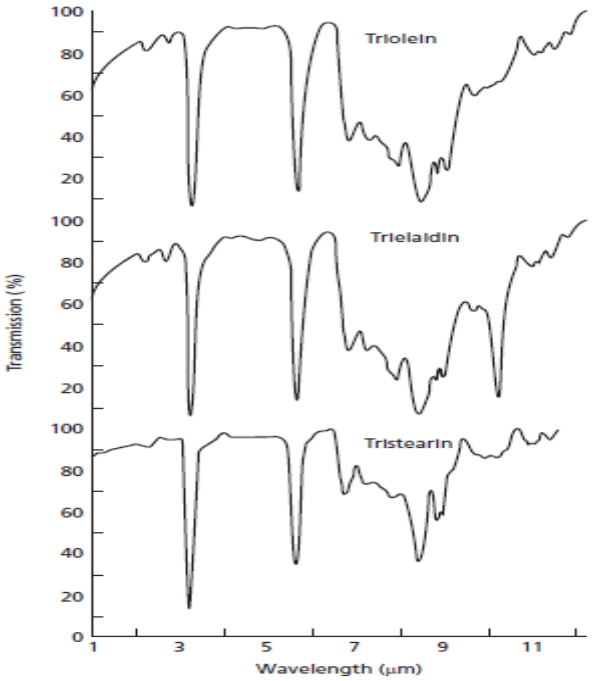

Fig. 5 Infrared absorption spectra of triolein, trielaidin and tristearin in chloroform

Pregnancy

It was previously believed that trans fatty acids do not reach the placenta and that the foetus is therefore, shielded from trans fatty acids based on animal studies (Stender et al. 1994). Recent human studies have shown that trans fatty acids are passed to the foetus, as they were found in the same amounts in the blood of newborn infants as in the mothers' (Berghaus et al. 1998; Elias and Innis 2001). Trans fatty acid levels, including conjugated linoleic acid (CLA), in the umbilical blood of neonates were found to represent the mother's trans fatty acid levels in the blood and thus the mother's trans fatty acid intake, according to Elias and Innis (2001). The pregnancy cycle was also found to be shorter in mothers whose infant's blood contained higher levels of trans fatty acids. Olsen et al. (1992) found that n-3 fatty acids from fish oils prolonged pregnancy, while trans fatty acids tended to shorten it. n-3 fatty acids have an effect on the ion channels in uterine cells, they inhibit contractions and thus prolong pregnancy. Trans fatty acids, on the other hand, might have the opposite effect. Since trans fatty acid consumption by mothers is related to lower levels of polyunsaturated fatty acids in newborn infants' blood, it is recommended that trans fatty acid consumption be limited during pregnancy (Hornstra 2000).

Breast cancer

The evidence for TFA's potential involvement in breast cancer is conflicting. TFA concentration in adipose tissue is related to breast cancer, regardless of age, BMI, use of exogenous hormones, or socioeconomic status. The levels of trans and cis fatty acids in women's blood serum were studied, and it was discovered that as the level of trans fatty acids increased, the risk of breast cancer increased, suggesting that refined food intake

was a factor. According to study, women with high trans fatty acid levels in their blood have double the chance of developing breast cancer than women with lower levels.

Colon cancer

According to Slattery et al. (2001), men and women over the age of 67 who did not take nonsteroidal anti-inflammatory drugs (NSAIDs) had a 50% higher risk of colon cancer when they ate high levels of trans-fatty acids. Women who were oestrogen negative, that is, who did not take hormone replacement therapy after menopause, had a twofold increased risk of colon cancer from high levels of trans-fatty acids in their diet, while oestrogen positive women did not have an increased risk of colon cancer regardless of the amount of trans-fatty acids ingested. Trans fatty acids have been related to an increased risk of cancer due to changes in immune response, cell wall integrity, and prostaglandin synthesis.

Diabetes

After 14 years of observation, the Nurses' Health Research revealed that trans fatty acid consumption was related to the development of type II diabetes (Salmeron et al. 2001). It discovered that since the average energy consumption of industrially produced trans fatty acids in the United States is 3%, a 2% reduction in trans fatty acid intake could reduce the incidence of type-II diabetes by 40% if the fats containing the trans fatty acids were eaten in their natural unhydrogenated form. However, no such connection could be identified in either the Iowa Women Study (Meyer et al. 2001) or the Health Professionals Study (Wahle and James 1993). Saturated fatty acids (SFA) (5 g/100 g, 10% energy) and trans fatty acids (TFA) (3 percent energy) both improved insulin resistance in rats, according to studies conducted at the National Institute of Nutrition (NIN) in Hyderbad, India (decreased insulin sensitivity). TFA, on the other hand, had a greater influence on insulin resistance than SFA. Since increasing dietary linoleic acid did not prevent TFA-induced insulin resistance, it is now important to minimise TFA intake in its entirety (Ghafoorunissa 2008).

Obesity

Research indicates that trans fat may increase weight gain and abdominal fat deposits, despite a similar caloric intake. Trans fatty acids from ruminants and industrially processed trans fatty acids both have the same number of calories as other edible fats. According to a Swedish study, some conjugated linoleic acid isomers contained in ruminant fat at very low levels increase insulin resistance in men with abdominal obesity (Ricerus et al. 2002). Monkeys fed a trans fat diet gained 7.2 percent of their body weight over six years, compared to 1.8 percent for monkeys fed a monounsaturated fat diet (Kavanagh et al. 2007).

CONCLUSION

Trans fatty acids have several beneficial aspects for processed foods owing to their characteristic structures. These distinct structures have been linked to the possibility that trans fatty acids influence the development of a number of health issues, including

coronary heart disease, foetal and infant neurodevelopment and growth, childhood allergies, and so on. Food producers are showing a lot of interest in zero- and low-trans fats, and the use of these products is growing.

REFERENCE

Ascherio, A., Katan, M. B., Zock, P. L., Stampfer, M. J., and Willett, W. C. (1999). Trans fatty acids and coronary heart disease. New England Journal of Medicine, 340, 1994-1998.

Berghaus, T. M., Demmelmair, H., and Koletzko, B. (1998). Fatty acid composition of lipid classes in maternal and cord plasma at birth. European journal of pediatrics, 157(9), 763-768.

Chapman, D. (1965). Infrared spectroscopy of lipids. Journal of the American Oil Chemists' Society, 42(5), 353-371.

Elias, S. L., and Innis, S. M. (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. The American journal of clinical nutrition, 73(4), 807-814.

Ghafoorunissa, G. (2008). Role of trans fatty acids in health and challenges to their reduction in Indian foods. Asia Pacific journal of clinical nutrition, 17, 212-215.

Gould, A. L., Rossouw, J. E., Santanello, N. C., Heyse, J. F., and Furberg, C. D. (1998). Cholesterol reduction yields clinical benefit: impact of statin trials. Circulation, 97(10), 946-952.

Hagemann, J. W., Tallent, W. H., & Kolb, K. E. (1972). Differential scanning calorimetry of single acid triglycerides: effect of chain length and unsaturation. Journal of the American Oil Chemists' Society, 49(2), 118-123.

Hagemann, J. W., Tallent, W. H., Barve, J. A., Ismail, I. A., and Gunstone, F. D. (1975). Polymorphism in single-acid triglycerides of positional and geometric isomers of octadecenoic acid. Journal of the American Oil Chemists' Society, 52(6), 204-207.

Hamilton, R. J., and Cast, J. (Eds.). (1999). Spectral properties of lipids (Vol. 2). CRC Press.

Hornstra, G. (2000). Essential fatty acids in mothers and their neonates. The American journal of clinical nutrition, 71(5), 1262S-1269S.

Iqbal, M. P. (2014). Trans fatty acids–A risk factor for cardiovascular disease. Pakistan journal of medical sciences, 30(1), 194.

Jackson, F. L., and Callen, J. E. (1951). Evaluation of the twitchell isooleic method: Comparison with the infrared trans-isooleic method. Journal of the American Oil Chemists' Society, 28(2), 61-65.

Lichtenstein, A. H., Ausman, L. M., Jalbert, S. M., and Schaefer, E. J. (1999). Effects of different forms of dietary hydrogenated fats on serum lipoprotein cholesterol levels. New England Journal of Medicine, 340(25), 1933-1940.

Litin, L., and Sacks, F. (1993). Trans-fatty-acid content of common foods. New England Journal of Medicine, 329(26), 1969-1970.

Markley, K. S. (1947). Fatty acids. Their chemistry and physical properties. Fatty acids. Their chemistry and physical properties.

Mensink, R. P., and Katan, M. B. (1990). Effect of dietary trans fatty acids on high-density and low-density lipoprotein cholesterol levels in healthy subjects. New England Journal of Medicine, 323(7), 439-445.

Meyer, K. A., Kushi, L. H., Jacobs, D. R., and Folsom, A. R. (2001). Dietary fat and incidence of type 2 diabetes in older Iowa women. Diabetes care, 24(9), 1528-1535.

Mozaffarian, D., Katan, M. B., Ascherio, A., Stampfer, M. J., and Willett, W. C. (2006). Trans fatty acids and cardiovascular disease. New England Journal of Medicine, 354(15), 1601-1613.

Olsen, S. F., Sørensen, J. D., Secher, N. J., Hedegaard, M., Henriksen, T. B., Hansen, H. S., and Grant, A. (1992). Randomised controlled trial of effect of fish-oil supplementation on pregnancy duration. The lancet, 339(8800), 1003-1007.

Oomen, C. M., Ocké, M. C., Feskens, E. J., van Erp-Baart, M. A. J., Kok, F. J., and Kromhout, D. (2001). Association between trans fatty acid intake and 10-year risk of coronary heart disease in the Zutphen Elderly Study: a prospective population-based study. The Lancet, 357(9258), 746-751.

Salmeron, J., Hu, F. B., Manson, J. E., Stampfer, M. J., Colditz, G. A., Rimm, E. B., and Willett, W. C. (2001). Dietary fat intake and risk of type 2 diabetes in women. The American journal of clinical nutrition, 73(6), 1019-1026.

Slattery, M. L., Benson, J., Ma, K. N., Schaffer, D., and Potter, J. D. (2001). Trans-fatty acids and colon cancer. Nutrition and cancer, 39(2), 170-175.

Stender, S., Dyerberg, J., and Holmer, G. (1994). Transfedtsyrers betydning for sundheden. Ugeskrift for Laeger, 156(25), 3764-3769.

Wahle, K. W., and James, W. P. (1993). Isomeric fatty acids and human health. European journal of clinical nutrition, 47(12), 828-839.

Zock, P. L., De Vries, J. H., de Fouw, N. J., and Katan, M. B. (1995). Positional distribution of fatty acids in dietary triglycerides: effects on fasting blood lipoprotein concentrations in humans. The American journal of clinical nutrition, 61(1), 48-55.