Trans Fatty Acids in Vegetable Oils and Ghee

Asifa Tareen*, Abdul Basit Jasra, M. Shafiq Malik***, Nasir Ishaq Tahir***, M. Riaz*** and Rafi Ahmed*****

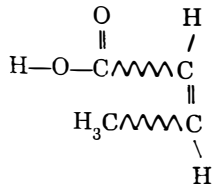
*College of Home Economics Lahore,
**Government College Sargodha,
***P.C.S.I.R. Laboratories Complex,
Lahore, Pakistan.

Oils and fats are the constituents of food due to their established nutritional value. They contribute as concentrated source of energy and are carriers of fat soluble vitamins. One gram of oil or fat usually provides 9 kilocalories as compared to 4 kilocalories of energy from either carbohydrates or proteins.[1]

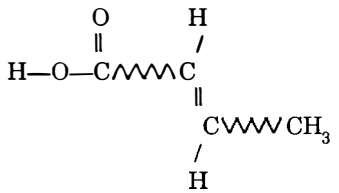
In earlier times the edible oils were used without refining and bleaching which remained unaltered except hydrolysis and oxidation. But nowadays, the crude oils are treated to modify their taste and appearance. They are refined, bleached and deodorized. These oils are further processed and modified by hydrogenation inter-esterification and blending for different food preparations.

Almost all the unsaturated fatty acids occur in nature in cis form. It has been observed practically that during hydrogenation process, trans-isomers of fatty acids are formed. During processing, carbon-carbon double bond may be broken and reformed. During this short time the group on the same side may rotate and become fixed in trans position resulting in change of molecular geometry.

Cis fatty acid



Trans fatty acid[2]



In the cis form the molecule folds back upon itself at the double bond while in trans form it extends to maximum length[3,4]. Trans fatty acids are generated in vegetable oils during different processes such as catalytic partial hydrogenation, biohydrogenation, and isomerization.

Hydrogenation involves the catalytic addition of hydrogen to unsaturated bonds of fatty acid carbon chains. As a result of hydrogenation, the melting point of the oil increases and hard fat is formed. The hardening process transforms a part of the naturally occurring cis unsaturated fatty acids into trans unsaturated fatty acids.

Formation of trans from cis isomers as a result of isomerization is the result of change in geometry or position of double bond in fatty acids. Both geometric and positional isomers are known among unsaturated fatty acids[5]. The positional isomers of oleic acid and of other unsaturated fatty acids have different characteristics, for example, their melting points are different[6].

The geometrical isomers of fatty acids have different structures owing to a restricted rotation of either a double bond, for example, cis oleic acid and trans oleic acid or elaidic acid. In trans oleic acid, groups are on opposite sides of the double bond[7].

The mixture of isomers resulting from hydrogenation of vegetable oil is very complex. The patterns of accumulation of the different trans fatty acid isomers found in partially hydrogenated vegetable oils are different from those of isomers of ruminant

fat. The Δ-11 trans fatty acids (ruminant fat) metabolize more like saturated fatty acids and mono unsaturated fatty acids which are synthesized in all mammals, while the other more unusual trans isomers are metabolized more slowly. The lowest level of trans fatty acids in dairy products has been reported to be 1.8% (trans fatty acids)[8].

The trans fatty acids depress the fat percentage in milk from lactating females in all species including human. In ruminant animals trans fatty acids are formed by biohydrogenation and appear in milk and meat in human diet. Koletzky (1992) found that trans fatty acids inhibit arachidonic biosynthesis and Romo *et al.,* (1996) reported that trans acids (such as 18:1) when present in diets of dairy cows reduced their milk fat and energy output[9-15]. Higher dietary trans isomers intake during pregnancy lowers the growth rate of the child in prenatal period by affecting essential fatty acid metabolism[16, 17, 18].

In recent years it has been recorded that the trans fatty acids are causing cardiovascular diseases thus damaging human health. The trans fatty acids can adversely affect lipoprotein cholesterol profile[19]. Because of this awareness, the developing countries are encouraging the use of unhydrogenated oils and fats avoiding hydrogenated fats and oils.

Elson (1981) studied the effects of dietary hydrogenated fat in swine, as a result, swine developed increased arteriosclerosis. Kummerow (1979) reported that trans fatty acids due to slow oxidation accumulate in heart tissues and thus disrupt its function[20, 21].

Burr in 1920's demonstrated that trans fatty acids compete with utilization of natural polyunsaturated fatty acids and lack the essential metabolic activity, adversely affecting metabolism[22]. The trans fatty acids competitively inhibit the metabolic action of enzyme Δ-6 desaturase[23]. It has been advised by the Adult Treatment Panel of the National Cholesterol Education Program (Jankins, 1995) that the saturated trans fatty acids should be reduced in the diet[24]. The intake of trans fatty acids is directly related to the progression of coronary diseases and to reduce their progression their content in the diet should be restricted.

National Heart Foundation has reported that higher intake of both saturated and trans fatty acids elevates serum cholesterol and LDL-cholesterol levels, thus increasing the chances of heart diseases. The effects of trans fatty acids have also been observed through data collection on animals and humans[25, 26].

Cholesterol produces steroid hormones, such as cortisol, which helps to regulate blood sugar level and other hormones, which are related to sex and reproduction. It also produces bile that is important for fat digestion. Higher level of cholesterol narrows the arteries causing coronary diseases. Cholesterol level below 200 mg/100 ml is considered normal and above 240 mg/100 ml, it is dangerous. High-density lipoprotein (HDL) commonly known as good cholesterol, removes cholesterol from capillaries and arteries. According to the National Heart, Lungs, and Blood Institute, the HDL level below 35 is a risk factor for heart diseases. The LDL, low-density lipoprotein (bad cholesterol) levels should be under 160 mg/100 ml. The intake of trans fatty acids effects the concentration of LDL and HDL cholesterol in blood. Ascherio and Willet (1997) state that trans fatty acids increase the concentration of LDL-cholesterol and reduce HDL-cholesterol concentration[26-32].

It was noted in an experiment that trans rich fats significantly elevated total cholesterol and LDL and depressed HDL-cholesterol relative to all fats tested. Thus, elaidic acid (trans isomer) so adversely affected plasma proteins in humans that no other fatty acid can do[18, 33-36]. In a recent report of Booyens and Van-der-Verme, the elaidic acid rich diet led to significant elevation in levels of lipoprotein (alpha) as compared to all other diets (Table 1)[23]. Demmelmair, (1996) reported that a higher intake of trans fatty acids may affect lipoprotein metabolism in children[37].

Experiments carried out by Chiang (1996) on rats showed that dietary trans fatty acids may alter the plasma lipoprotein metabolism (Table 2)[38]. The effects of margarine corn oil on cholesterol synthesis and LDL oxidation were studied by an expert panel of the *Journal of Clinical Nutrition.* It was reported that the diet had hypercholesterolemic properties[39] (Table 3).

It has been shown by many researchers that trans fatty acids have relationship not only with heart diseases but may also cause cancer, diabetes, low birth weight, obesity and immune dysfunctions[40]. The increased risk of cancer due to trans fatty acid intake was first reported by Sincflair (1956) in England. Prior to this, researchers had noted increased chances of cancer due to partially hydrogenated fat[40-42]. Ewertz reported the risk of breast cancer associated with increased trans fatty acids in diet[43]. Kuller reported increased obesity in women and stated that women

TABLE 1

Plasma Lipoprotein and Lipoprotein α changes with substitution of Elaidic Acid for Oleic Acid

S. No.	Sample Diet	LDL Cholesterol mg/dl	HDL Cholesterol mg/dl	Lipoprotein α (I.U.)
1.	Enriched with butter fat	163	42	235±182
2.	Oleic acid rich	161	38	236 ± 201
3.	Elaidic acid rich	165	38	296 ± 220
4.	Palmitic acid rich	161	42	249 ± 402
	Normal values[38]	< 160	45-50 for men 50-60 for women	

TABLE 2

Composition of Diet given to subjects

Diet	% of Energy	SFA*	MUFA*	TFA*	PUFA*	Cholesterol Mg/4.2 MJ
Enriched corn oil	30%	7%	9%	0.45	11%	85%
Enriched in stick corn oil margarine	30%	8%	12%	4.2%	8%	77%

*SFA: saturated fatty acids, MUFA: monounsaturated fatty acids, TFA: trans fatty acid, PUFA: Polyunsaturated fatty acid.

TABLE 3

Effects of Diet on the Lipoprotein Profile of the subject

Diet	Mean Total Level Cholesterol mmol/L	LDL-Cholesterol mmol/L
Corn oil enriched diet	5.01 ± 0.51	3.24 ± 0.51
Corn oil margarine enriched diet	5.30 ± 0.58	3.50 ± 0.54

who consumed more trans fatty acids were several kilograms heavier than those who consumed less, with the same caloric intake[44]. Thus rise in the use of higher levels of trans fatty acids in substandard vanaspati vegetable ghee is poisoning the country's population causing a number of diseases[45].

Advances in food processing technologies, for example, in hydrogenation and inter-esterification can reduce trans fatty acid content in food. Genetic engineering in plants is going to modify fatty acid composition of oils and thus the need for hydrogenation.

Unilever Laboratories, Holland has developed Virtually Trans fatty acid Free (VTF) technology, which has been introduced in Pakistan by Lever Brothers to provide virtually trans fatty acid free (VTF) Dalda banaspati. The VTF technology has brought trans fatty acid content from 40% to less than 1%. Out of 150 edible oil processing companies, only Lever Brothers is using VTF technology[46]. Consumption of partially hydrogenated fats is almost universal and the number of deaths due to such fats with higher levels of trans fatty acids is likely to be substantial.

Health organizations should require manufacturers to include trans fatty acid content in food labels and should aim to reduce and ultimately eliminate the use of partially hydrogenated fats. Additional research is also needed to solve the question about the independent effects of trans fatty acids on human health and their mechanism of action.

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