Trans Fatty Acids - Nutritional Considerations and Labelling: an Update and Implications for Palm Oil

Yusof Basiron* and Kalyana Sundram*

INTRODUCTION

Trans fatty acids are produced when oils and fats containing unsaturated fatty acids are hydrogenated in the presence of a catalyst. Hydrogenation primarily increases the melting range of the unsaturated fats and thereby enables their incorporation into many solid fat formulations. When an unsaturated fat or oil is fully hydrogenated, all the unsaturated fatty acids are converted into their saturated analogues. Since the unsaturation in most vegetable oils is largely in the 18-carbon fatty acids, namely, oleic (18:1 n-9), linoleic (18:2 n-6) and linolenic (18:3 n-3), full hydrogenation of such oils would result in a stearic acid (18:0), high melting block of fat. Partial hydrogenation, usually in the presence of nickel catalysts, results in the formation of *trans* fatty acids that are the geometrical isomers of the unsaturated fatty acids, containing at least one double bond in the *trans* configuration. This *trans* double bond configuration impacts the physical properties of the fatty acid with a potential for reducing the fluidity of the fatty acid thereby increasing its melting point. Thus, partial hydrogenation of liquid oils has been the tool of choice to enable their use in solid fats, especially margarine formulations. Partial hydrogenation actually results in both *cis* and *trans* fatty acids anywhere between carbon 4 and carbon 18 of the fatty acid molecule with elaidic acid (9*trans* 18:1) being a major isomer and smaller amounts of numerous other *trans* isomers occurring concurrently. Upwards of 20 different *cis* and *trans* geometrical isomers have been recorded following partial hydrogenation of vegetable oils. Small amounts of *trans* fatty acids occur naturally in dairy fat (butter) and meat as a result of bio-hydrogenation in the fore stomach of ruminants.

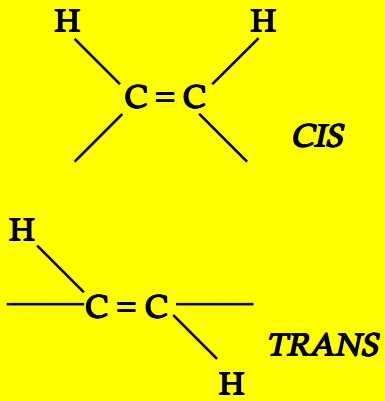

Figure 1. Structure of cis *and* trans *double bonds.*

FOOD SOURCES AND DIETARY INTAKE OF *TRANS* FATTY ACIDS

Trans fatty acids are present in foods containing traditional stick margarine, bakery and frying fats, vegetable shortenings and vanaspati that have been subjected to hydrogenation. They have now become a universal food culture and are readily reflected in bakery products, fried foods, and breakfast margarine and, to a smaller extent, in dairy and meat products. Estimates of *trans* consumption are very varied and this has been hampered by a lack of an accurate database to reflect their contents in common foods. Indeed, even in the United States and Europe, this is a problem since *trans* fatty acid intake is still not featured in the national surveys of the United States and European Community. Current *trans* consumption in the United States is estimated at about 2.6-3.0 energy percent whereas in some Middle Eastern and South Asian populations it may be as high as 7 energy percent.

NUTRITIONAL CONSEQUENCES OF *TRANS* FATTY ACIDS

Since their introduction into the human diet and until the early 1990s, partially hydrogenated fats

* Malaysian Palm Oil Board,
P .O. Box 10620,
50720 Kuala Lumpur, Malaysia.

containing *trans* fatty acids were advocated as the preferred fatty acid base for solid fats, especially margarines. They were initially designed to replace butterfat and with advancements in our knowledge about the adverse impacts of saturated fatty acids on cardiovascular disease (CVD) risk, *trans* fatty acids were made prominent as a safe alternative. Similar to other common fatty acids, *trans* fatty acids are efficiently absorbed in humans and completely catabolized to carbon dioxide and water. Variations in their geometrical configurations (relative to their *cis* fatty acids), melting behaviour and position of double bonds have no measurable effect on absorption efficiency. They are also incorporated into human adipose tissue and other organs just like *cis* fatty acids.

Current reflections on the string of events, largely advocated by powerful lobbies of the liquid vegetable oils producers, magnify the masking of important regulatory tools that were overlooked in favour of the use of partially hydrogenated fats by the food industry. Indeed had *trans* fatty acids being subjected to the same level of safety scrutiny as other food components, their adverse effects would have been spotted many decades ago. Yet after almost 50 years of a prescribed *safe-use standard*, *trans* fatty acids have been thrust to the forefront by a series of studies that deliberately and surgically dissected their effects on blood cholesterol, lipoprotein metabolism and enhanced risk for cardiovascular disease.

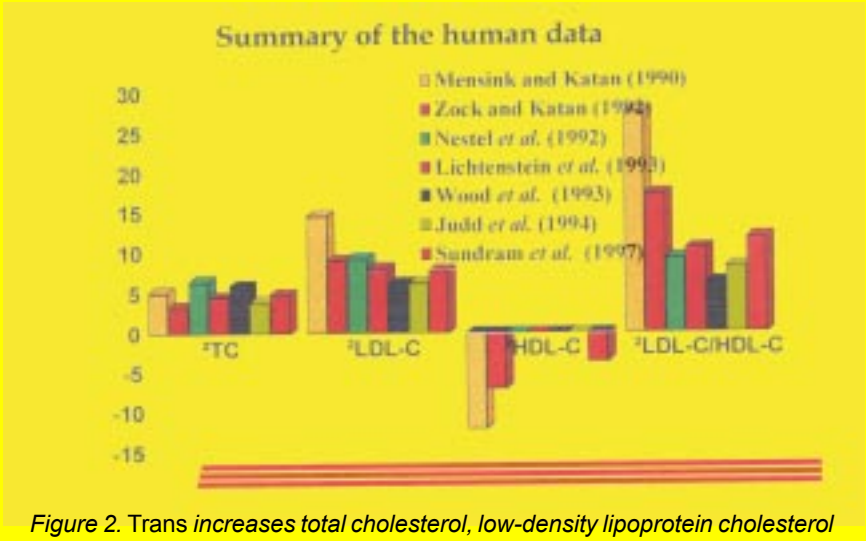

Figure 2. Trans *increases total cholesterol, low-density lipoprotein cholesterol and low-density/high-density lipoprotein cholesterol ratio while reducing high-density cholesterol.*

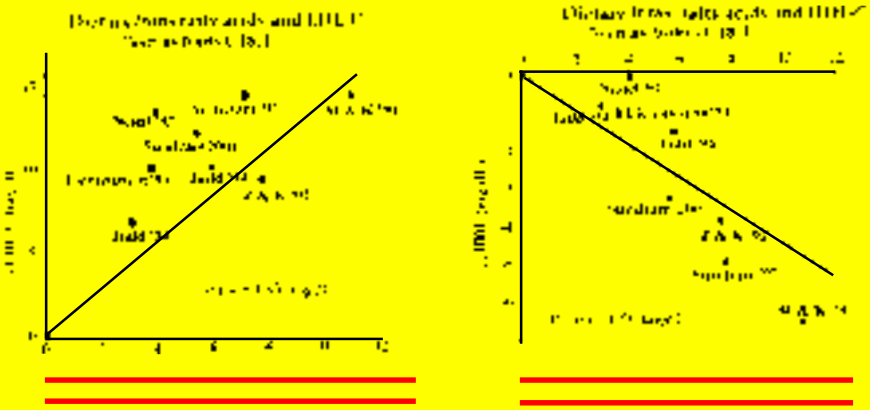

Figure 3.

HEALTH HAZARDS OF *TRANS* FATTY ACIDS

Effects on Lipoprotein Cholesterol Concentration

After almost 50 years of little concern about the increased consumption trends of hydrogenated fats at the expense of saturated fatty acids, the study of Mensink and Katan (1990) suggested that *trans* increased total and low-density lipoprotein cholesterol (LDL-C) and decreased the beneficial high-density lipoprotein cholesterol (HDL-C) resulting in a less desirable total/HDL-C ratio. Nearly a dozen other studies quickly fortified this finding, almost all reflecting increases in the atherogenic LDL component and decreases in the beneficial HDL-component following the consumption of a *trans* enriched diet (Institute of Medicine, 2002). Invariably it was clearly established that *trans* fatty acids are worse than the saturated fatty acids they were designed to replace in the first instance. In this context, two palm oil studies (Sundram *et al.*, 1997; Wood *et al.*,1993) stand out in this important groundbreaking cluster of studies and continue to be quoted by most expert panels as the standards of comparison that led to the conclusion that *trans* constitute an increased and greater risk for cardiovascular risk than saturated fatty acids.

Effects on Lipoprotein Lp(a) Concentration

Lipoprotein (a) or Lp(a) concentration in human plasma when increased is considered an independent risk factor for CVD. The Lp(a) is mostly under genetic control and normally the diet has little influence on this risk predictor. However, Lp(a) concentration has been reported to be increased after the consumption of diets enriched in hydrogenated fats containing *trans* fatty acids. The magnitude of the increase in Lp(a) associated with *trans* fatty acids is of concern

especially in populations consuming high levels of *trans* fatty acids and in individuals with initially high concentrations of Lp(a). Of interest are several observations that have recorded decreases in Lp(a) following a saturated fat diet. Indeed, one of the earliest observations that detailed dietary modulation of Lp(a) was the Dutch palm oil study of Sundram *et al.* (1992). This demonstrated that maximal replacement of the regular fat content in the Dutch diet with palm oil resulted in significantly reduced Lp(a) concentrations accompanied by increases in the beneficial HDL-C. Sundram *et al.* (1997) subsequently demonstrated that when palm oil replaced a *trans* enriched diet, Lp(a) was significantly reduced by the palm oil diet, even in a low fat environment.

EPIDEMIOLOGICAL EVIDENCE

The Harvard researchers led by Willett *et al.* (1993) spearheaded studies elucidating the effects of *trans* fatty acids using epidemiological data from the Nurses Health Study consisting of 85 095 women. They examined the association between *trans* fatty acids and incidence of non-fatal myocardial infarction or death from coronary heart disease (CHD) in these women followed for eight years. A positive and significant association between *trans* and CHD was apparent. Foods that were major sources of *trans* including margarine and cookies also revealed a positive correlation. A follow-up study in 239 patients (Ascherio *et al.*,1994) also established a positive association between *trans* containing margarines and myocardial infarction. *Trans* intake was associated with increased total and LDL-cholesterol and negatively related to HDL-cholesterol in men suffering a myocardial infarction. Relative risk for CVD was increased by 27% as a result of *trans* consumption. These studies clearly established an association of *trans* fatty acid consumption with increased incidence and death from CVD and it was estimated that almost 80 000 deaths in the United States alone are associated with continued consumption of foods rich in *trans* fatty acids.

***TRANS* FATTY ACIDS AND DIABETES**

Recent studies have implicated *trans* fatty acids not only with coronary heart disease but also with increased risk and incidence of diabetes. Dietary fat intake was evaluated for CHD risk (Hu *et al.*, 1997) and type II diabetes in women. A 2% increase in *trans* fatty acid consumption relative to carbohydrate intake resulted in a relative risk score of 1.93 for CHD and 1.39 for type II diabetes. In comparison, the score for saturated fatty acids was significantly lower: 1.17 for CHD and 0.97 for type II diabetes. These findings served to highlight additional concerns about the safety of *trans* fatty acids in humans.

Based on these findings and a complete review of all available published literature relating to *trans* fatty acids, the Institute of Medicine (IOM) of the National Academies of Sciences, Engineering, Medicine and Research Council, USA declared that there are no data available to indicate a health benefit from consuming *trans* fatty acids. Therefore an Adequate Intake, Estimated Average Requirement, and Recommended Dietary Allowance are not established for *trans* fatty acids. There is a positive linear trend between *trans* fatty acid intake and total and LDL-C concentration and therefore increased risk of coronary heart disease. This suggests a Tolerable Upper Intake Level (UL) of zero for *trans* fatty acids.

LABELLING OF *TRANS* FATTY ACIDS: CURRENT STATUS

Currently, *trans* fatty acid labelling is neither mandatory in the United States nor required by the Codex Alimentarius Commission. However, when Codex invited comments for the Nutrition Panel labelling which included claims for saturated fatty acids and cholesterol-free declarations, MPOB instituted a petition for the inclusion of *trans* fatty acids. MPOB proposed that wherever a saturated fatty acids declaration was made mandatory, the *trans* fatty acids content should also be included as a separate entry. However, the Codex Commission in its wisdom made a decision not to enforce *trans* labelling on the basis that there was insufficient information to adopt the MPOB petition. Nevertheless, after many years of relentless debates on the issue by MPOB, Codex agreed to include *trans* fatty acids as a footnote to the nutrition panel.

From the beginning, MPOB took a stand that *trans* fatty acids should be labelled separately from saturated fatty acids as opposed to other health authorities (FDA, Health Canada, European Commission, *etc.*) that viewed that both *trans* and saturated fatty acids should be simply lumped as a single entry. In 2000 as a result of mounting evidence and concerns from consumer organizations in the United States, the FDA proposed new rules for *trans* fatty acids. The FDA proposed to amend its regulations to require that the amount of *trans* fatty acids in a food be included in the Nutrition Facts panel. Included in this were definitions for *trans fat free* and a limit on *trans* fatty acids wherever there were limits imposed on saturated fat content claims or health claims. Unfortunately, no attempt was made to separately declare *trans* and saturated fatty acids, which meant that consumers must learn to count *trans* fatty acids by deducting saturated, monounsaturated and polyunsaturated fatty acids from total fat declared in the label. This motive of the FDA was heavily protested against by US consumer organizations and MPOB.

In light of mounting scientific evidence about the health hazards of *trans* fatty acids, the Codex Committee on Food Labelling (CCFL) at its deliberations in 2002 made a surprise detour of its earlier stand. CCFL considered the mandatory labelling of *trans* fatty acids in foods; the proposal was accepted without debate. However, CCFL was again divided about requirements that proposed the separation of *trans* and saturated fatty acids in food labels (again mooted by Malaysia through MPOB). Since this is primarily a nutrition related issue, CCFL then referred the matter to the Codex Nutrition Committee for its consideration.

The publication of the recent report on *Dietary Reference Intakes for* Trans *Fatty Acids* by the Institute of Medicine, USA has however resulted in a spate of renewed activity with respect to *trans* labelling. This report is expected to lay to rest any opposition towards separate declaration of *trans* fatty acids in foods and has currently forced the FDA to act. The FDA is now considering *trans* as a separate line item in food labelling and this should surely start the final demise of hydrogenated fats, as we know it currently. The new FDA ruling is expected to be registered in 2003 and enforced fully by 2006. It is indeed heartening that MPOB was a prime mover in these developments and in the end, our science-based logic for separate labelling of *trans* and saturated fatty acids has finally prevailed.

OPPORTUNITIES FOR THE PALM OIL INDUSTRY

Hydrogenated fats appear to be on their way out as a result of the developments and concerns outlined. The question that is paramount currently is how best to reformulate margarine, vanaspati, bakery, frying, and other solid fats such that these products are *trans*-free. To the palm oil industry this is obvious - use palm oil and its fractions to provide the solids that allow the functionality of these food products. Furthermore, a large volume of nutritional data that shows palm oil would be a neutral fat with respect to CHD risk backs the use of palm-based products. This advantage is already being exploited as we are seeing new palm-based products appearing in the US markets today. MPOB's own patented formulation sold in the United States under the brand name *Smart Balance* has already registered impressive market volumes throughout the United States.

Despite the obvious answer, we should not expect our competitors to sit back and allow palm oil to capture the market at the expense of the traditional liquid oils such as soya, canola and rapeseed that are used as hydrogenated fats in these food formulations. What happens to the existing hydrogenation capacities is another important consideration that would dictate the trend in the coming years.

An obvious attempt to use available liquid oils and hydrogenation capacities would be to fully hydrogenate the liquid oils into a hard stock. This would mean conversion of all the 18-carbon fatty acids (18:1, 18:2 and 18:3) in liquid oils to a stearic acid (18:0) block. Another common fat modification tool - interesterification - would then gain greater acceptance since it would allow fully hydrogenated vegetable oils to be randomized with the native vegetable oils to provide the required hard stock for solid fat formulations.

This approach has great merit since currently stearic acid is considered a neutral fatty acid with respect to CHD risk. MPOB, however, feels that the issue may not be so straightforward and new concerns regarding the nutritional efficacy of strearic-rich interesterified hard stock can likely arise in the near future. To address such concerns, MPOB has already initiated human dietary trials that are aimed at evaluating the effect of such stearic-rich interesterified hard stocks for their effects on CHD risk.

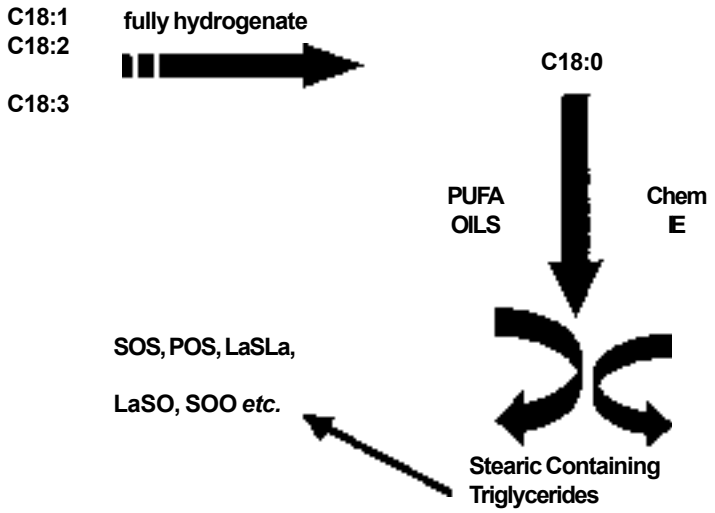

Figure 4.

REFERENCES

ASCHERIO, A; HENNEKENS, C H; BURING, J E; MASTER, C; STAMPFER, M J and WILLETT, W C (1994). *Trans* fatty acid intake and risk of myocardial infarction. *Circulation, 89*: 94-101.

HU, F B; ST AMPFER, M J; MANSON, J E; RIMM, E; COLDITZ, G A; ROSNER, B A, HENNEKENS, C H and WILLETT, W C (1997). Dietary fat intake and risk of coronary heart disease in women. *N. Engl. J. Med., 337*:1491-1499.

INSTITUTE OF MEDICINE (2002). Letter report on dietary reference intakes for *trans* fatty acids. National Academy of Sciences, USA. July 2002.

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. *N. Engl. J. Med., 323*:439-445.

SUNDRAM, K; ANISAH, I; HAYES, K C; JEYAMALAR, R and PATHMANATHAN, R (1997). *Trans* (elaidic) fatty acids adversely impact lipoprotein profiles relative to specific saturated fatty acids in humans. *J. Nutr., 127*:514S-520S.

SUNDRAM, K; HORNSTRA, G; HOUWELINGEN, A C and KESTER, A D (1992). Replacement of dietary fat with palm oil: effect on human serum lipids, lipoproteins and apolipoproteins. *Br. J. Nutr., 68*:677-692.

WILLETT, W C; STAMPFER, M J; MANSON, J E; COLDITZ, G A; SPEIZER, F E; ROSNER, B A; SAMPSON, L A and HENNEKENS, C H (1993). Intake of *trans* fatty acids and risk of coronary heart disease among women. *Lancet, 341*:581-585.

WOOD, R; KUBENA, K; O'BRIEN, B; TSENG, S and MARTIN, G (1993). Effect of butter, mono- and polyunsaturated fatty acid-enriched butter, *trans* fatty acid margarine and zero *trans* fatty acid margarine on serum lipids and lipoproteins in healthy men. *J. Lipid Res., 34*:1-11.