Palm Oil and its Fractions, Best Alternative Natural Fat for TFAs

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INTRODUCTION

Good knowledge on nutrition is important to help enhance health literacy and promote healthier dietary choices among consumers. Better awareness and understanding of different types of fats and their health effects may also help increase the usefulness of food labels. The US Food and Drug Administration's (FDA) final ruling on *trans*-fatty acids (TFAs) labelling issued in 2003 has caused a rapid transformation in the oils and fats industries. Recently, FDA also has taken a serious step to revoke the GRAS (generally regarded as safe) status for partially hydrogenated oils (PHOs), which are the primary dietary source of industrially-produced TFA. If it is finalised, food manufacturers would no longer be permitted to sell PHOs, either directly or as ingredients in other food products, without prior FDA approval for use as food additive. Novel ingredients and improved technologies are emerging to replace PHOs in foods.

WHAT ARE *TRANS*-FATTY ACIDS (TFAs)

Chemical hydrogenation is an industrial process, whereby hydrogen atoms are added to unsaturated bonds at carbon chains of fatty acids with the presence of catalyst to reduce the number of double bonds. 'Partial hydrogenation' describes an incomplete saturation process of the double bonds. This process leads to formation of *trans*- from *cis*- configuration. TFAs are unsaturated fatty acids with at least one double bond in the *trans* configuration. The *trans* arrangement of hydrogen atoms results in straight configuration of fatty acids and increases melting point, shelf life and flavour of these hydrogenated oil. Due to physical and chemical properties, PHOs have been widely used in food industry mainly in margarine, vanaspati, cooking fats, vegetable shortening and bakery goods.

TFAs are also formed during the production of non-hydrogenated refined vegetable oils by using high temperature during deodorisation process. Here, the content of TFAs is rather lower and below 2% compared to PHOs which have an average of 25% to 45% TFAs. Small amount of naturally occurring TFAs are found in dairy products including butter, cheese and meat as a result of bio-hydrogenation in the rumen of ruminants.

These partially hydrogenated oils and fats have been shown to have detrimental effects on health. Existing evidence has shown detrimental effects of TFAs intake on human health. Furthermore, TFAs from partially hydrogenated fats and oils have no health value. Adverse effects are seen even at very low intake of TFAs, for example, 1%-3% of total energy or approximately 2-7 g (20-60 calories) for a person consuming 2000 calories/day. Thus, total avoidance of industrial TFAs (≤0.5% of energy) is necessary to avoid adverse health effects.

RESEARCH FINDINGS ON ASSOCIATION OF TFAs WITH CVD RISK

Detrimental health effects of TFA on cholesterol and lipid profiles have been documented in numerous human clinical trials. It has been demonstrated that TFA increased

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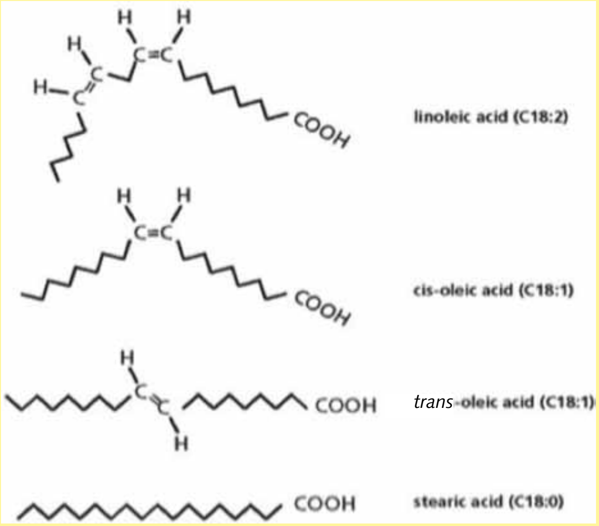


Figure 1. Chemical structure of common polyunsaturated, cis- and trans-*mono-unsaturated and saturated fatty acids.*

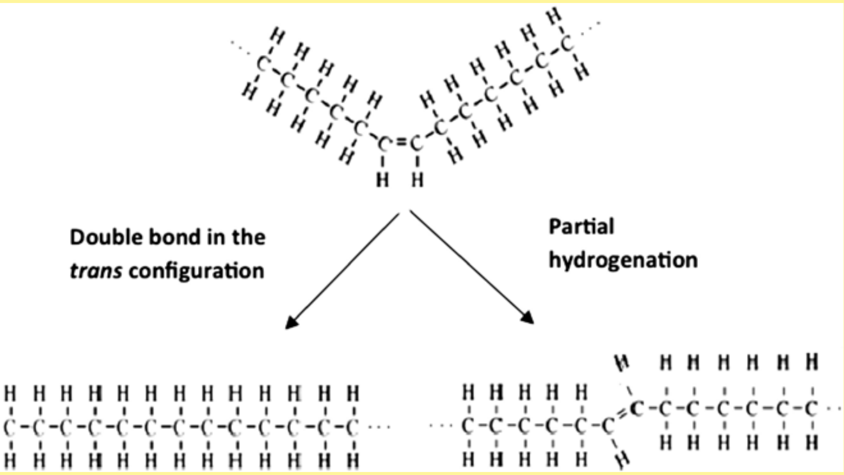
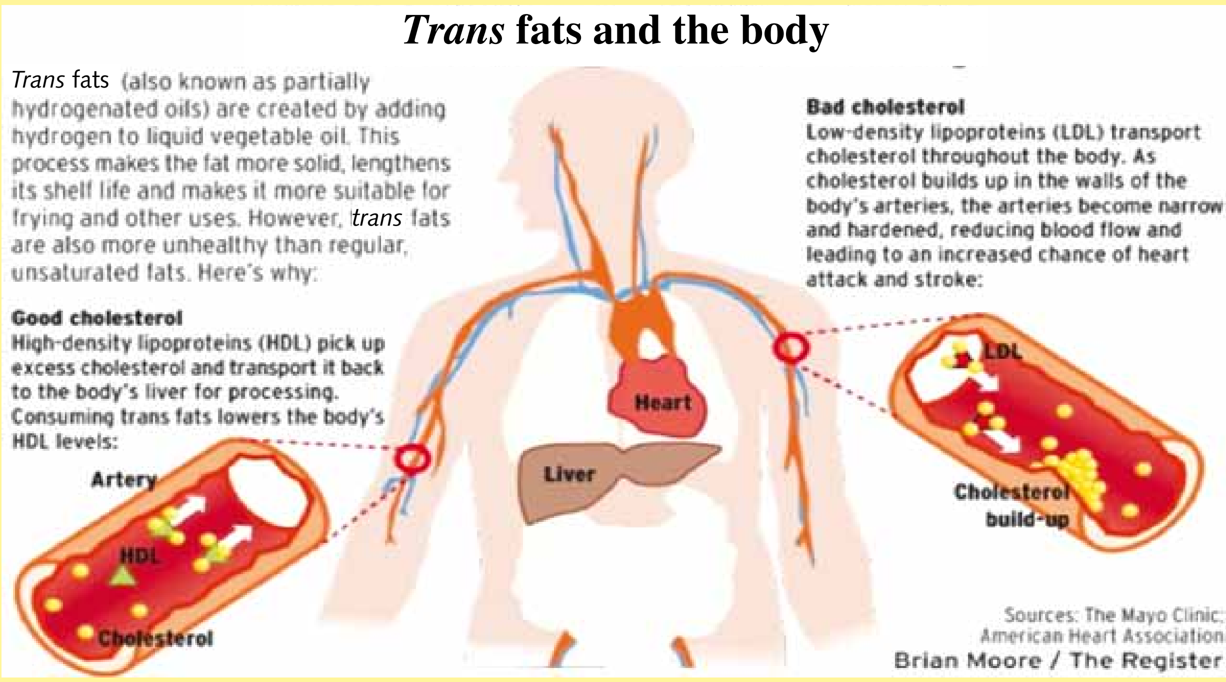


Figure 2. Complete chemical hydrogenation and partial hydrogenation.

cardiovascular disease (CVD) risk by raising blood low density lipoprotein cholesterol (LDL-C), triglycerides (TG), lipoprotein (a) and lowering high density lipoprotein cholesterol (HDL-C) (Mensink and Katan, 1990; Sundram *et al.*, 1997; Teng *et al.*, 2010). A recent meta-analysis of 13 randomised controlled trials indicated that replacement of TFA with either polyunsaturated fatty acids (PUFA), monounsaturated fatty acids (MUFA), or saturated fatty acids (SFA) increased the total cholesterol (TC) to HDL-C ratio, increased the ratio of apolipoprotein B (apo-B) to apolipoprotein A (apo-A), and increased lipoprotein (a) levels (Micha and Mozaffarian, 2009). Replacement of either saturated or *cis* unsaturated fats with TFA also raises LDL-C and reduces HDL-C (Mozaffarian *et al.*, 2006). Each of these changes in serum lipids is independently associated with higher CVD risk.

Apart from lipid markers, TFAs also have been implicated in inflammation, endothelial dysfunction, adiposity and



insulin resistance. TFAs raise the level of inflammatory markers such as C-reactive protein (hs-CRP), Interleukin-6 (IL-6) and Tumor necrocis factor-α (TNF-α) (Mozaffarian *et al*., 2004; Lopez-Garcia *et al*., 2005). These pro-inflammatory markers are often linked to CVD. TFAs consumption produces endothelial dysfunction by raising plasma markers such as soluble adhesion molecules (ICAM-1, VCAM) and E-selectin. TFAs intake may increase weight gain and visceral fat accumulation by affecting adipogenesis (Field *et al*., 2007). Recent studies have also implicated TFA with insulin resistance, a marker for type two diabetes mellitus in overweight individuals (Louheranta *et al*., 1999). Meta-analysis of four prospective cohort studies on the relationship between TFAs and CHD have reported that each 2% increase in energy intake from TFAs was associated with a 23% higher incidence of myocardial infarction and CHD death (Mozaffarian *et al*., 2006). These findings served to highlight additional concerns about safety of TFA in humans.

PALM OIL- A NATURAL TFA SUBSTITUTE

Elimination of TFAs from food sources resulted in pursuit to find for the best alternative fat replacer to replace TFAs. Technically, reformulation of the fats is to exclude TFAs and simultaneously preserve the structural and palatable characteristics of the food product (*e.g.*, mouth-feel, plasticity, and flavour). The logical and cost effective choice would be a semi-solid vegetable oil such as palm oil.

Deep-frying is an important culinary method in cooking. For deep-frying purposes the frying oil or fat should have low PUFA content. As high PUFA content frying oil tends to oxidize very rapidly, industrial frying operations prefer to use solid fats rather than liquid oils to minimise oxidation of the oils and to extend the shelf life of the fried products. Interestingly, very few of unsaturated oils can be used for industrial frying. The common practice is to use partially hydrogenated liquid oils. Palm olein has been shown to be stable during industrial (continuous) frying operations. Another common alternative is to blend unsaturated vegetable oils with palm olein to reduce the overall linoleic acid content and confer stability to such blends (Nor Aini *et al*., 2000).

The 50% SFA content, higher melting points and structure of triacyglycerol in palm oil allow it to be incorporated in food products without hydrogenation. Palm oil and its fractions are the best candidate to formulate *trans*-free margarine, vanaspati, bakery products and other solid fats. Fractionation of these oils by physical methods allows the isolation of fractions with different melting points suitable for numerous applications (Deffense, 1985). Typical palm oil fractions are palm olein (liquid oil), used as an ingredient in cooking and salad oils; and palm stearin (hard fat), used as an ingredient in frying fats, shortenings, and margarines.

The natural semi-solid fat in the range of 20%-25% solids at 20°C in palm oil enables it to be incorporated into shortening formulations. The semi-solid state of palm oil stabilizes shortening and allows its use in various applications in baking such as cakes, breads, sweet dough, pastry and bread fats (Noraini *et al*., 2000). Palm-based margarines are healthy alternative choice to TFA containing margarines.

Interesterification is usually done by interesterifying high-saturated hard fats (*e.g.*, palm oil, palm stearin, and fully hydrogenated vegetable oils) with liquid edible oils to produce fats with intermediate characteristics. Chemical and enzymatic interesterification has been specially used in the formulation of margarines and shortenings (List *et al.,* 1995) to provide products with no TFAs which still maintain physical properties, taste, and stability. Some of the zero *trans* margarines may have a higher content of SFA (32% SFA, 0% *trans* fat) compared to conventional margarines that contain 8.5% to 23.4% SFA and 15% to 28% *trans* fat (List *et al*.,1995).

Vanaspati or vegetable ghee is widely used in cooking fat in many developing countries such as Pakistan, India, West Asia, Afghanistan and South East Asia. Iran has high consumption up to 75% of PHOs. The TFA content in Iranian households is around 25%-35% and go up to 50% in food industries (Mozaffarrian *et al*., 2007). Palm oil has been the excellent choice to reduce TFA in these products. Palm oil also enables the production of various textures of vanaspati products ranging from smooth to granular, depending on specific culinary choices. It is also possible to produce vanaspati using 100% palm oil and the product has been found to be highly acceptable in many West Asian countries (Noraini *et al*., 2000).

POTENTIAL IMPLICATION OF TFA REPLACEMENT ON PALM OIL INTAKE

If TFA are replaced by palm oil, the potential exists for a significant change in the overall pattern of fatty acid consumption from TFA to SFA. Several controlled feeding studies have shown that palm oil, that contains 50% SFA [45% palmitic (16:0), 5% stearic (18:0)], 40% MUFA, and 10% PUFA has no detrimental effects on blood lipid profiles. In fact, in some studies, a slight positive effect on HDL cholesterol and lipoprotein was observed. Experiments with animal models have indicated that palm oil shows antithrombotic effects similar to those exerted by PUFA. Unprocessed and processed palm oil contains rich amounts of tocopherols and tocotrienols (vitamin E), and crude palm oil is the richest natural plant source of carotene in terms of retinol equivalents (vitamin A) (Ong, 1994) which have excellent antioxidant properties.

CONCLUSION

TFAs do not provide any known nutritional benefits, but produce unfavourable health effects. Switching from TFA to palm oil may produce a relative improvement in the dietary quality of processed foods that traditionally contained TFA. Current trends indicate that the palm oil will continue to be used in the food industry as an alternative to TFAs and providing nutritional benefits to the public.

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