World Nutrition

Volume 2, Number 4, April 2011
Journal of the World Public Health Nutrition Association
Published monthly at www.wphna.org

The Association is an affiliated body of the International Union of Nutritional Sciences
For membership and for other contributions, news, columns and services, go to: www.wphna.org

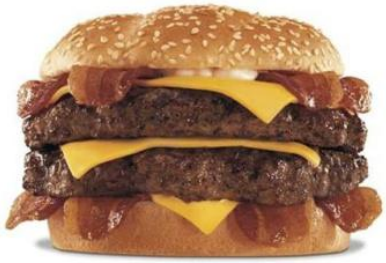
Commentary. The big issue is ultra-processing

The hydrogenation bomb

Carlos Monteiro
Centre for Epidemiological Studies in Health and Nutrition
University of São Paulo, Brazil
Biography posted at www.wphna.org

Cite as: Monteiro C. The big issue is ultra-processing. The hydrogenation bomb. [Commentary] *World Nutrition* April 2011, **2,** 4, 176-194

Introduction



Virtually all food is processed in some way before it is consumed. If crop and animal cultivation and breeding, and food preparation and cooking, are counted as types of processing, then only wild food eaten raw is unprocessed. The development of human settlements, cities, and civilisation was made possible by the development of methods of cultivating, breeding, preserving, preparing and cooking food. Various industrial methods of processing, such as airtight bottling, canning, pasteurisation, vacuum packing, sealing, and chilling and freezing, enable the worldwide distribution of food, and make it microbiologically safer and available all year round. Points like these are often made, properly and correctly, by food industry representatives.

So it would be foolish to claim or imply that food processing in general is harmful to health. Indeed, some industrial food processes have negligible effects on the quality of the food when fresh, or are beneficial directly or indirectly. Drying, freezing, and steaming, are examples. These can be classed as benign. Other types of process have the effect of degrading the original fresh food at least to some extent, but also have benefits, such as making food more palatable or available. Polishing, canning and boiling, are examples. These are more or less neutral. The processes mentioned so far can all be described as 'minimal' in their effects, and in the classification used in this series of commentaries, minimally processed foods are grouped with fresh foods. (See Table 1, below).

Some processes useful to preserve foods, or for other technical or commercial reasons, are malign in their effect on health, unless the resulting foods are consumed only occasionally. These include the age-old traditional processes of salting, salt-pickling, and smoking. There is also an industrial food process, now known to be intrinsically malign, which continues to have a far more devastating effect on human health than these traditional methods, if only because the scale of its use and its continued presence in a vast range and number of ultra-processed products. This is hydrogenation. Oils are hydrogenated so as to have a higher melting point, to become solid like animal fats, and to be less susceptible to oxidation and thus rancidity. Hydrogenated oils (also known as hydrogenated fats) have been and often still are an essential part of practically all types of ultra-processed packaged products that contain fat and that have long shelf lives. (Again, see Table 1, below).

Industrial hydrogenation is harmful to health because it converts healthy poly- and mono-unsaturated fatty acids, from plant and also animal and marine sources, into unhealthy saturated fatty acids and also toxic *trans* fatty acids. Together with industrial animal production, hydrogenation is the overwhelming reason for the rise in production and consumption of saturated fats to levels known to be an important cause of cardiovascular disease, the biggest single cause of death in the world (1).Alone, hydrogenation is the sole cause of the introduction of industrial *trans* fats in food supplies and thus diets, with all the harmful consequences caused by their consumption.

Hydrogenation amounts to a vast chemical experiment whose consequences could not have been known at first. In this respect it is similar to the experiments that resulted in baby formula, whose risks are now well known. Yet until recently few nutrition scientists or policy-makers have paid much attention to hydrogenation as such. It has in effect been a ticking time-bomb. The bomb exploded in the last two decades, with the realisation that *trans* fats, artificial substances created by the partial hydrogenation process, are especially liable to cause heart disease (2,3). It is now generally agreed that there is no safe upper limit for consumption of *trans* fats (4). Together with reduction of energy-dense ultra-processed products and sugared soft drinks, the greatest challenge of all in public health nutrition, is how to reduce saturated fats and to get rid of industrial *trans* fats from the world's food systems. This implies prompt elimination not just of *trans* fats, but of all forms of the hydrogenation process used to produce human food and animal feed.

Discussion

Box 1

Hydrogenation: My view

Like practically all nutrition scientists concerned with public health, I agree that at present levels, consumption of saturated fatty acids and *trans* fatty acids in industrialised countries and settings, and increasingly now also in lower income countries, are a major cause of serious including deadly diseases.

But I also believe that this way of describing what remains a huge global public health crisis, and increasingly so now in most lower-income countries, has limited value, is misleading, and does not address the real issue. The focus of attention should not primarily be chemical constituents of foods. It should be the driver of increased production, supply and consumption of saturated fats and *trans* fats, which is the process of hydrogenation itself. This converts oils rich in healthy mono- and poly-unsaturated fatty acids into saturated fats, and when partial, generates large amounts of *trans* fatty acids.

Especially since the middle of the last century, consumption of saturated fats has increased as a result of the industrial production of animals and their products, and also the promotion of cow's milk. As well as this, the use of hydrogenation by food manufacturers has resulted in huge increases of saturated fats in industrialised food systems and therefore in dietary patterns first of high-income countries, and now of most countries. Also, *trans* fats, in the form known to be toxic, are a product of the hydrogenation process.

Identification of hydrogenation, the process, rather than saturated and *trans* fats, the chemical constituents produced by the process, as the main problem, has vast public policy implications. I am sure that official and other expert recommendations made in the last half-century to reduce consumption of naturally occurring sources of saturated fats, such as fresh meat, full-fat milk, butter and other dairy products, are appropriate. The industrial production of animals increases the levels of saturation in their body fat, as well as making meat, meat products, and dairy products, cheap and liable to be consumed excessively.

But a prime focus of public health attention always should have been hydrogenated oils (also known as hydrogenated fats), and the products that contain them as ingredients. Hydrogenated oils/fats have been and are contained in practically any type of energy-dense ready-to-heat or ready-to-eat 'fast' or 'convenience' meals, dishes, and snack products that include fat and that have longer shelf-lives. (See Table 1).

The most recent UN advice on prevention of cardiovascular disease states: 'The potential effect of human consumption of hydrogenated oils … is of great concern' and includes in its dietary recommendations: 'Avoiding the use of hydrogenated oils and fats in cooking and manufacture of food products' (2). I emphatically agree. The issue is not so much avoiding the consumption of industrially produced saturated fats and *trans* fats, which puts the burden on customers and consumers, as eliminating the manufacture of hydrogenated oils/fats. The solution now becomes apparent. It is time to make the hydrogenation process illegal.

A very short history of hydrogenation

The function of hydrogenation is to convert liquid oils which become rancid, into semi-solid or solid stable fats. Among other things this lengthens the shelf-life of packaged ultra-processed products. Its first use was in the manufacture of the industrially produced food ingredient, margarine.

Margarine: edible alchemy

Chemists who created margarine and later, hydrogenation: Michel-Eugène Chevreul, Hippolyte Mége-Mouriés, Paul Sabatier, Wilhelm Normann

The story of hydrogenation is bound up with that of margarine, but margarine preceded hydrogenation. In 1813 the French chemist Michel-Eugène Chevreul, pictured above (left) in 1887 at the age of 100, identified the saturated fat margaric acid, now known as heptadecanoic acid. He identified and named stearic acid and oleic acid, devised improved soaps, and invented the modern candle made not with tallow or wax but with stearic acid.

The authorities in the France of Napoleon III were anxious to ensure that their armies and workers were fed enough fat at a time of butter shortages and imminent war. In 1869 Hippolyte Mége-Mouriés, a protégé of Chevreul (pictured next to him above) patented the first margarine, made from tallow with some skimmed milk, which cost half the price of butter. In 1871 he sold the rights to the Dutch firm of Jurgens, which after a series of mergers became part of the Anglo-Dutch conglomerate Unilever, now the world's largest manufacturers of fats and oils used as the basis for soaps, detergents, and in various edible forms. Margarine factories were in business in Europe and the US as from the 1870s. In 1900 world annual margarine production was about 400,000 tons (5). The product was mainly used by lower class people as a cheap substitute for lard and tallow.

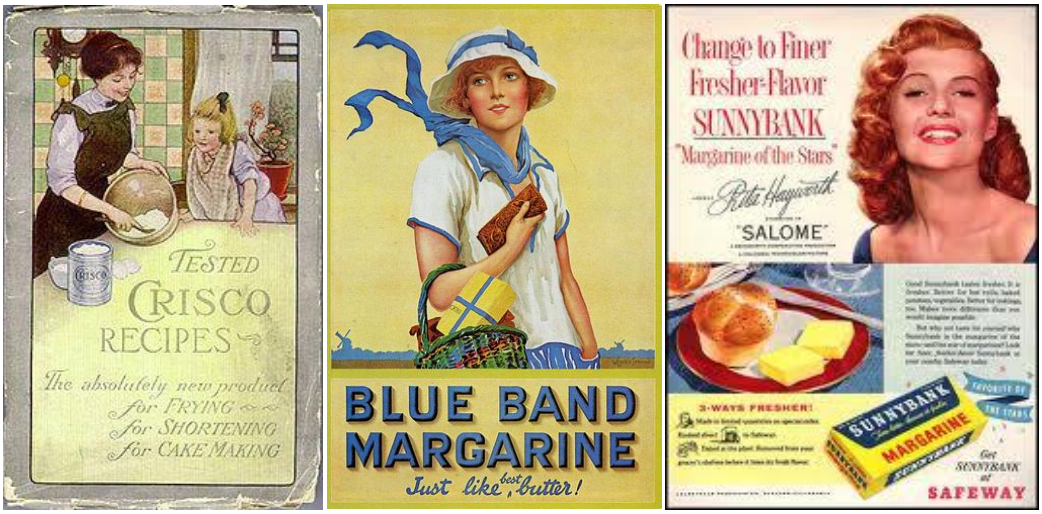
The hydrogenation bonanza

Margarine became big business as a result of the invention of the hydrogenation process. The Frenchman Jean Sabatier (in academic robes, above) discovered in 1897 that the reason that oils are fluid is because they contain less hydrogen than solid fats such as butter, tallow and lard. The German chemist Wilhelm Normann (right, above) invented the hydrogenation process, patenting it in 1902. Essentially this involves pushing hydrogen into oils with the use of metal catalysts and in effect forcing it into their chemical structure. Hence the name: 'saturation' means

'saturation with hydrogen'. The process now is basically the same as then, while now being far more sophisticated then it was a century ago (6-8).

Hydrogenation was a technical development of stupendous commercial importance. It meant that hard, stable margarines and all sorts of other edible fats could be made from any type and any combination of refined edible animal or plant oil, including that available very cheaply from tropical countries (8).

Until late last century hydrogenation was not seen as problematic. In 1911 the then US soap and candle manufacturer Proctor and Gamble formulated a product made with hydrogenated cottonseed oil, for use in home cooking, in frying, and for pastry, bread, cakes, cookies (biscuits) and other baked items. It was essentially a type of margarine, but with no water, and a higher flash point. It was cheaper than lard and remained stable for years. It became known as 'shortening' – hence 'shortbread', and the ditty 'Mama's little baby loves shortenin' shortenin'; Mama's little baby loves short'ning bread'. The cover of the first cookbook promoting the first shortening, published in 1912, is shown below. Other shortenings were formulated and branded, and in many countries replaced lard in use for home baking, frying and broiling (roasting). (The product named in the picture now has a different manufacturer and formulation. It is now a mix of naturally saturated fats with oil. Its label states that of every 12 gram serving 3 grams is saturated fat and 8.5 grams is unsaturated).



Shortening and margarines with images of homely, country and glamorous women: 1912, 1930s, 1954. Historic products like these are now reformulated.

Production and consumption of hydrogenated margarine took off at the same time. For half a century after the introduction of hydrogenation, margarine, which is roughly 80 per cent fat and 16 per cent water, was made from any suitable and commercially attractive animal fats, such as beef or mutton tallow, pig lard, or whale or fish oils, or from plant oils, such as coconut, palm, olive, peanut, cottonseed, soya

or sunflower, singly or in combination. The rest was mostly salt, flour, added vitamins, and an array of additives (9). While commercially enormously attractive, it was also seen as beneficial, especially for families on tight budgets and at times of shortages of food. As shown in the pictures above, publicity for margarine, notwithstanding is cheapness, hinted that it was better than butter, constantly associated it with quality, and with the charms of women, as mothers, providers and the stuff of dreams. Historic products such as those shown in the pictures above have also been reformulated – see below.

By 1925 world annual production of margarine was around a million tons. The figures for 1950, 1960, 1970, 1980 and 1990 are in round numbers, 2, 4, 5, 7.5 and 9 million tonnes (or billion kilograms) a year. In the US, where more detailed data are available, total consumption of butter and margarine together remained at around an average of 10 kilograms a person a year until around 1980. In 1930, on average people in the US ate about three times more butter than margarine. In the Second World War butter was often in short supply, and consumption of margarine rose. Around 1950 it overtook that of butter. By 1970, twice as much margarine as butter was produced and consumed. Thereafter in the US consumption of margarine sold as such dropped. Since the 1990s butter consumption in the US has remained roughly constant, and is now again about the same as that of margarine.

Up to the 1980s practically all margarine was of the hard block type. Hard margarines and shortenings contained very high levels of saturated fats, and a considerable quantity of *trans* fats. Formulations of specific brands of margarine made in this period are not known. But until the 1960s, fatty food was generally not seen as a special problem, even in high-income countries, and few people outside the trade thought about saturated fats, let alone *trans* fatty acids.

Many older readers of this commentary, from most countries where cardiovascular disease became epidemic as from the 1950s and 1960s, when younger may well have consumed large amounts of industrially produced saturated fats and *trans* fats. Any firm estimate of the percentage of deaths from cardiovascular disease caused as a result of consumption of hard margarine and shortening, which might be expected to peak say 20 years after regular consumption, would depend on information on product formulation. From what is known now, any reasonable estimate would, I believe, amount to a substantial percentage. (See Box 2).

Beginning of the end of home cooking

At first, the main sources of hydrogenated oils/fats were margarine and shortening, and foods made at home using them as spreads or ingredients. Soon though, there was a second stage. Various types of commercial baked and other goods sold in shops, such as pies, pastries, cakes, cookies (biscuits), and breads, and early forms of ready-to-eat shop or street foods such as fatty snacks, fried fish, French fries (chips)

and chips (crisps) also switched their recipes and used the cheaper hydrogenated oils/fats in industrial quantities.

The industrial use of hydrogenation dramatically increased notably in high-income countries as from the 1940s. In countries involved in the Second World War, a major reason was the war itself. A rapidly increasing number of women worked outside the home. Far more people ate out and did not cook regularly at home. 'Convenience' food was increasingly seen as desirable and even essential. As a result, manufacturers and retailers rapidly increased production and sale of the types of product mentioned above, and they increasingly displaced food eaten in the form of meals.

As from the 1950s in high-income countries, television was introduced and very rapidly spread, and with it the 'tv dinner', seen below in the picture taken in the US in 1952. Meals increasingly became displaced by snacks. Early forms of any type of savoury snack food would usually have been made with the use of hydrogenated oils/fats. A more sophisticated version of the tv dinner is indicated in the second picture below. Until recently many forms of fatty 'fast food' products made with the use of hydrogenated oils/fats have contained very high levels of saturated fats and *trans* fats. Some still do.

An early tv dinner (1952) and a sign for 24/7 fast food (recent). These US habits have become global, with the aid of cheap hydrogenated oils/fats.

In the US and other high-income countries, rates of death from cardiovascular disease rose very rapidly indeed from the 1940s, peaked around the 1960s, and started to fall from very high levels in the 1970s. For the last half century the judgement of experts in the field has been, and with some exceptions remains, that the main single dietary cause of cardiovascular disease is excessive consumption of saturated fats. I agree with this judgement. Again, what proportion can be attributed to consumption – and production – of hydrogenated oils/fats, as distinct from animal sources such as meat, milk and their products, remains a matter of conjecture.

Bearing in mind that hydrogenated oils/fats also contain toxic *trans* fatty acids, I believe that a safe guess would be a substantial proportion. (Again, see Box 2).

Margarine reformulation

Since the 1980s, margarine manufacturers have been well aware that excessive amounts of saturated fats are a major cause of heart disease, and gradually and then more rapidly reformulated many of their product lines, to improve their fatty acid composition. This has been an important positive change from the public health point of view. The pre-eminent oils used now as the basis for margarine and other fat spreads are only from plant sources, notably corn, soya, rapeseed (canola), sunflower, and olive.

Then beginning in the 1990s, as evidence of the toxicity of *trans* fatty acids accumulated, manufacturers of margarines made further reformulations, to reduce *trans* fat content. 'Old fashioned' stick margarines made using the partial hydrogenation process contained high percentages of their fats and therefore calories in the form of *trans* fats. In the 1990s this changed rapidly. For instance, in the US between 1992 and 1999, the *trans* fat content of stick margarines dropped from 19.5 to 8.8 per cent, and the *trans* fat content of soft table spreads is much lower. Further cuts are constantly being made. In properly regulated countries, the labels of margarines now state their current fatty acid composition, and a claim on labels or by caterers that their products are free from *trans* fats will be made in accordance with regulations agreed with national government statutory agencies. Many parts of the world are not yet well regulated.

The unresisted rise of ultra-processed products

Since the 1980s in high-income countries, and later in lower-income countries, the history of hydrogenation and its uses has largely also been the history of the so-far generally unresisted rise of ultra-processed products. For an initial account of these, please access my first ***World Nutrition*** commentary (10). This includes a table (adapted as Table 1, below) making three classifications, of Group 1 unprocessed and minimally processed foods, Group 2 processed culinary and industrial ingredients, and Group 3 ultra-processed products. The general thesis of this and subsequent commentaries, is that the big public health issue is not foods, and not nutrients, so much as what is done to foods before they are purchased and consumed. Specifically, the big issue is ultra-processing, and within this, one of the biggest issues is hydrogenation. The table below shows, in red, the ingredients (margarine and shortening) made by hydrogenation, and the types of ultra-processed products that contain hydrogenated oils/fats (11,12).

Table 1

Food classification based on the extent and purpose of industrial and other processing.

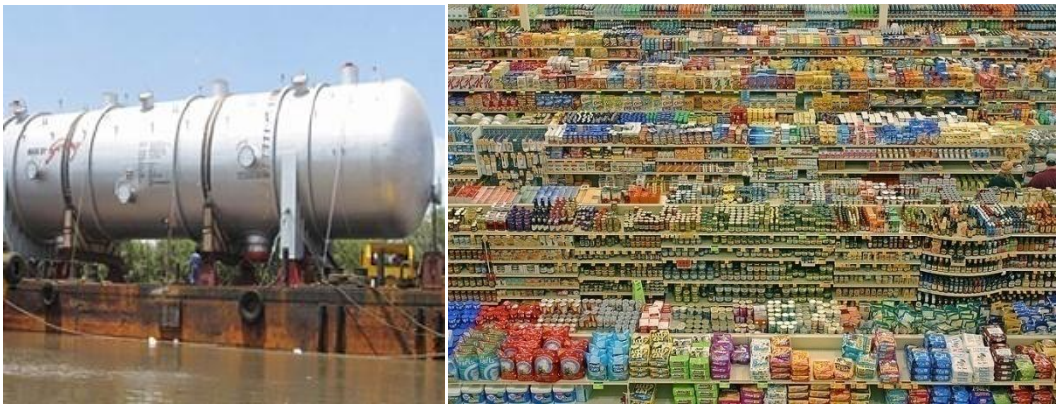
Types of products containing or liable to contain hydrogenated oils/fats are shown in red *

Food group	Extent, purpose of processing	Examples[1]
Group 1 foods Unprocessed or minimally processed foods	No processing (as defined here), or mostly physical processes used to make single whole foods more durable, accessible, convenient, palatable, or safe. Specific processes include cleaning, removal of inedible fractions, grating, squeezing, draining, flaking, drying, parboiling, bottling (without additions other than water), chilling, freezing, fermentation (when the result is not alcoholic), pasteurisation, vacuum and gas packing, and simple wrapping.	Fresh, chilled, frozen, vacuum-packed fruits, vegetables, fungi, roots and tubers; cereals (grains) in general; fresh, frozen and dried beans and other pulses (legumes); dried fruits and 100% unsweetened fruit juices; unsalted nuts and seeds; fresh, dried, chilled, frozen meats , poultry and fish; fresh and pasteurised milk, fermented milk such as plain yoghurt; eggs; teas , coffee, herb infusions, tap water, bottled spring water
Group 2 ingredients Processed culinary or food industryingredients	Extraction and purification of components of single whole foods aiming the production of ingredients used in the preparation and cooking of dishes and meals made up from Group 1 foods in homes or on the spot in catering outlets, or else in the formulation by manufacturers of Group 3 foods. Specific processes include pressing, crushing, milling, refining, 'purifying', hydrogenation, hydrolysation, extrusion, and use of enzymes and additives.	Vegetable oils, **margarine, shortening,** butter, milk, cream, lard; sugar, sweeteners in general; salt; starches, flours, 'raw' pastas and noodles. Food industry ingredients usually not sold to consumers as such, including high fructose corn syrup, lactose, milk and soy proteins, gums and similar products.
Group 3 products Ultra-processed products *Unless explicitly stated otherwise on labels, it is best to	Combination of already processed group 2 ingredients usually with some unprocessed or minimally processed group 1 foods in order to create durable, accessible, convenient, and palatable drinks or ready-to-eat	**Breads, biscuits (cookies), cakes and pastries; ice cream**; jams (preserves); fruits canned in syrup; **chocolates, confectionery (candies), cereal bars, breakfast cereals with added sugar; chips (French**

assume that any product shown in red in this table contains hydrogenated or partially hydrogenated oils/fats. A statement that a product contains no *trans* fats does not mean that it contains no hydrogenated oils/ fats.	or to-heat products liable to be consumed as snacks or desserts or to replace home- or restaurant-prepared dishes and meals.. Specific processes include as well as those listed above, baking, battering, frying, deep frying, curing, smoking, pickling, canning, use of preservatives and cosmetic additives, the addition of synthetic vitamins and minerals, and sophisticated types of packaging.	**fries), crisps (chips), sauces; savoury and sweet snack products**; cheeses; sugared fruit and milk drinks and sugared and 'no-cal' cola and other soft drinks; **frozen pasta and pizza dishes; pre-prepared meat, poultry, fish, vegetable and other 'recipe' dishes; processed meat including chicken nuggets, hot dogs, sausages, burgers, fish sticks; canned or dehydrated soups, stews and pot noodles;** salted, pickled, smoked or cured meat and fish; vegetables bottled or canned in brine, fish canned in oil; infant formulas, follow-on milks, baby food.

Adapted from (11, 12).
[1] These listings do not include alcoholic drinks. The examples given are not meant to be complete. Many others can be added, especially to Group 3.

The scale of production and consumption of energy-dense fatty ultra-processed products, at first in higher-income countries, and now in most lower-income countries, is colossal. The pictures below give a glimpse. That on the right is of a supermarket in the US. Most of the types of packaged 'long life' ultra-processed fatty products shown here are liable to contain hydrogenated oils/fats. The picture on the left was taken in India. It shows a hydrogenation machine being delivered to its destination by barge on a river. Its purpose may be to produce human food, animal feed, or drugs or chemicals.



Hydrogenation comes by boat in India (left). Fat in most types of fatty 'long-life' ultra-processed packages in supermarkets (right) is hydrogenated.

The trans fat time bomb

Trans fatty acids became identified as a public health issue at first in the 1980s (13). Decades later it is now generally agreed that *trans* fats are in effect toxic, and that there is no safe upper limit for their consumption. The implication is that industrial *trans* fats should be eliminated from food systems. In practice this implies elimination of hydrogenation (2-4, 14). (Again, see Box 2, below).

Some distinguished researchers, including a group at the Harvard School of Public Health, are inclined to the view that *trans* fats are the pre-eminent issue. Recent studies published in the influential *New England Journal of Medicine* stress the toxicity of *trans* fats, and estimate that the number of cardiac deaths attributable to specified amounts of *trans* fats in the US is around 23 per cent of the total, amounting to between 30,000-100,000 deaths a year (15,16). A paper published as this commentary was being prepared suggests that naturally occurring saturated fats are not in themselves a big public health issue, unless they crowd out healthy unsaturated oils from food supplies and thus diets (17).

I do not share this view. The evidence known to me shows, without any serious doubt, that indeed *trans*-fatty acids are toxic, and as such an acute cause of cardiovascular and probably other diseases, that their dangers have been overlooked, that industrial *trans* fats are an artificial element in food supplies, and that they should be eliminated. So far I agree. But this does not mean that saturated fats, of any origin, present in the quantities they are in industrialised food supplies, are not a problem. They are.

Furthermore, as I have I hoped made clear by now, reduction of *trans* fats, which manufacturers can do without significantly affecting their portfolios of fatty energy-dense ultra-processed products, is not the way forward. It would be a mistake to focus only on *trans* fats.

Recently, manufacturers and caterers of ultra-processed products have followed margarine manufacturers, and have also reformulated many of their products with the declared purpose of reducing their saturated fat and *trans* fatty acid content. This positive change does not, however, make these products healthy. For example, potato and corn chips (crisps) made with plant oils are still high energy-dense salty snack products, that consumed in quantity as part of a generally energy-dense diet, will cause overweight and also problems caused by excessive sodium. Furthermore, marketing of reformulated products that make health claims based on the nature of their fat content and absence of *trans* fats, implying that such products can be consumed constantly, could even cause a public health crisis even worse than now.

The *trans* fat content of all sorts of ultra-processed products and also fast foods has varied and continues to vary greatly, in different countries and settings. Papers and

reports making recommendations on oils and fats in food supplies, addressed to industry as well as customers and consumers, tend to assume a well-regulated local environment, which in many lower-income countries and settings does not exist.

The position of this commentary is that more intense forms of hydrogenation, which do not generate substantial amounts of *trans* fats, but which generate larger amounts of industrial saturated fats, should also be eliminated. All forms of hydrogenation in the manufacture of human food, and also animal feed, should become illegal, worldwide. This will require the agreement of UN member states, as a food safety issue, and as such administered by the UN Codex Alimentarius Commission, and enforced by the food safety divisions of national governments.

Box 2

Hydrogenation. The damage done

Hydrogenation of oils, when partial, increases the amount of saturated fats in food supplies, and also generates *trans* fats, an artificial and in effect a toxic type of unsaturated fat. More intensive forms of hydrogenation greatly increase saturated fats. Hydrogenation of all types is damaging to health and certainly is a substantial cause of heart disease. The only question is just how big a part it has played and continues to play.

There have been many attempts made to estimate the percentage of deaths from cardiovascular disease attributable to over-consumption of saturated fats (or to corresponding under-consumption of healthy oils), and more recently specifically to *trans* fats, and also to obesity. Any estimate can only be in round figures or ranges, and it is agreed that smoking and use of tobacco, and also physical inactivity, are important causes. The amount attributable to saturated fats and to *trans* fats taken together, with some weighting for obesity, might be a high percentage. Any estimate is likely to be substantial. An estimate for the period between say 1930 and 1990, allowing for a time-lag between exposure and clinical appearance of disease, might well be considerably higher than any estimate made now, bearing in mind product reformulations made since the 1980s.

But suppose that it is now a fairly modest 20 per cent, and suppose that of this half is attributable to saturated fats not generated by hydrogenation. That makes 10 per cent, which in my view is a low figure. At current global rates (1), this makes around 1.8 million deaths a year, from heart disease alone, attributable to hydrogenation. The figure corresponding to projected global heart disease death rates for 2030 is around 2.4 million deaths a year. This is roughly a quarter of the 10 million deaths a year projected as attributable to tobacco. The figure of 10 per cent is a conjecture. If a reasonably accurate estimate turned out to be a lot lower, say 5 per cent, the number of annual deaths would be around 900,000 a year now and 1,200,000 a year as projected for 2030.

Any estimate of the total number of deaths from heart disease alone, attributable to hydrogenation since its introduction almost a century ago, would surely amount to tens and perhaps to many tens of millions.

Trans fats

A report on fats issued by the Food and Agriculture Organization of the UN in 2010 (14) states as follows, specifically on the issue of *trans* fats. (Paragraphing has been introduced).

'There is convincing evidence that TFA [*trans* fatty acids] from commercial partially hydrogenated vegetable oils (PHVO) increase CHD risk factors and CHD events – more so than had been thought in the past. There also is probable evidence of an increased risk of fatal CHD and sudden cardiac death in addition to an increased risk of metabolic syndrome components and diabetes.

'In promoting the removal of TFA, which are predominantly a by-product of industrial processing (partial hydrogenation)... particular attention must be given to what would be their replacement; this is a challenge for the food industry. It was noted that among adults, the estimated average daily ruminant TFA intake in most societies is low. The experts acknowledged the current recommendation of a mean population intake of TFA of less than 1%E may need to be revised in light of the fact that it does not fully take into account the distribution of intakes and thus the need to protect substantial subgroups from having dangerously high intakes.

'This could well lead to the need to remove partially hydrogenated fats and oils from the human food supply'.

My comment here, is that the task is not just to eliminate *trans* fats and thus partially hydrogenated oils/fats. It is to identify all forms of hydrogenation as in effect toxic, and to make the process illegal, worldwide.

Seven objections to hydrogenation

The hydrogenation process became a feature of industrial food systems almost a century ago. It was well-intentioned. At that time, consumption of fat and of saturated fat was generally low, and energy-dense foods were often needed. Chronic diseases were not a big issue. This was decades before domestic refrigeration became common, and well over half a century before the identification of the toxic effects of *trans* fats. But hydrogenation, in all its forms, is a malign food process. Its cheapness and its technical, industrial and commercial benefits do not justify its use.

1 It is in effect a huge experiment whose results have proved to be disastrous

Technically hydrogenation makes sense. It turns liquid oils that become rancid, into hard fats that are stable. Commercially it also makes sense. It enables oils from any animal or plant source to be converted into a uniform product, for use as a table fat (margarine), in cooking, and particularly in the manufacture of ultra-processed products with long and sometimes very long shelf lives. Hydrogenation has made fatty energy-dense ultra-processed cheap packaged products with long shelf lives, lead lines in every type of shop that sells food, from supermarkets to convenience stores, gas stations, and vending machines. But the human organism is not evolved to tolerate saturated fats in the amounts present in industrialised food supplies. Also, *trans* fats of industrial origin are toxic in their effects. The hydrogenation process amounts to a vast experiment that has never been monitored with public health in mind, and until recently has been almost completely overlooked.

2 It is a major cause of cardiovascular disease

By generating saturated fats and also *trans* fats, as contained in a vast number of cheap industrial ingredients and ultra-processed products, hydrogenation is a substantial cause of cardiovascular disease, the biggest single cause of death in the world. (See Box 2, above).

3 It enables a vast increase in energy-dense ultra-processed products, and therefore obesity

As shown above, the history of hydrogenation falls into three phases. Its main original use, since early last century, has been for the manufacture of table and cooking fats. Its second use, since around the middle of the last century, has been also for the manufacture of 'long life' baked goods, such as packaged cakes and biscuits. Its third use, most of all since the 1980s, is also in the manufacture of a vast range of packaged items with long shelf-lives, including ready-to-eat and ready-to-heat energy-dense ultra-processed meals, dishes and snacks. These are now being exported to and manufactured in middle- and low-income countries. These products, and therefore in large part the hydrogenation process itself, together with sugared products and drinks, are probably the main causes of the explosive global rise in overweight and obesity, including in lower-income countries.

4 It is concealed

The labels on ultra-processed products often do not state when they contain hydrogenated oils, and as far as I know rarely if ever state how much. Outside the US and a few other countries (including my own country of Brazil) the *trans* fat content of such products is not stated by law. Instead, manufacturers may choose to disclose this information, often by means of a health claim. Many products now state that

they are free from *trans* fats, including many that never contained the substance. But this does not amount to clear information. The best course of action for customers and consumers is not to buy or eat any packaged products with long shelf-lives that contain oils or fats. This is a good policy also to prevent overweight and obesity caused by consumption of energy-dense ultra-processed products. Better still, is to act as a citizen too, and tell the manager of the retail outlet that this is what you are doing, and why.

5 It has been overlooked

One of the main themes of this series of commentaries is that nutrition scientists, one of whose responsibilities is to assess the effect of food and drink on health, have focused on food either as if it is its chemical constituents, or else as if it is fresh. They generally have overlooked the impact of processing on the nature and quality of industrialised food supplies and therefore dietary patterns. Hydrogenation as such has been rarely identified as a public health problem, or even mentioned in official dietary guidelines, until recently. One likely reason is that many of the people who sit in judgement on matters of food, nutrition and public health, are either not independent from the food manufacturing industry, or else have no special knowledge of food technology. So recommendations designed to prevent chronic diseases, issued by UN agencies, national governments and other authoritative bodies for the last 50 years have been skewed – fatally so.

6 The issue is saturated fats as well as trans fats

Originally hydrogenation had two main functions. One was to increase the supply of cheap fat in food supplies, at a time when undernutrition was endemic in industrialised countries. The other was to extend the shelf-life of such fats, and of products of which they were ingredients. The result, as already stated, has been sharply to increase the amount of saturated fats in food supplies, and also to introduce industrial *trans* fats. Refrigeration and chilling make hard stick margarine redundant, and it is now not likely that margarine would be recommended as suitable for undernourished populations. However, the main use of hydrogenation now, as already stated, is in the manufacture of a vast number of energy-dense ultra-processed products. Some of these, such as some ready-to-heat meals and dishes, could if sold chilled avoid the use of hydrogenation and instead be made with oils as the fatty ingredient, as in the home, or by other methods that avoid hydrogenation. But all types of packaged fatty ready-to-eat snacks with long shelf-lives are liable to contain hydrogenated oils/fats. Customers and consumers are best advised to avoid all such products unless the label explicitly states that they contain no hydrogenated oils/fats. A claim that a product contains no *trans* fats does not mean that it contains no hydrogenated oils/fats, because the combination of fully hydrogenated oils/fats with liquid oils results in a product with no *trans* fats but lots of saturated fats.

7 Hydrogenation should be illegal

The use of hydrogenation in the manufacture of food for humans and feed for animals should be made illegal, promptly. This will require concerted action by UN member states, to agree laws that prohibit use of the hydrogenation process in the manufacture of food and feed, and use of hydrogenated oils in all forms of catering, worldwide.

Box 3

A request from the editors

Recently, manufacturers and caterers of ultra-processed fatty products have reformulated product lines so as to reduce saturated fat, reduce or avoid hydrogenation, and reduce or eliminate *trans* fats. Such reformulations are being made constantly. If any manufacturer or caterer whose lead products have contained hydrogenated oils/fats in the past, has now sharply reduced or eliminated the hydrogenation process in any of its 10 top selling lines, this information will be published in *WN*. The editors are not asking for information specifically about *trans* fats. I must make clear though, as stated in the text, that such reformulated products remain ultra-processed, energy-dense, fatty and often salty, and therefore unhealthy.

Conclusion

Hydrogenation has turned out to be the great disaster of food technology, perhaps comparable, in other areas of public health, with DDT and lobotomy. The difference is that hydrogenation is still not identified as a catastrophe.

It is technically possible to formulate fatty products without using the hydrogenation process. But making it illegal will make the manufacture of fatty energy-dense ultra-processed cheap packaged products with long shelf-lives, more difficult and more expensive. This is an additional good reason for a statutory measure. Experience indicates that proposals to make hydrogenation illegal will be resisted by industry, as is usual when any statutory public health measure of any type is proposed and then introduced. Some transnational manufacturers are already pledged to improve public health. The new laws will encourage them and other large corporations that largely control the production, distribution and sale of ultra-processed products, to evolve and to diversify. The food manufacturing and catering industries, including the snack and fast food industries, should continue to review all their technologies, and add to their product portfolios minimally processed foods such as frozen and chilled vegetables and fruits.

The automobile industry has learned to live with lead-free petrol. In many countries the coal industry has been obliged to adjust to clean air acts. Reputable employers support health and safety acts. Designated national and state parks and wilderness areas are protected from land speculators. Tobacco smoke-free zones are now generally respected. If the transnational and other big manufacturers and caterers of ultra-processed products want to stop being identified as enemies of public health, their responsibility begins at home. They should press for hydrogenation in all its forms to become illegal. This will protect them from irresponsible competitors, encourage them all to diversify their product portfolios, and will also, dare I say, make the world a better place.

References

1 Gaziano J. Global Burden of Cardiovascular Disease. In: *Braunwald's Heart Disease: a Textbook of Cardiovascular Medicine*. Eighth edition. Philadelphia PA: Elsevier Saunders, 2008.

2 World Health Organization. *Diet, Nutrition and the Prevention of Chronic Diseases.* Report of a joint WHO/FAO/UNU consultation. WHO technical report series 916. Geneva: WHO, 2003.

3 Uauy R. Nishida C. WHO scientific update on health consequences of trans fatty acids: Introduction. *European Journal of Clinical Nutrition* 2009; 63: S1-S4.

4 Institute of Medicine. Panel on Macronutrients. Report on dietary reference intakes for *trans* fatty acids. In: *Dietary Reference Intakes for Energy, Carbohydrate, Fiber, Fat, Fatty Acids, Cholesterol, Protein, and Amino Acids.* Washington DC: IOM, 2002.

5 Hoffmann G. 100 years of the margarine industry. [Chapter 1]. In: Stuyvenberg J (ed): *Margarine. An Economic, Social and Scientific History, 1869-1969*. Liverpool: Liverpool University Press, 1969.

6 Boldingh J. Research. [Chapter 5] In: Stuyvenberg J (ed): *Margarine. An Economic, Social and Scientific History, 1869-1969*. Liverpool: Liverpool University Press, 1969.

7 Rylander P, Hydrogenation and Dehydrogenation. In: *Ullmann's Encyclopedia of Industrial Chemistry*. Weinheim: Wiley, 2005.

8 Henry J. Processing, manufacturing, uses and labelling of fats in the food supply. *Annals of Nutrition and Metabolism* 2009, **55**, 273-300.

9 Frazer A. Nutritional and dietetic aspects. [Chapter 4]. In: Stuyvenberg J (ed): *Margarine. An Economic, Social and Scientific History, 1869-1969*. Liverpool: Liverpool University Press, 1969.

10 Monteiro C. The big issue is ultra-processing. Commentary. *World Nutrition*, November 2010; **1**, 6: 237-269.

11 Monteiro C, Levy R, Claro R, Castro I, Cannon G. Increased consumption of ultra-processed food and drink, and likely impact on human health: evidence from Brazil. *Public Health Nutrition.*2011; **14**,1: 5-13

12 Monteiro C, Levy R, Claro R, Castro I, Cannon G. A new classification of foods based on the nature and extent and purpose of food processing. Its use to characterise food systems and dietary patterns. *Cadernos de Saúde Publica*, November 2010; **26** (11): 2039-2049.

13 Department of Health and Social Security. *Diet and Cardiovascular Disease.* Committee on Medical Aspects of Food Policy. Report 28. London: HMSO, 1984

14 Food and Agriculture Organization of the United Nations. *Fats and Fatty Acids in Human Nutrition.* Report of an expert consultation. FAO food and nutrition paper 91. Rome: FAO, 2010.

15 Ascherio A, Katan M, Zock P, Stampfer M, Willett W. Trans fatty acids and coronary heart disease. *New England Journal of Medicine* 1999; **340**: 1994-1998. [PMID: 10379026]

16 Mozaffarian D, Katan MB, Ascherio A, Stampfer MJ, Willett WC. Trans fatty acids and cardiovascular disease. *New England Journal of Medicine* 2006; **354** (15): 1601–1613. doi:10.1056/NEJMra054035. PMID 16611951.

17 Astrup A, Dyerberg J, Elwood P, Hermansen K, Hu F, Jakobsen M et al. The role of reducing intakes of saturated fat in the prevention of cardiovascular disease: where does the evidence stand in 2010? *American Journal of Clinical Nutrition* 2011. Doi: 10.3945/acjn.110.004622

Acknowledgement and request

Readers are invited please to respond. Readers may make use of the material in this commentary, provided acknowledgement is given to the authors and the Association, and WN is cited.

Please cite as: Monteiro C. The big issue is ultra-processing. The hydrogenation bomb. [Commentary] *World Nutrition*, April 2011, **2,** 4: 176-194. Obtainable at www.wphna.org

CAM states: Geoffrey Cannon has worked with me on all these commentaries and I regard him as my co-author. They have benefited from discussions I have had in the last two years or so with Inês Castro, Renata Bertazzi-Levy, and Rafael Claro, and also with Geoffrey Cannon and Fabio Gomes, who are all co-authors with me of other papers, published and in preparation. I am grateful to Jose Alfredo Gomes Areas and Elizabeth Torres for technical advice on specific points. I have no conflicts of interest. WN commentaries are subject to internal review by members of the editorial team.