



REPLACE
TRANS FAT



**REPLACE TRANS FAT: AN ACTION PACKAGE TO ELIMINATE
INDUSTRIALLY PRODUCED TRANS-FATTY ACIDS**

MODULE 2: **P**PROMOTE

**How-to guide for determining the best replacement
oils and interventions to promote their use**



**World Health
Organization**

© **World Health Organization 2019**

Some rights reserved. This work is available under the Creative Commons Attribution NonCommercial-ShareAlike 3.0 IGO licence (CC BY-NC-SA 3.0 IGO; <https://creativecommons.org/licenses/by-nc-sa/3.0/igo>).

Under the terms of this licence, you may copy, redistribute and adapt the work for noncommercial purposes, provided the work is appropriately cited, as indicated below. In any use of this work, there should be no suggestion that WHO endorses any specific organization, products or services. The use of the WHO logo is not permitted. If you adapt the work, then you must licence your work under the same or equivalent Creative Commons licence. If you create a translation of this work, you should add the following disclaimer along with the suggested citation: “This translation was not created by the World Health Organization (WHO). WHO is not responsible for the content or accuracy of this translation. The original English edition shall be the binding and authentic edition”.

Any mediation relating to disputes arising under the licence shall be conducted in accordance with the mediation rules of the World Intellectual Property Organization.

Suggested citation. Module 2: Promote. How-to guide for determining the best replacement oils and interventions to promote their use. In: REPLACE trans fat: an action package to eliminate industrially produced *trans*-fatty acids. Geneva: World Health Organization; 2019 (WHO/NMH/NHD/19.13). Licence CC BY-NC-SA 3.0 IGO.

Cataloguing-in-Publication (CIP) data. CIP data are available at <http://apps.who.int/iris>.

Sales, rights and licensing. To purchase WHO publications, see <http://apps.who.int/bookorders>. To submit requests for commercial use and queries on rights and licensing, see <http://www.who.int/about/licensing>.

Third-party materials. If you wish to reuse material from this work that is attributed to a third party, such as tables, figures or images, it is your responsibility to determine whether permission is needed for that reuse and to obtain permission from the copyright holder. The risk of claims resulting from infringement of any third-party-owned component in the work rests solely with the user.

General disclaimers. The designations employed and the presentation of the material in this publication do not imply the expression of any opinion whatsoever on the part of WHO concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. Dotted and dashed lines on maps represent approximate border lines for which there may not yet be full agreement.

The mention of specific companies or of certain manufacturers' products does not imply that they are endorsed or recommended by WHO in preference to others of a similar nature that are not mentioned. Errors and omissions excepted, the names of proprietary products are distinguished by initial capital letters.

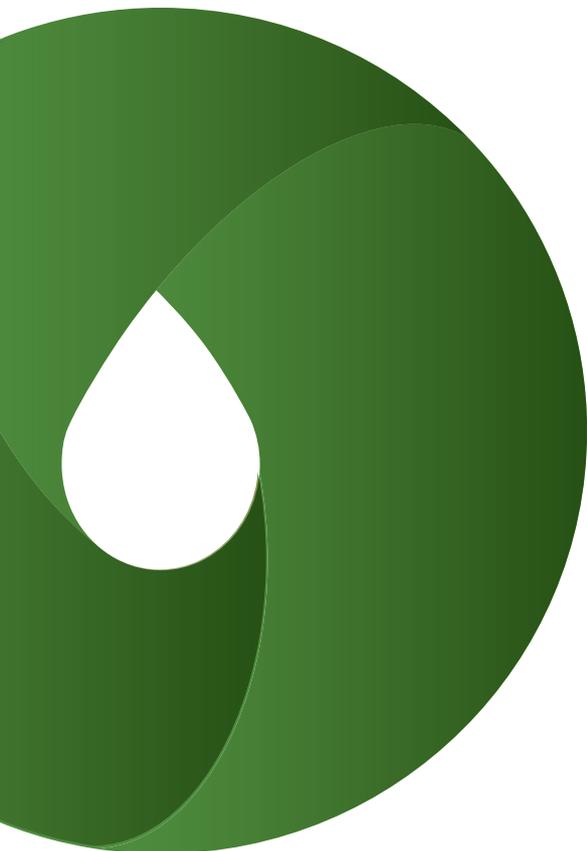
All reasonable precautions have been taken by WHO to verify the information contained in this publication. However, the published material is being distributed without warranty of any kind, either expressed or implied. The responsibility for the interpretation and use of the material lies with the reader. In no event shall WHO be liable for damages arising from its use.

CONTENTS

Acknowledgements	3
REPLACE action package	4
1. Background	6
2. Basics of oils and fats	6
3. Replacement oils and fats	8
4. Agricultural policies	12
5. Import policies	21
6. Tax incentives	21
7. Support to industry	22
References	26
ANNEX 1. Fat application glossary	28
ANNEX 2. Alternatives to PHO: overview of technical solutions	29
ANNEX 3. Sample brochure for restaurants and food service establishments	33

ACKNOWLEDGEMENTS

The REPLACE modules benefited from the dedication, support and contributions of a number of experts from the World Health Organization (WHO); Resolve to Save Lives (an initiative of Vital Strategies); Vital Strategies; Global Health Advocacy Incubator (a programme of the Campaign for Tobacco-Free Kids); and the United States Centers for Disease Control and Prevention. WHO thanks the contributing organizations and individuals for their technical inputs to the development of some or all of the modules of the REPLACE action package. WHO also thanks the numerous international experts who contributed their valuable time and vast knowledge to the development of these modules.



REPLACE ACTION PACKAGE

Elimination of industrially produced *trans*-fatty acids (TFA) from the global food supply by 2023 is a priority target of the World Health Organization (WHO). The REPLACE action package provides a strategic approach to eliminating industrially produced TFA from national food supplies, with the goal of global elimination by 2023. The package comprises:

- › an overarching technical document that provides a rationale and framework for this integrated approach to TFA elimination;
- › six modules; and
- › additional web resources to facilitate implementation.

The REPLACE modules provide practical, step-by-step implementation information to support governments to eliminate industrially produced TFA from their national food supplies. To achieve successful elimination, governments should implement best-practice legal measures (outlined in modules 3 and 6). Strategic actions outlined in the other modules are designed to support this goal, but it may not be necessary to implement each module.

The modules will be most useful to national governments, including policy-makers, food control or safety authorities, and subnational government bodies that advocate for, and enforce, policies relating to nutrition or food safety. Other audiences that may find these modules and accompanying web resources useful include civil society organizations, academic and research institutions, nutrition scientists and laboratories, and food industry associations and food companies.

MODULES OF THE REPLACE ACTION PACKAGE

SIX STRATEGIC ACTION AREAS	OBJECTIVE
RE REVIEW dietary sources of industrially produced TFA and the landscape for required policy change	Introduce the REPLACE action package, and provide guidance on initial scoping activities and drafting of a country roadmap for TFA elimination. Initial scoping activities rely on information that is already known, or can be obtained through desk review or discussions with key stakeholders, with reference to other modules as needed
P PROMOTE the replacement of industrially produced TFA with healthier oils and fats	Describe oil and fatty acid profiles, and available replacement oils and fats, including feasibility considerations and possible interventions to promote healthier replacements
L LEGISLATE or enact regulatory actions to eliminate industrially produced TFA	Describe policy options and the current regulatory framework to eliminate industrially produced TFA. Provide guidance on assessment steps to guide policy design, and development of regulations suitable to the country context or updating of the existing legal framework to match the approach recommended by the World Health Organization
A ASSESS and monitor TFA content in the food supply and changes in TFA consumption in the population	Describe the goals and methods for TFA assessment. Provide guidance on designing and carrying out a study of TFA in food and human samples
C CREATE awareness of the negative health impact of TFA among policy-makers, producers, suppliers and the public	Describe approaches to advocacy and communications campaigns to support policy action. Provide guidance on key steps to design and implement effective advocacy and communications campaigns, and evaluate progress
E ENFORCE compliance with policies and regulations	Describe TFA policy enforcement approaches, offences and roles. Provide guidance on mapping existing and creating new enforcement powers and mechanisms, public communications, penalties, funding and timelines

1. BACKGROUND

The most effective and consistent way to eliminate industrially produced TFA from the global food supply is by implementing legislative or regulatory actions to prohibit or strictly limit their use in any food. TFA legislation and regulations generally do not specify what types of oils or fats should replace industrially produced TFA. Replacement with healthier oils and fats will maximize population health benefits. This module provides guidance on determining the best replacement oils for industrially produced TFA, and on designing and implementing strategies to promote use of these healthier replacements. These strategies include government support to industry to accelerate the transition to replacement oils, and agricultural policies and incentives to support the production of oilseeds and prioritize healthier replacement options.

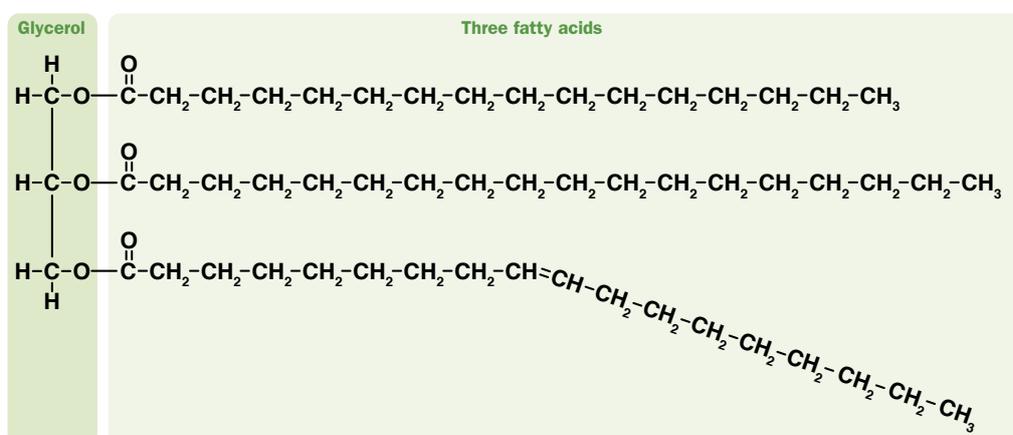
2. BASICS OF OILS AND FATS

2.1 OVERVIEW

Oils and fats are made up of triglycerides, which consist of a glycerol molecule attached to three chain-like molecules that mostly consist of carbon and hydrogen, called fatty acids. Oils and fats are mixtures of different types of fatty acids as components of triglycerides. Both the type of fatty acid and the placement can affect the functional properties of oils and fats, including melting temperature (temperature at which the mixture is liquid rather than a solid – higher melting temperatures mean that the fat is more likely to be solid at room temperature), crystallization characteristics and resistance to oxidation (a reaction with oxygen that leads to off-flavours and dark colours). Rules of thumb for how fatty acid composition affects the properties of oils and fats are as follows.

1. Longer fatty acids (bigger fat molecules) have higher melting temperatures.
2. Straight fatty acids can pack closely together in crystals and have a higher melting point.
3. 'Kinked' fatty acids (rather than straight) cannot pack. Fatty acids can have 0-3 kinks, called *cis* unsaturated bonds. Higher numbers lead to lower melting points.
4. Oxygen reacts easily with unsaturated bonds. More unsaturated bonds mean more oxidation and spoilage.

Unsaturated bonds are also called double bonds, and form when adjacent carbon atoms bond twice with each other rather than with a hydrogen atom. Fatty acids with no double bonds are "saturated" with hydrogen and therefore called saturated fatty acids (SFA). Fatty acids with one double bond are called mono-unsaturated fatty acids (MUFA). Fatty acids with more than one



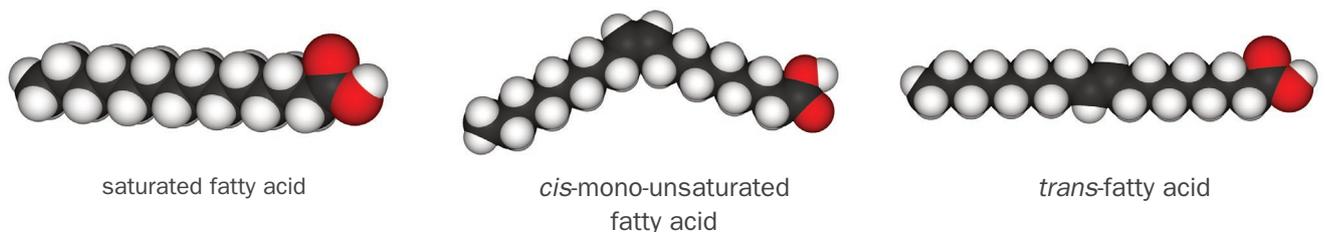
▲ Fig 1: Molecular structure of a fat molecule with two saturated fatty acids and one *cis* mono-unsaturated fatty acid

double bond are called poly-unsaturated fatty acids (PUFA). In food processing, SFA give solidity and texture, and high resistance to oxidation. MUFA oil is liquid and has good resistance to oxidation. PUFA oil is liquid and not resistant to oxidation.

Fatty acids are identified by a code that gives the number of carbon atoms in the molecular chain and the number of double bonds. For example, oleic acid, a common MUFA in many oils that has an 18-carbon chain, is labelled C18:1; palmitic acid, a common SFA in palm oil that has a 16-carbon chain, is C16:0. Two types of PUFA are “essential fatty acids”: the human body cannot make them out of other dietary components, and the required amount needs to be in the diet. These are linoleic acid (C18:2), an omega-6 or *n*-6 PUFA; and alpha-linolenic acid (C18:3), an omega-3 or *n*-3 PUFA.

2.2 TFA

Like the unsaturated fatty acids described above, trans fats are also unsaturated and have at least one double bond. However, the arrangement of the molecule is different and no longer kinked; the resulting TFA is almost as straight as an SFA (see Fig. 2). The resulting trans fat behaves more like an SFA than like an unsaturated fat.

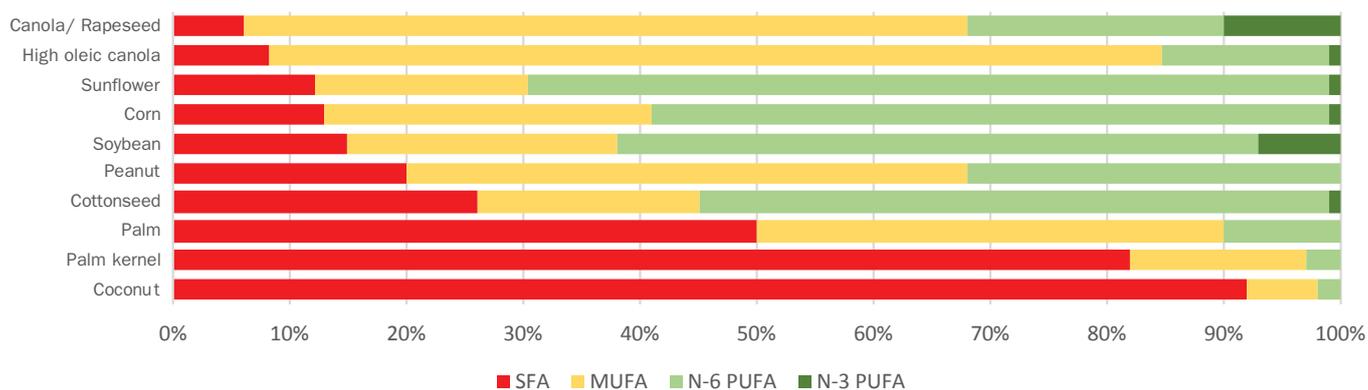


▲ **Fig. 2.** Models of fatty acids
Source: Wikimedia Commons (2014, 2015)

Unsaturated fatty acids, as found in commodity and gourmet oils and fats, naturally only have *cis* double bonds. The primary source of TFA targeted by the REPLACE action package is partially hydrogenated oils (PHO), which are created through a chemical process called partial hydrogenation. This process breaks up unsaturated bonds, and converts them partly to saturated bonds and partly to *trans* unsaturated bonds. This raises the melting point, so liquid oil can be turned into a liquid, semi-solid or solid fat at room temperature. PUFA are usually turned into MUFA TFA, so PHO have increased resistance to oxidation. The partial hydrogenation process can be adapted to create oils and fats with a variety of properties, regardless of the starting materials.

TFA are also formed in nature. Bacteria that can convert *cis* double bonds into *trans* double bonds live in the digestive system of ruminant animals (for example, cows and sheep); as a result, their meat and milk fat can contain 2–6% TFA. In addition, commercially refined oils may also contain low levels of TFA (0.5–2%), resulting from the high temperatures used to refine edible oils.

▼ **Fig. 3.** Approximate fatty acid composition of selected vegetable oils^a



^a Oils such as olive, safflower and sesame are not used extensively because of their limited availability and high cost.

Sources: Kodali (2014a); Orsavova et al. (2015)

2.3 HEALTH EFFECTS OF DIFFERENT CLASSES OF FATTY ACIDS

When partial hydrogenation was invented, the assumption was that all unsaturated fatty acids were healthier than SFA, and that replacing SFA with TFA would lead to lower cholesterol levels and lower incidence of cardiovascular disease. It is now known that TFA are less healthy than SFA (Mozaffarian & Clarke, 2009). It is also clear that reducing SFA intake is only beneficial if it is replaced with healthier alternatives. Replacing SFA with unsaturated fat – in particular, with PUFA – will have the most beneficial effect. Hence, current WHO advice (WHO, 2003, 2018; FAO, 2010) is to eliminate PHO from the diet, to limit intake of TFA to less than 1% of total energy intake, to limit SFA intake to less than 10% of total energy intake, and to replace energy from SFA with energy from unsaturated fat (in particular, PUFA). Since people do not consume fatty acids alone but rather consume food items that contain a mixture of nutrients and fatty acids, the general advice is to use liquid plant oils, nuts and seeds that are high in PUFA, and eat products made with these healthy oils. Fig. 3 shows the approximate fatty acid composition of selected vegetable oils.

3. REPLACEMENT OILS AND FATS

3.1 USES OF FATS AND PHO IN THE FOOD INDUSTRY

All oils and fats are mixtures of different fat molecules with different melting points. When fat cools, fat molecules form crystals with different forms and sizes. The form and size of the fat crystals depends on the fatty acid composition in the molecule and on the way the fatty acids are arranged within the fat molecule (triglyceride). The arrangement within the fat molecule also determines the speed at which crystals are formed when cooling (or broken down when melting). Hence, fats have a melting curve rather than a melting point. As a rule of thumb, fat with more than 80% solid fat content is hard. As temperature increases, the solid fat content decreases. The fat becomes softer and semi-solid, then becomes a viscous liquid. Once more than 80% of the molecules are liquid, the fat is perceived as a liquid oil (completely molten fat).

The temperature of softening and melting, the steepness of the melting curve, the shape and size of the solid fat crystals, the speed of fat crystal formation when cooling, and the oxidative stability of the fat determine the fat's suitability for specific applications in food manufacturing. Food manufacturers use oils and fats as a heat transfer medium, release agent, lubricant and moisture barrier. They are also used to create body and texture, to create mouthfeel and melt, as a flavour carrier and release, for oil binding, and for creaming and lamination (see Annex 1 for definitions). Many different PHO have been developed to be suitable for the main applications described below. For all applications, PHO-free alternatives are now commercially available.

FRYING AND GRILLING

Oxidative stability is very important for frying and grilling, especially if fats are used at higher temperatures for a prolonged time (for example, in deep-frying). Solid fat is not needed for structure in frying and grilling. Solid fats can be chosen for oxidative stability, but oils are a healthier choice. For deep-frying of doughnuts, for instance, solid fat can be needed to give glaze and prevent migration of liquid oil into coatings and/or packages. For grilling and shallow-frying, and as a pan release agent, liquids are sprayed on and viscous liquids are brushed on.

BAKING

Semi-solid fats are often used in baked goods because they enable easy mixing and give pliability to the dough. Specific solid fat crystals give flakiness, hardness, volume increase, layer separation and air entrapment to baked foods. Coatings for baking goods need to be hard at room temperature and have a steep melting curve at 30–35 °C to melt in the mouth. For icings and creams, semi-solid fats are selected that give enough fat crystals for aeration, are soft at both lower and higher temperatures (a flat melting curve), and do not leave a waxy mouthfeel (few solids above 40 °C).

MARGARINES AND SPREADS

Margarines were developed as an alternative to butter, at 80% fat. Products with other fat levels are generally called spreads. Consumers often use a single product for spreading on bread, cooking and baking. Industrial margarines are designed for different baking applications. Both butter and spreads are emulsions in which a matrix of solid fat crystals binds liquid oil and small droplets of water that hold flavour compounds. Solid fat ("hardstock") is needed to make spreads. By selecting hardstocks and processing conditions, spreads can be designed to be softer or harder at refrigerator and room temperature, and to be lower or higher in total fatty acids and SFA.

3.2 ALTERNATIVES TO PHO: SUMMARY AND RECOMMENDATION

PHO in products should be replaced with formulations that contain as little SFA and as much unsaturated fatty acid as possible. SFA should only be used in a limited number of applications where there is no alternative (see Table 1). There is a critical difference between replacing an oil high in TFA with palm kernel oil (which is very high in SFA) and replacing it with an oil mixture high in MUFA that also contains some SFA – the latter approach is much healthier.

Existing technical solutions for PHO replacement are summarized in Table 1.

Table 1. Existing technical solutions for PHO replacement

TECHNICAL SOLUTION	EXAMPLES
Stable plant oils: liquid at room temperature	Naturally stable oils; trait-enhanced oils (high oleic oils); oils with antioxidants and emulsifiers
Natural hardstocks: fats that are naturally high in SFA and solid at room temperature	Animal fats; tropical oils and fats (palm, coconut, palm kernel)
Fully hydrogenated hardstocks: full hydrogenation turns oils into 100% SFA waxy fats	Fully hydrogenated soy oil or other oils
Fractionated oils and fats: use slow cooling to separate more solid and more liquid fat fractions	Low melting (liquid) palm olein; high melting (solid) palm stearin
Rearranged fats: fatty acids are reshuffled (“interesterified”) within the triglycerides	Chemically or enzymatically rearranged hardstocks
Blending of oils and fats	Mix of soy oil and palm oil, which gives a viscous liquid
Combinations of approaches 1-6	Liquid oil interesterified with a specific hardstock or fractionated oil

Recommendations for alternatives are as follows.

- › Use the healthiest replacements – lowest SFA and highest PUFA with both omega-3 and omega-6 PUFA.
- › When fat is only needed as a heat transfer medium, release agent or lubricant (for example, for frying), use liquid oils that do not oxidize quickly, such as high oleic canola oil.
- › For other products that need “body” or other functionalities of SFA:
 - Hardstocks such as animal fats, tropical oils and its fractions, and fully hydrogenated oils may be more affordable, but are not recommended as full PHO replacement because they have high SFA content; for example, palm oil can be used as a baking shortening but is around 50% SFA.
 - For some applications, blending of liquid oils with the above hardstocks is the most economical way to replace PHO. Blending is the mixing of fat molecules. For example, liquid oil blended with 1% or 2% of fully hydrogenated oil gives a viscous liquid that is easy to use in professional kitchens.
 - Fat rearrangement is often the method of choice since it mixes the fatty acids within the fat molecule. This gives more solid fat structuring capacities at lower overall SFA levels. For example, a baking shortening made by interesterifying 25% of palm stearin with soybean oil will have around 30% SFA.
 - Combinations of technologies (fractionating, full hydrogenation, fat rearrangement and blending) are well suited to formulate products. This also allows cost-effective use of local materials and equipment. However, each extra processing step adds costs.

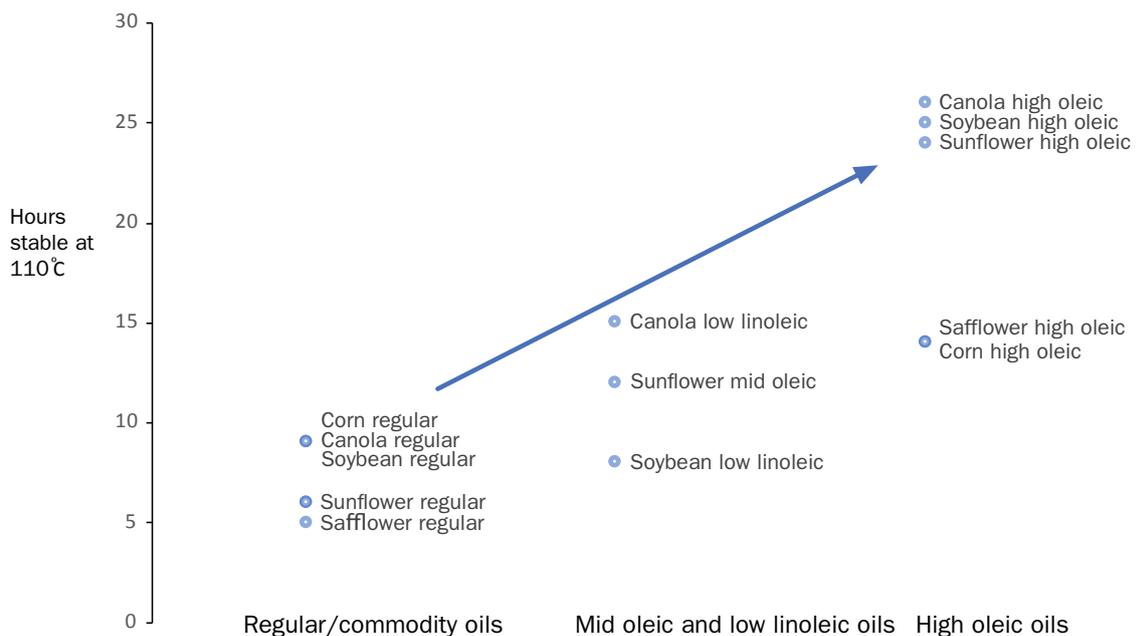
Fig. 4 summarizes the balance in choices between positive health impact and need for solid fat functionality. All alternatives should contain less SFA than the sum of SFA and TFA in the currently used PHO products.

▼ Fig. 4. Summary of PHO alternatives by health impact and solid fat functionality

<p>POSITIVE HEALTH IMPACT (lower SFA + more PUFA)</p>	<ul style="list-style-type: none"> > High PUFA oil with antioxidants > High oleic oils, moderate PUFA 	<ul style="list-style-type: none"> > Hardstocks interesterified with high PUFA oils > Hardstocks blended with high PUFA oils 	Not available
	<ul style="list-style-type: none"> > High oleic oils with no/low PUFA 	<ul style="list-style-type: none"> > Hardstocks interesterified with low PUFA oils > Hardstocks blended with low PUFA oils 	<ul style="list-style-type: none"> > Hardstocks interesterified with some PUFA oils > Hardstocks blended with some liquid oils > Hardstocks interesterified with some MUFA oil
	<p>Not recommended:</p> <ul style="list-style-type: none"> > Liquid palm fractions > Animal or tropical fats 	<p>Not recommended:</p> <ul style="list-style-type: none"> > Semi-solid palm fractions > Animal or tropical fats 	<p>Not recommended:</p> <ul style="list-style-type: none"> > Solid palm fractions > Fully hydrogenated oil > Coconut oil > Palm kernel oil
	LIQUID	SEMI-SOLID	SOLID

Oxidative stability of oils and fats determines how long a frying oil can be used without developing off flavours (that is, fry life), and how long a product can be stored and sold without developing off flavours (that is, shelf life). Longer shelf and fry lives result in easier use, less waste and lower costs. High SFA fats have the highest oxidative stability but are not a healthy choice. C18:1 MUFA and C18:2 PUFA oxidize 10 and 100 times quicker than C18:0 SFA, respectively (Kodali, Fan & DeBonte, 2003). Oils high in oleic acid (18:1 MUFA) improve oxidative stability at low SFA, with acceptable fry and shelf lives for food industries. Fig. 5 gives the shelf life index for different oils.

▼ Fig. 5. Shelf life index (hours stable at 110 °C) for different oils



Source: Liu (2014)

3.3 LOCAL APPLICATION OF PHO ALTERNATIVES

Major oil and fat suppliers worldwide now use combinations of the technologies described in Table 2 and offer PHO-free solutions for a range of applications. For local application, the following characteristics of PHO substitutes should be balanced.

- › **Health:** PHO replacements should, as a minimum, contain less SFA than the sum of SFA and TFA in the currently used PHO products. SFA should be as low as possible, and PUFA should be as high as possible, and should preferably include both omega-6 and omega-3.
- › **Functionality** of substitutes should closely mimic their partially hydrogenated counterparts to minimize local investments, reformulation time and research and development efforts, especially for smaller local food industries.
- › **Oxidative stability** of the products should be high enough for necessary shelf lives of PHO substitutes and of end products.
- › **Cost** of any substitute should preferably be the same as, or minimally greater than, currently used PHO. Vegetable oil prices are volatile, and depend on production and demand. Historical data from the United States (AOCS lipid library, 2001–2011) show that palm oil was often 15–35% cheaper than soy oil, which is generally the cheapest liquid oil. Canola/food-grade rapeseed oil was often 1–10% more expensive than soy oil. Sunflower oil was often 1–15% more expensive than soy oil. Each step to process oils and fats to create PHO-free solutions (refining, fractionation, hydrogenation, interesterification, blending) will add some costs.
- › **Availability:** A reliable, large supply of oils and hardstocks is required to support food manufacturing. For example, larger quantities of trait-enhanced oils need to be contracted two years ahead.
- › **Local production of crude oils:** The domestic oilseed industry may need to shift – for example, to trait-enhanced varieties. More import of palm oil may reduce domestic production.
- › **Local production of hardstocks and blends:** If partial hydrogenation is done locally and imports are not wanted, facilities may need adaptations to allow full hydrogenation, interesterification and blending. Operators will need to be trained.

4. AGRICULTURAL POLICIES

Policies and incentives can increase the availability, affordability and acceptability of oilseeds that can be used to produce healthier replacement oils. Government incentives to support the production of healthier oilseeds include investment in research and development (R&D), investment in farm equipment, crop insurance, assistance in establishing farming cooperatives, support for market access, and support for farmers as they transition to new crops. The private sector can also play a role in supporting agricultural production by investing in infrastructure and technology, and providing support to farmers for production.

Alongside investment in agricultural production, investment in other steps of the supply chain may be necessary to increase the supply of healthier replacement oils. Farmers need to have access to adequate postharvest storage. As well, sufficient road infrastructure is needed to ensure that oilseeds can be transported from farms to processing facilities, and these facilities need to have the appropriate equipment and technology to efficiently crush the oilseeds. Without investment in the supply chain beyond the farm, there is increased risk of food loss between the farm and the processing facilities, which could reduce the availability and affordability of the oilseed supply.

4.1 INVESTMENT IN RESEARCH AND DEVELOPMENT, AND FARM EQUIPMENT

Investment in R&D by both governments and the private sector can help to:

- › increase yields of oilseeds that are currently being produced but are attaining suboptimal yields
- › breed and produce new varieties of oilseeds that can be used as replacement oils.

In addition to investment in R&D, the edible oilseed supply could be improved through support for farmers to purchase farm equipment (for example, machinery and tools) that can increase production efficiency and reduce on-farm loss. The role of R&D and farm equipment in increasing yields of existing oilseeds and developing new varieties is described in more detail below.

In many parts of the world, the yields of oilseeds do not reach their full potential. This can be attributed to a variety of factors, including poor-quality seeds, lack of access to irrigation, climate variability, lack of machinery and tools, and poor agronomic practices. Governments can support oilseed farmers to improve their yields by:

- › providing subsidies for improved seed varieties;
- › increasing access to irrigation, particularly in rainfed areas;
- › providing access to credit to enable low-income farmers to purchase inputs and farm equipment that can improve their yields; and
- › strengthening extension services to smallholder farmers to increase the adoption of best practices in agricultural production.

The private sector also has a role, in developing farming equipment that is both affordable and suited to the needs of small-scale farmers.

Alongside improvements in production practices for existing oilseed crops, investment in R&D may be needed to develop and refine new varieties of oilseeds with more appealing characteristics from a production, processing/application and health perspective. These varieties could include those that are designed to withstand the changing climatic conditions that many countries currently face, produce higher yields, have modified fatty acid profiles (for example, high oleic sunflower) and have higher efficiency of yields during the crushing process. In addition, investment in R&D could help develop additional varieties that are acceptable for use in different processing applications. Once new varieties that are appropriate from a processing, health and cost perspective are identified, investment and support to get them to market will be necessary. To ensure that this process is not prohibitively expensive, governments can provide incentives to support farmers (for example, seed subsidies, extension, crop insurance), small- and medium-scale enterprises (for example, tax incentives), and researchers (for example, funding for R&D) to increase the uptake of the oilseeds.

An important consideration for governments is the time lag between investment in R&D and improvements in outcomes. Although investing in R&D has the potential to lead to marked increases in yields and to substantially affect the oil supply in a given country or region, the time frame in which these investments produce positive outcomes can be lengthy. Box 1 provides an example of how the Canadian Government's investment in the canola oil (a food-grade rapeseed oil variant) sector has led to significant increases in yields during the past four decades and how the government continues to support R&D.

Table 2. Healthier alternatives for replacement of trans fats by food applications

APPLICATION	ALTERNATIVE	TYPE OF OILS	HEALTH CHARACTERISTICS	RELATIVE VALUE	COMMENT
Frying fats	Medium- and high-stability vegetable oils	High oleic canola oil High oleic sunflower oil	High in MUFA Small amounts of <i>n</i> -6 and <i>n</i> -3 PUFA Low in saturates	Low cost impact Medium to high health impact	Better oxidative stability than PUFA-rich vegetable oils
		Low linolenic soya oil Mid oleic sunflower oil	High in MUFA or <i>n</i> -6 PUFA Low in saturates	Low cost impact Medium to high health impact	Better oxidative stability than general vegetable oils
Consumer and food service margarines (soft)	Interesterified oils with vegetable oil	Palm and palm kernel (PK) stearins, with canola oils	High in MUFA Moderate in <i>n</i> -6 High in <i>n</i> -3 PUFA Low in saturates	Medium to high cost impact High health impact	Adding sunflower oil can increase <i>n</i> -6 PUFA
		Palm and PK stearins, with soya oils	Moderate in MUFA High in PUFA High in <i>n</i> -6 PUFA Moderate in <i>n</i> -3 PUFA Moderate in saturates	Medium to high cost impact Medium to high health impact	Higher PUFA with both <i>n</i> -6 and <i>n</i> -3 is preferred from a health perspective
		Fully hydrogenated vegetable oils and liquid vegetable oils, with vegetable oils	Some MUFA High in <i>n</i> -6 PUFA Moderate in <i>n</i> -3 PUFA Moderate in saturates	Medium to high cost impact Medium to high health impact	<i>n</i> -6 and <i>n</i> -3 content depends on choice of vegetable oil
	Blending of soft oils and highly saturated oils	Palm oil or palm mid fraction and PUFA-rich vegetable oils	High in MUFA Moderate in <i>n</i> -6 and <i>n</i> -3 PUFA Moderate in saturates	Low to medium cost impact Medium health impact	<i>n</i> -6 and <i>n</i> -3 content depends on choice of vegetable oil
Consumer and food service margarines (hard)	Interesterified oils with vegetable oil	Palm and PK stearins, with soya oils	Moderate in MUFA and <i>n</i> -6 PUFA Small amount of <i>n</i> -3 PUFA High in saturates	Medium to high cost impact	Dietary advice is to limit consumption of hard margarines and butter and replace with soft margarines
		Fully hydrogenated vegetable oils and liquid vegetable oils, with vegetable oils	Some MUFA Moderate in <i>n</i> -6 and <i>n</i> -3 PUFA High in saturates	Low to medium cost impact Low to medium health impact	<i>n</i> -6 and <i>n</i> -3 content depends on choice of vegetable oil

TYPE OF APPLICATION	ALTERNATIVE	TYPE OF OILS	HEALTH CHARACTERISTICS	RELATIVE VALUE	COMMENT
Baking margarines (soft)	Interesterified oils with vegetable oil	Palm and PK stearins, with canola oils	High in MUFA Moderate in <i>n</i> -6 PUFA High in <i>n</i> -3 PUFA Low in saturates	Medium to high cost impact High health impact	
	Blending of soft oils and highly saturated oils	Palm oil or palm stearin and general vegetable oils	High in MUFA Moderate in <i>n</i> -6 and <i>n</i> -3 PUFA Moderate in saturates	Low to medium cost impact Medium health impact	<i>n</i> -6 and <i>n</i> -3 content depends on choice of vegetable oil
	Interesterified oils with vegetable oil	Palm and PK stearins, with soya oils	Moderate in MUFA High in <i>n</i> -6 PUFA Moderate in <i>n</i> -3 PUFA Moderate in saturates	Medium to high cost impact Medium health impact	
		Fully hydrogenated vegetable oils and liquid vegetable oils, with vegetable oils	Some MUFA High in <i>n</i> -6 PUFA Moderate in <i>n</i> -3 PUFA Moderate in saturates	Medium to high cost impact Medium health impact	<i>n</i> -6 and <i>n</i> -3 content depends on choice of vegetable oil
Baking margarines (hard and laminating)	Blending of soft oils and highly saturated oils	Palm oil or palm stearin and high-stability vegetable oils	Moderate in MUFA Small amount of <i>n</i> -6 and <i>n</i> -3 PUFA High in saturates	Low to medium cost impact Low health impact	Dietary advice is to limit consumption of baked products high in saturates
		Interesterified oils with vegetable oil	Palm and PK stearins, with soya oils	Moderate MUFA and <i>n</i> -6 PUFA Small amount of <i>n</i> -3 PUFA High in saturates	Medium to high cost impact Low to medium health impact
	Interesterified oils with vegetable oil	Fully hydrogenated vegetable oils and liquid vegetable oils, with vegetable oils	Some MUFA Moderate in <i>n</i> -6 and <i>n</i> -3 PUFA High in saturates	Medium to high cost impact Low to medium health impact	Dietary advice is to limit consumption of baked products high in saturates

TYPE OF APPLICATION	ALTERNATIVE	TYPE OF OILS	HEALTH CHARACTERISTICS	RELATIVE VALUE	COMMENT
Bakery or food processor shortening (spray/liquid)	General vegetable oils	Canola or soya oils	High in MUFA or <i>n</i> -6 PUFA High in <i>n</i> -3 PUFA Low in saturates	Low cost impact High health impact	Poor oxidative stability Addition of antioxidants can improve oxidative stability
	Medium- and high-stability vegetable oils	High oleic canola oil High oleic sunflower oil	High in MUFA Small amount of <i>n</i> -6 and <i>n</i> -3 PUFA Low in saturates	Low to medium cost impact Medium to high health impact	Better oxidative stability than general vegetable oils Highest amounts of <i>n</i> -6 and <i>n</i> -3 are preferred from a health perspective
		Low linolenic soya oil Mid oleic sunflower oil	High in MUFA or <i>n</i> -6 PUFA Low in saturates	Low to medium cost impact Medium to high health impact	Better oxidative stability than PUFA-rich vegetable oils Highest amounts of <i>n</i> -6 and <i>n</i> -3 are preferred from a health perspective
Bakery or food processor shortening (solid)	Blending oils for solids and performance	Palm oil or palm stearins or fully hydrogenated oil, and medium-stability vegetable oils	High in MUFA Moderate in <i>n</i> -6 PUFA High in <i>n</i> -3 PUFA Low in saturates	Low to medium cost impact High health impact	Emulsifiers may be added for increased functionality
	Interesterified oils with vegetable oil	Palm and PK stearins, with canola oil	High in MUFA Moderate in <i>n</i> -6 PUFA High in <i>n</i> -3 PUFA Low in saturates	Medium to high cost impact High health impact	
		Palm and PK stearins, with high oleic canola oil	High in MUFA Small amount of <i>n</i> -6 and <i>n</i> -3 PUFA Low in saturates	Medium to high cost impact Medium to high health impact	Higher amounts of <i>n</i> -6 and <i>n</i> -3 are preferred from a health perspective but may give insufficient oxidative stability and shelf life
	Blending oils for solids and performance	Palm oil or palm stearins or fully hydrogenated oil, and medium-stability vegetable oils	Moderate in MUFA Moderate in <i>n</i> -6 and <i>n</i> -3 PUFA Moderate to high in saturates	Medium cost impact Low to medium health impact	Lower saturated is preferred but may not give the required functionality
	Interesterified oils with vegetable oil	Palm and PK stearins, with high oleic canola oil	High in MUFA Small amount of <i>n</i> -6 and <i>n</i> -3 PUFA Moderate to high in saturates	Medium to high cost impact Low to medium health impact	Lower saturated is preferred but may not give the required functionality
Fully hydrogenated vegetable oils and liquid vegetable oils, with liquid vegetable oils		High in MUFA Small amount of <i>n</i> -6 and <i>n</i> -3 PUFA Moderate to high in saturates	Medium to high cost impact Low to medium health impact	Lower saturated is preferred but may not give the required functionality	

Source: Adapted from Health Canada (2006)

BOX 1. OVERVIEW OF THE ROLE OF R&D IN STRENGTHENING CANOLA OIL PRODUCTION IN CANADA

Canola oil (a food-grade rapeseed variant) was developed by researchers from the Canadian Government and academia in the 1970s, using traditional plant breeding techniques. Through investment in R&D that enabled cross-breeding experiments, plant breeders developed a variety of rapeseed that had lower quantities of the undesirable components of the oilseed (erucic acid). Over the next four decades, canola oil production increased in Canada. It is now the country's largest crop, accounting for one fifth of crop land. From a health perspective, canola oil is high in unsaturated fat and low in saturated fat. It also has a high smoke point, and high oleic/low linoleic canola variants can replace PHO in frying applications.

Investment in R&D for canola has continued and has led to the development of varieties – including high oleic varieties – that are more resistant to disease and weeds, and have higher yields, better quality and shorter time to maturation. The Canadian Government continues to invest in R&D to optimize yields and improve sustainability of the crop.

4.2 AGRICULTURAL COOPERATIVES AND MARKET ACCESS

In many parts of the world, oilseeds are produced by smallholder farmers. These farmers often have limited access to inputs (for example, credit, fertilizer, machinery) and have difficulty accessing markets. These problems affect their yields, as well as their income and livelihoods. When smallholder farmers form farming groups, they are better able to advocate for their needs, and to access inputs and services at more affordable prices. Agricultural cooperatives pool resources, which allows them better access to inputs, while cluster farming involves groups of farmers who work together to consolidate products to sell to the market. Both these approaches can help smallholders to improve yields for their crops and to gain better market access, including higher prices for their products.

Small-scale farmers may struggle to find consistent buyers who will accept products that may not meet their preferred quality standards. The creation of food hubs can offer much-needed stability by providing a central location for smallholders to combine their crops into a larger quantity to meet the needs of larger buyers. Moreover, these hubs can help streamline the value chain by connecting farmers, processors and retailers with one another, in one location. The Government of India has invested in establishing “mega food parks”, with a view to linking production with markets to maximize value, minimize wastage, increase farmers' incomes and create employment opportunities. Governments, nongovernmental organizations, civil society organizations and the private sector can support farmer groups and food hubs. This support could help to shore up the edible oil supply in many countries where production is suboptimal and where supply chains are fragmented.

4.3 AGRICULTURAL SUPPORT PAYMENTS DURING THE TRANSITION PERIOD

As farmers shift their production from seeds used to produce oils for partial hydrogenation to seeds that produce healthier replacement oils, there may be disruptions in production. During this period, governments can provide agricultural support payments to farmers as they switch their crops. These payments protect farmers' incomes during the transition. In some cases, the transition can take 3–5 years, and payments provide the protection needed to take on the risk of changing crops.

4.4 CROP INSURANCE

Providing oilseed farmers with crop insurance is another way to incentivize the production of oilseeds. Crop insurance provides funding to farmers if their crops do not produce the expected yields (for any number of reasons) or remuneration. Crop insurance can also provide a safety net for farmers when they make a transition to new oilseeds. Providing farmers with crop insurance will become increasingly important as farmers continue to face climate variability, including extreme events, that have the potential to drastically affect production. Index-based insurance, which takes into account weather variables such as rainfall when determining payouts, could be adopted to provide support for the oilseed sector. As many oilseed farmers engage in rainfed agriculture, this could be particularly important.

5. IMPORT POLICIES

One strategy to encourage replacement of TFA with oils higher in PUFA and lower in SFA is to incentivize their use by lowering their price compared with oils higher in SFA, such as palm oil. One of the reasons that palm oil is often used as a replacement oil for TFA is its low cost. Some governments in Asia and Africa have invested heavily in the palm oil sector, including by providing farmers and plantation owners with incentives to promote palm oil production. Over the past few decades, this has driven marked increases in the availability, and reductions in the cost, of palm oil. In addition, in some countries there may be a low import tax (such as duty) on palm oil, while duties for other healthier oils high in unsaturated fat are higher. One approach to reducing some of the discrepancy in the cost of oils is to increase the duty on palm oil and simultaneously reduce (or remove) the duty on oils higher in unsaturated fat. There are examples of countries using trade policy to incentivize shifts in edible oil consumption in an effort to improve population health. Fiji announced in its 2012 budget that it would raise the duty on palm oil from 15% to 32%, with the aims of increasing its cost, reducing its purchase by consumers and reducing population saturated fat intake (Coriakula et al., 2018).

Although this approach has been feasible in small island countries such as Fiji, there may be more resistance to this type of policy approach in countries with larger economies. For example, in 2016, the French Government withdrew a proposal to add a 300% duty to palm oil. For countries that still import PHO, significantly raising the duty (as high as the upward bound allows) would increase the cost; this could deter consumers and businesses from using it in their cooking and products. If countries that are members of the World Trade Organization (WTO) are to avoid a successful challenge to increasing duties on PHO, they will need to ensure that the increased duty remains within their agreed tariff bound with the WTO.

In India, a simulation modelling study found that including a 20% excise tax on palm oil could modestly reduce hyperlipidaemia and cardiovascular mortality; however, calorie intake would increase slightly if this were not balanced with incentives to increase affordability of healthier oils (Basu et al., 2013).

6. TAX INCENTIVES

Small- and medium-scale enterprises (SMEs) that are transitioning from either producing PHO or using them as an ingredient in their products may need some additional support to move to TFA-free products. Some companies may not have the necessary machinery and equipment to adopt approaches such as interesterification or blending. To facilitate uptake of healthier replacement oils, governments could provide SMEs with subsidies for equipment. Tax incentives can also be offered to companies that use replacement oils in their products. In addition to

economic incentives for using healthier replacement oils, some SMEs are likely to require technical guidance and support to increase their capacity to make the necessary changes.

In Singapore, the Health Promotion Board introduced a programme in 2015 to increase the availability and use of healthier ingredients through subsidies to suppliers stocking healthier items, starting with cooking oil low in SFA. The aim of the subsidy is to eliminate the difference in price between these healthier oils and those high in saturated fat. Suppliers who take advantage of the subsidy commit to pass savings on to wholesalers, distributors and, ultimately, food vendors (Ho, 2015).

7. SUPPORT TO INDUSTRY

As TFA elimination policies are planned and implemented, governments and industry groups can provide technical support to companies in the supply chain, and communicate with stakeholders about the importance of eliminating oils and fats that contain TFA. This will help to accelerate the transition to replacement oils and prioritize healthier replacement options.

7.1 DEVELOPMENT OF TECHNICAL RESOURCES

Technical reference documents can support the transition to replacement oils and fats for the key components of the supply chain (such as the agricultural sector, edible oils and fats processors, packaged food manufacturers, food distributors, restaurants, food service companies and street vendors). Developing technical resources will depend on an understanding of the supply chain, discussions with key industry stakeholders and input from local technical consultants, such as a food technologist or culinary school chef. The sections above on replacement oils and fats can also be a helpful information source.

Key types of resources may include:

- › **guidance document** – description of the health impact of TFA, country goal, fat types, how to determine if TFA is present, and steps to take to find replacement oils;
- › **replacement oil and fat options** – organized by use and arranged by saturated fat content (see Table 2); and
- › **frequently asked questions (FAQs) and answers** – organized by type of oil or fat, or by sector, informed by stakeholder interviews and discussions with industry, and updated to reflect new issues as they arise.

Additional technical resources or materials to consider developing include:

- › **website**, with a relevant name and a short web address; include
 - an email address where users can send questions to a technical expert
 - sign-ups for email/text alerts on policy changes and training opportunities
 - links to all technical materials;
- › **helpline** – a phone number for people to call culinary experts with specific questions about finding replacement oils, and adjusting recipes to adapt to new oils and fats;
- › **training** for chefs and owners of restaurants, food service companies, and staff in the informal food sector on choosing an appropriate replacement oil or fat;
- › **letters** – examples of letters for companies to share with customers or suppliers to alert them to a request for healthier oils or to reflect a change in product formulation;

- › **postcard** directing companies to a website, helpline, training or other technical resource – distributed at training events, at food industry association meetings, to food industry email lists and during food safety inspections; and
- › **poster** reminding chefs and restaurant owners to use oils without TFA, and to alert customers that the restaurant only uses oils and fats without TFA.

Box 2 describes some resources used in New York City to restrict TFA in foods.

BOX 2. CASE EXAMPLE: NEW YORK CITY TRANS FAT HELP CENTER

In 2006, the New York City (NYC) Board of Health approved an amendment to the NYC Health Code requiring restaurants to restrict the amount of artificial trans fat in ingredients and foods served to less than 0.5 grams per serving. All NYC restaurants and other locations serving food, such as cafeterias, carts and kiosks, were affected by the amendment. To support full compliance, the NYC Health Department added a training module to the Health Department’s food protection courses, which are required for all food handlers, and created the NYC Trans Fat Help Center. The Trans Fat Help Center included a telephone helpline; brochures on frying, baking and purchasing prepared foods without trans fat; free classes on trans fat in three languages; and online resources, such as lists of compliant oils and tips on reformulating recipes to eliminate artificial trans fat (Angell et al., 2009). The Center was created in partnership with a leading culinary school and with support from the American Heart Association. Once the restriction went into effect, the transition to trans fat-free was relatively easy for restaurants and other affected stakeholders, and the NYC Department of Health and Mental Hygiene telephone helpline received very few calls (NYC DOHMH, 2018). (See Annex 3 for an excerpt of brochure created by the NYC Department of Health and Mental Hygiene.)

Guidance document

Guidance provided via brochure or other mode of communication should include the following information (example text is in italics):

- › Description of the health impact of consuming TFA – for example:
 - *Consuming oils and fats that contain trans fat is bad for your heart*
 - *Industrially produced trans fat is the focus, not naturally-occurring trans fat*
 - *Common sources of trans fat in the diet include fried foods, baked goods, some packaged foods and any product that contains partially hydrogenated vegetable oil.*
- › Description of country goal – for example:
 - *Goal of eliminating intake of industrially produced TFA by [date]*
 - *Current intake is an estimated [X] grams per person per day.*
- › Summary of fat types – for example (NYC DOHMH, 2019):
 - *Healthy fats that help lower the risk of heart disease include*
 - *poly-unsaturated fats (preferred), such as corn, soybean, safflower, sunflower, and cottonseed oils; fish and seafood*
 - *mono-unsaturated fats, such as olive, canola and peanut oils; nuts; and avocados*
 - *Unhealthy fats that increase the risk of heart disease include*
 - *trans fats such as partially hydrogenated oils, some margarine, shortening and Vanaspati ghee, and some fried and baked foods*
 - *saturated fats such as whole milk, butter, cheese, lard, meat, palm oil, palm kernel and coconut products, including milk and oil*

- › Steps to determine if a product contains TFA – for example:
 - *Read ingredients label, look for “partially hydrogenated vegetable oil” (if that description is required by law)*
 - *Read a nutrition label, look for trans fat content (if nutrition labels are used/required).*
- › Next steps to take, if a product contains TFA – for example:
 - *Consult the replacement oil and fat options list to find products for a similar use*
 - *Contact your supplier to ask for alternatives*
 - *Use the helpline, training, FAQs or other resources to make changes*
 - *Reformulate recipes and products*
 - *Consider changes to labels or communication with customers, to alert them to the change in trans fat content*
 - *Plan to fully eliminate trans fat from all products by 2023.*

Replacement oil and fat options

To ensure that the food industry can easily find the appropriate replacement oils, create a resource that lists replacement oils by use, and highlights oils and fats that are lower in saturated fat. Use Table 2 as a starting point for types of oils, and adapt it based on local availability of different types of replacements.

The second tab of the Edible Oils and Fats Worksheet (Replacement oil and fat options) that was developed as part of module 1 provides a template for a usable reference document, populated with specific, locally available oils. Use this template to create public documents, such as a list of replacement oil and fat options, which may be included in a website, and used in training and other technical support activities. Consider interviews with suppliers, restaurants, packaged food manufacturers, bakeries and the informal food sector to generate local information for the list.

Update the list regularly, particularly if the market changes substantially in response to a proposed or approved policy. It may also be helpful to indicate a way for companies to submit products for inclusion in the list, via the website or another mechanism. For public documents, consider noting that the list is not exhaustive and does not constitute an endorsement of a specific product.

Design elements can reinforce the main message – that is, choose products with no TFA and lower saturated fat. For example, a symbol can highlight oils that are lower in SFA.

FAQ document

Finally, it may be helpful to provide information to address FAQs that are received through stakeholder meetings, advisory group meetings, the helpline, training or other interactions with industry. FAQs will be country specific but may address topics or areas such as:

- › using replacement shortenings;
- › baking issues that result from using different oils and fats, such as changes in cooking time, browning and dough spread;
- › change in taste of fried products; and
- › adapting the frying temperature of replacement oils.

7.2. TARGETED SUPPORT BY COMPANY TYPE

Develop a communication plan to support dissemination of technical resources to each type of food sector.

Considerations and communication options to support each sector to comply with regulations, while minimizing the increase in SFA from oils and fats, include those listed below. These methods can also be used to communicate a policy proposal, a comment period, a policy approval or the policy implementation date. Communications options by sector may include the following.

- › Agricultural sector:
 - If significant change in crop types is required to ensure an adequate supply of healthy alternatives, consider developing guidance, in conjunction with producers of edible oils and fats, for farmers to shift agricultural production.
 - Engage farmers' associations and agricultural groups to disseminate information.
 - Communicate changes in policies related to subsidies and tariffs that may affect agricultural production.
- › Processors of edible oils and fats (key stakeholders for informing content of the Edible Oils and Fats Worksheet relating to replacement oil and fat options):
 - Send a letter informing processors of regulations to eliminate TFA and/or PHO; include the guidance document and replacement options. Note whether the company's products are on the list of replacement options and solicit additional submissions.
 - Provide a draft letter for processors to share with customers, encouraging them to shift to healthier oils and fats, and recommending specific replacements.
 - Encourage processors to provide technical assistance to customers to make the transition.
- › Packaged food manufacturers and distributors:
 - Send a letter informing manufacturers and distributors about regulations to eliminate TFA and/or PHO; include the guidance document, replacement options and FAQ.
 - Encourage companies to talk to their suppliers about healthier replacement oils and fats.
- › Importers and exporters of oils and fats:
 - Send a letter informing importers and exporters about regulations to eliminate TFA and/or PHO, and how they require a shift to importing and exporting oils that are not PHO; include the guidance document and replacement options. Note whether the company's products are on the list of replacement options.
 - Encourage companies to shift to fats with lower SFA, providing examples. Note what types of customers will be receiving similar information.
- › Restaurants, food service companies and the informal food sector:
 - Send a letter informing restaurants, food service companies and the informal food sector about regulations to eliminate TFA and/or PHO, and the implications for oil selection; include the guidance document, replacement options and FAQ.
 - Add training on the health impact of TFA and finding replacement oils to food licensing courses for restaurant and food service staff. At the training sessions, distribute the guidance document, replacement options and FAQ.
 - Train food safety inspectors on TFA and replacement oils; distribute the guidance document, replacement options and FAQ.

- Provide materials for food safety inspectors to distribute on routine visits, such as posters and other resources.
- If the informal food sector is not licensed, contact the main oil and fat distributors to the sector, and organizations that represent street vendors to discuss how to encourage use of healthier replacement oils.
- Consider more targeted support for bakeries – for example, visits to bakeries and training on how to reformulate recipes.

REFERENCES

- Angell SY, Silver LD, Goldstein GP, Johnson CM, Deitcher DR, Frieden TR, et al. (2009). Cholesterol control beyond the clinic: New York City's trans fat restriction. *Ann Intern Med.*, 151:129–34.
- AOCS (American Oil Chemists' Society). AOCS lipid library: prices of commodity oils [website]. (2013). Urbana, Illinois (<http://lipidlibrary.aocs.org/OilsFats/content.cfm?ItemNumber=39460>, accessed 12 February 2019).
- Basu S, Babiarz KS, Ebrahim S, Vellakkal S, Stuckler D, Goldhaber-Fiebert JD. (2013). Palm oil taxes and cardiovascular disease mortality in India: economic–epidemiologic model. *BMJ*, 347:f6048.
- Coriakula J, Moodie M, Waqa G, Latu C, Snowdon W, Bell C. (2018). The development and implementation of a new import duty on palm oil to reduce non-communicable disease in Fiji. *Global Health*, 14(1):91.
- FAO (Food and Agriculture Organization of the United Nations). (2010). Fats and fatty acids in human nutrition: report of an expert consultation. FAO Food and Nutrition Paper 91. Rome: Food and Agriculture Organization of the United Nations.
- Gupta MK. (2017). Practical guide to vegetable oil processing, second edition. Urbana, Illinois: AOCS Press.
- Health Canada. (2006). TRANSforming the food supply: report of the Trans Fat Task Force. Ottawa: Health Canada. (<http://publications.gc.ca/site/eng/9.688572/publication.html>).
- Ho O. (2015). HPB offers subsidy to suppliers in bid to help food operators switch to healthier oil. *Straits Times*. (<https://www.straitstimes.com/singapore/health/hpb-offers-subsidy-to-suppliers-in-bid-to-help-food-operators-switch-to-healthier>, accessed 1 April 2019).
- Kodali DR. (2014). Trans fats: health, chemistry, functionality, and potential replacement solutions. In: Kodali DR, editor. *Trans fat replacement solutions*. Urbana, Illinois: AOCS Press, a:1–39.
- Kodali DR, editor. (2014). *Trans fat replacement solutions*. Urbana, Illinois: AOCS Press, b.
- Kodali DR, Fan Z, DeBonte LR. (2003). Plants, seeds, and oils having an elevated total monounsaturated fatty acid content. U.S. Patent 6,649,782 B2, 18 Nov 2003.
- Liu L. (2014). High-oleic oils and their uses for trans fats replacement. In: Kodali DR, editor. *Trans fat replacement solutions*. Urbana, Illinois: AOCS Press.
- Mensink RP, Sanders TA, Baer DJ, Hayes KC, Howles PN, Marangoni A. (2016). The increasing use of interesterified lipids in the food supply and their effects on health parameters. *Adv Nutr.*, 7(4):719–29.

Mozaffarian D, Clarke R. (2009). Quantitative effects on cardiovascular risk factors and coronary heart disease risk of replacing partially hydrogenated vegetable oils with other fats and oils. *Eur J Clin Nutr.*, 63(Suppl 2):S22–33.

NYC DOHMH (New York City Department of Health and Mental Hygiene) Trans Fat Help Center [website]. (2018). (<https://www1.nyc.gov/site/doh/health/health-topics/trans-fat-help-center.page>, accessed 13 July 2018).

NYC DOHMH (New York City Department of Health and Mental Hygiene). (2019). Trans fat brochure [website]. 2019 (<https://www1.nyc.gov/assets/doh/downloads/pdf/cardio/cardio-transfat-brochure.pdf>, accessed 22 January 2019).

Orsavova J, Misurcova L, Ambrozova JV, Vicha R, Mlcek J. (2015). Fatty acids composition of vegetable oils and its contribution to dietary energy intake and dependence of cardiovascular mortality on dietary intake of fatty acids. *Int J Mol Sci.*, 16:12871–90.

WHO (World Health Organization). (2003). Diet, nutrition and the prevention of chronic diseases: report of a Joint WHO/FAO Expert Consultation. WHO Technical Report Series, No. 916. Geneva: World Health Organization.

WHO (World Health Organization). (2018). Healthy diet. Fact sheet [website]. Geneva: World Health Organization, (<https://www.who.int/news-room/fact-sheets/detail/healthy-diet>).

Wikimedia Commons [website]. <https://commons.wikimedia.org/wiki/File:Lauric-acid-3D-vdW.png#filelinks> (2014); <https://commons.wikimedia.org/wiki/File:Oleic-acid-3D-vdW.png> (2015); <https://commons.wikimedia.org/wiki/File:Elaidic-acid-3D-vdW.png> (2015).

Zetzi SAK, Marangoni AG. (2014). Structured emulsions and edible oleogels as solutions to trans fat. In: Kodali DR, editor. *Trans fat replacement solutions*. Urbana, Illinois: AOCS Press.

ANNEX 1. FAT APPLICATION GLOSSARY

Body and texture:	The three-dimensional inner and outer form and structure of a food product – for example, hard or soft margarines, compact or airy baked goods.
Creaming:	Whipping of air into a mixture of fat and sugar to obtain a smooth cream. Solid fat crystals entrap air bubbles.
Heat transfer medium:	Role of fats in conducting heat from the pan to the product, allowing cooking and browning.
Lamination:	Use of solid fats to help create layers – for example, in puff pastry.
Moisture barrier:	Use of fats to help separate dry and wet parts in a product so that dry parts do not become soggy.
Mouthfeel:	How the food product is perceived in the mouth when eating – for example, dry or wet, sticky or lubricated, crispy or chewy, waxy or melting.
Melt:	How a solid fat melts in the mouth. Flavour is released when fats melt. A quick melt gives a ‘clean’ mouthfeel and a cooling sensation. A melt that is too slow can mean sticky or waxy mouthfeel.
Oil binding:	Property of solid fat crystals in entrapping liquid oils, so that these do not migrate in the product and are only released in the mouth – for example, to help lubrication and flavour release.
Oxidation:	Reaction of oils and fats with oxygen. Creates (off) flavours and dark colours.
Plasticity:	Ability of a product to be put into different shapes or kneaded.
Release agent:	Use of fats to ensure that a product will not stick to a pan or baking tin.

ANNEX 2. ALTERNATIVES TO PHO: OVERVIEW OF TECHNICAL SOLUTIONS

This annex briefly explain alternatives to PHO, with pros and cons. The American Oil Chemists' Society (Kodali, 2014b; Gupta 2017) has published review books for readers who need more detail.

PLANT OILS THAT ARE LIQUID AT ROOM TEMPERATURE

When fat is used only as a heat transfer medium, release agent or lubricant, there is no need for fat that gives “body”. However, off flavours from oxidation of oils are not wanted. Hence, oils with enough oxidative stability for the required fry life or shelf life can be used for frying or baking bread and soft cakes.

Stable oils such as olive and peanut oil are naturally moderate in SFA, high in MUFA and (very) low in PUFA. They are a healthy choice (although oils with higher PUFA and lower SFA would have more health benefits, since PUFA intakes are often below optimal). The downside is that they are generally expensive.

Stable trait-enhanced oils (for example, high oleic rapeseed, soy or sunflower oils) have been developed using conventional plant breeding and genetic engineering, which have resulted in variants of sunflower, canola/low erucic acid rapeseed and soybean plants with increased MUFA, reduced PUFA and low SFA. These so-called mid and high oleic oils will give fry lives and product shelf lives that are at least as good as for PHO. From a nutritional perspective, trait-enhanced oils that still contain valuable amounts of omega-3 and omega-6 PUFA are the preferred options, since intake of PUFA is often below optimal. The omega-3 PUFA linolenic acid oxidizes very easily. Good frying oil should contain no more than 3% omega-3 linolenic acid to prevent off flavours after a few days of frying (Liu, 2014). This level of linolenic acid is still meaningful from a nutritional perspective. Omega-6 linoleic acid in frying oil should be above 20% to provide attractive frying flavours, but should not exceed 37% to prevent off flavours (Liu, 2014). From a nutritional perspective, the higher end of linoleic acid content would be preferred.

Adding antioxidants (for example, a concentrate of natural mixed tocopherols) to affordable oils such as soy or sunflower will add some costs but can increase the fry life of the oil and the shelf life of the end products. With the additional benefit of high omega-3 and omega-6 PUFA, this would be the preferred choice for health. However, even with antioxidants, fry life and shelf life will be shorter than for stable oils such as high oleic oils. The requirement to declare additives, such as added antioxidants, depends on local legislation and must be carefully evaluated to ensure legal compliance of products sold.

Addition of emulsifiers and surfactants (for example, lecithin, monoglycerides, polysorbate) to all oil variants mentioned can reduce spattering during frying. It can also improve dough handling and end products in baking bread and cake.

NATURAL HARDSTOCKS

When fats are used in food applications for body and texture, oil binding, creaming and lamination, some solid, saturated fat is needed. Animal and tropical fats are semi-solid or solid at room temperature and resistant to oxidation during frying. They were used for selected applications before PHO became available. However, they are all high in SFA and therefore not preferred as a full PHO replacement from a health perspective.

Animal fats are not suitable for vegetarians or vegans, may not be used in processing operations that are kosher or halal certified, and are expensive. Ruminant and milk fat also contains small amounts of natural TFA. Butter and lard are semi-solid, which gives them wider application possibilities – for example, in baking. Tallow is harder than butter and lard at room temperature, which prohibits this type of use.

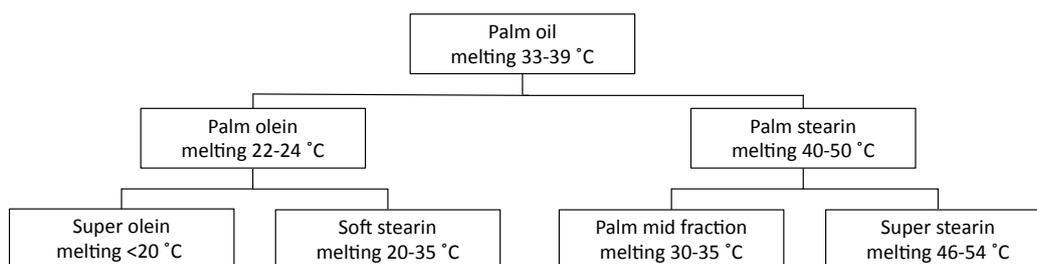
Tropical oils and fats are primarily coconut and palm kernel oil (also known as lauric fats), and palm oil. Both lauric fats are very high in SFA (>90%) and relatively expensive. They are hard at room temperature but melt at 30 °C. Palm oil is made from palm fruits, and mostly imported from Indonesia and Malaysia. Palm oil has the highest annual production of all plant oils and is often the most affordable oil. It contains around 50% SFA. Palm oil is semi-solid at room temperature, which allows baking, among other applications.

FULLY HYDROGENATED PLANT OILS (“FULLY HYDROGENATED HARDSTOCKS”)

Full hydrogenation means the conversion of all unsaturated fat into saturated fat, while the chain lengths of the fatty acids remain the same. The same equipment that is used for partial hydrogenation is used, so no additional investments are required. These fully hydrogenated fats have no TFA. However, they have limited functionality because they are very hard, waxy fats that do not melt at body temperature. Additionally, 100% saturated fat is not preferred as a PHO replacement for health reasons. However, fully hydrogenated fats can be made useful in frying and bakery applications after blending or interesterifying with liquid oils (see below).

FRACTIONATED OILS AND FATS

Oils and fats are made up of a broad range of different triglycerides. These molecules all have three fatty acids, but they differ in composition and configuration. Some triglycerides contain mostly SFA, while others contain mostly unsaturated fatty acids. The process of fractionating uses tightly controlled cooling to separate oils into fractions that melt at higher temperatures (more solid fats) and fractions that melt at lower temperatures (more liquid oils). A typical palm oil fractionation process with different sample fractions and their melting ranges is shown in Fig. 6.



▲ **Fig. 6.** Typical palm oil fractionation process

Oil fractionation is a mature technology that is broadly used on a global level. The technology needs considerable investments to set up. Palm oil fractions are often affordable and technically suitable to replace PHO in several applications. These oils provide a health benefit over PHO if SFA levels in the fraction are equal to, or lower than, the sum of SFA and TFA in the PHO; however, palm fractions may not be the lowest SFA and highest PUFA alternative that would be preferred from a health perspective. For example, palm super olein is liquid at room temperature and a stable frying oil, but at around 40% SFA is not a healthy choice for frying. A healthier choice is high oleic oils, which have good oxidative stability and lower SFA – for example, high oleic canola has less than 10% SFA.

The higher SFA palm oil fractions can be blended or interesterified with liquid oils (see below) to create products with healthier profiles that still provide body and texture, oil binding, creaming and lamination in food applications for which these properties are needed.

REARRANGED FATS (INTERESTERIFIED FATS)

The melting curve and crystal formation properties of a fat are defined not only by the fatty acid composition of the fat, but also by the way the fatty acids are arranged within single fat molecules. In nature, enzymes called lipases are used to digest fats and to rearrange fatty acids within the fat molecule. This process of fat rearrangement is also called interesterification.

Fat rearrangement is widely used in the food industry to create fats with specific melting and crystal formation properties. Oils and fats can also be mixed before rearrangement. If a highly saturated fat (melting point 70 °C) is mixed with a highly unsaturated oil (melting point 0 °C), fat rearrangement will give a range of fat molecules. Most of the fat molecules will have both unsaturated and saturated fatty acids, and the resulting fat melts at 30–35 °C. The combination of a waxy fat and a very liquid oil gives a fat that has good structuring capacity and a desirable melt.

Fat rearrangement is done using either chemical reactions or enzymatic processes. Chemical fat rearrangement is a mature technology that uses heat and a catalyst. It results in random rearrangement of the fatty acids. The chemical process is simpler and cheaper, but results in oil losses and effluents. Enzymatic fat rearrangement uses lipase enzymes at lower temperatures and produces no effluents. Selection of enzymes can result in rearrangement at preferred positions to steer melting properties. An enzymatic plant requires substantial investments, but costs are decreasing. Enzymatic fat rearrangement is an established technology in Europe and North America, but may not be established in other regions.

From a nutritional perspective, fat rearrangement is often the method of choice for solid baking shortening and margarines because it can be used to deliver the same solid fat structuring capacities at lower overall SFA levels (“harder working SFA”). Moreover, the method can be used to incorporate enough PUFA into products. For instance, palm oil or palm fractions have effective baking qualities for use as PHO alternatives for baking shortenings, but they are not favourable from a health standpoint: they deliver >50% SFA and very low levels of PUFA (<9%). An alternative baking shortening that is both effective for baking qualities and healthier can be made by interesterifying a structuring fat such as palm stearin (20%) with soybean oil (80%). This product will have 26% SFA, 23% MUFA and 51% PUFA. For more plasticity, the hard fat content can be increased, and, for more oxidative stability, high or mid oleic oils can replace commercial soy oil. This will increase the SFA level, but the level will still be below that of the palm products. The rearranged shortening will be more expensive than the palm-based shortening.

Fat rearrangement is a great tool to eliminate TFA from PHO and reduce SFA intake, but concerns have also been expressed. A recent review (Mensink et al., 2016) concluded that studies of rearranged fats have not revealed any health issues, but gaps in knowledge remain about potential longer-term health effects of consumption of rearranged fats.

Labelling of interesterified fats must be checked.

BLENDING OF OILS AND HARDSTOCKS

Oils can be blended with hardstocks to create products with the desired structure, melting behaviour and oxidative stability to replace PHO for specific applications. Natural, fractionated, fully hardened and rearranged hardstocks can all be used. Different hardstocks can also be

blended to produce certain functionalities. For instance, a moderate SFA margarine can be made by blending palm oil mid fraction and coconut fat with liquid oils. In margarines and butter, a network of saturated fat crystals binds liquid oil and water to give a spreadable product that melts in the mouth. Margarine manufacturers use oil blending combined with controlled cooling and mixing to form the desired product. A lower SFA and high PUFA margarine can be made by blending rearranged hardstock with some coconut oil or palm mid fraction and high PUFA oils. The rearranged hardstock provides oil-binding capacity with little SFA, whereas the coconut or palm oil helps to improve mouthfeel and melt.

Blending “simple” hardstocks with oils is fundamentally different from interesterifying hardstocks with liquid oils. With blending, it can be difficult to obtain the desired melting properties in the blended fat. Blending mixes fat molecules, whereas interesterification mixes fatty acids within the fat molecules. Interesterification is therefore better able to deliver a range of consistencies and melting properties for margarines, shortening and confectionery fats. The blending process will generally cost less than rearrangement through interesterification.

Component blending is not technically complicated, but the production facility must possess enough dedicated tanks for each component. The facility must also be able to precisely deliver the type and proportion required for each component to the blend tank. Blending was previously used for PHO products, so these facilities may now be used for TFA-free oil blending.

COMBINATIONS OF TECHNICAL SOLUTIONS

Combinations of fractionation, interesterification, full hydrogenation and blending of oils are particularly well suited to formulating oils and fats low in TFA and SFA. Interesterification of specific solid palm oil fractions with liquid oils can be particularly relevant for margarines and baking shortenings, resulting in improved mouthfeel, aeration and creaming. Combinations of technologies can also be selected to allow cost-effective use of locally available starting materials. However, not all processing solutions may be locally available, and every processing step will add costs.

NEW DEVELOPMENTS

Newer developments for replacement of TFA are the use of oleogels and structured emulsions to provide structure and functionality. These alternatives are not covered here because they are not mature technologies. The products may have notably different physical properties and functionality from oil- and fat-based hardstocks. For more details, see Zetzl & Marangoni (2014).

REPLACEMENT OF MINOR SOURCES OF TFA

As the process of replacing TFA moves forward, it may become important to examine sources of TFA that originally were seen as insignificant. Refining at lower temperatures can lower the level of TFA (by up to 2%) in vegetable oils. PHO in small amounts can be used as a carrier in preservatives, processing aids, flavours and colours. The technical solutions described above can also be used to make carrier fats that are PHO free, but each solution needs to be tested. These minor sources are not the first items to be addressed, but they should not be forgotten. Currently, these minor sources of TFA remain in foods in countries that are moving towards complete elimination of TFA. As companies in these countries work to eliminate these last sources of TFA, appropriate replacements will be available for additional countries to learn about and use.

ANNEX 3.

SAMPLE BROCHURE FOR RESTAURANTS AND FOOD SERVICE ESTABLISHMENTS

Below is an excerpt of a brochure created by the New York City Department of Health and Mental Hygiene for distribution to restaurants and other food service establishments to support implementation of the policy¹.

Does Your Kitchen Need an Oil Change?



What Every Restaurant and Food Service Establishment Needs to Know About Trans Fat

Clear Your Kitchen of Trans Fat

1. CHANGE your oils.

For cooking and frying, check the ingredients on all oils. If “partially hydrogenated” is listed, switch to a non-hydrogenated oil instead. If there is no ingredients list, ask your supplier or the manufacturer.

For baking, use non-hydrogenated oils or shortenings with low or **no trans fat**.

2. CHOOSE healthy spreads.

Instead of stick margarine or butter, use soft tub spreads with low saturated fat and **no trans fat**.

3. ORDER prepared foods without trans fat.

Check ingredients and ask your supplier for baked products, pre-fried, and pre-mixed foods that are free of partially hydrogenated vegetable oils.

INGREDIENTS: Pasteurized Grade A Non-fat Milk, Fructose, Red Bell Pepper, Partially Hydrogenated Soybean Oil, Salt, Modified Cornstarch, Garlic, Lemon Juice

¹ (NYC DOHMH, 2019)



FOR MORE INFORMATION, PLEASE CONTACT:

Department of Nutrition for Health and Development
World Health Organization
Avenue Appia 20, CH-1211 Geneva 27, Switzerland

Fax: +41 22 791 4156
Email: nutrition@who.int
www.who.int/nutrition

