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Scienza e Tecnologia
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Oils and Fats

Composition

Physico-chemical characteristics

Fat oxidation

Processing and refining

Extra-virgin olive oil

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Unit 1 Lipids: chemical nature, nomenclature and classification. Compositional characteristics of edible fats: saponifiable and unsaponifiable fraction, constituents, biosynthetic characteristics, chemical-physical properties. Essential fatty acids: concept of essentiality.

Unit 2 Reactions involving the lipid fraction: oxidative, hydrolytic and ketone rancidity. Autoxidation and photoxidation. Changes induced by exposure to high temperatures (deep-frying) and due to ageing.

Unit 3 Outline of technology: food fat extraction techniques (squeezing and extraction), rectification, hydrogenation, trans-esterification and fractionation processes, characteristics of the derived products.
Learn more about palm oil.

Unit 4 Olive oil: botanical notes, reference legislation, production technology, compositional characteristics, quality and authenticity parameters. Analysis of olive oil: chemical and sensory analyses

Contents

Extraction of fats

The extraction procedures vary according to the characteristics of raw materials:

- fat content and its chemical-physical characteristics (viscosity, composition - especially of the minor components: lipoproteins, phospholipids, waxes)
- protein content
- morphology of the primary material (seeds, fruits, etc)
- water content
- use of by-products

All these variables must be considered for the optimization of both the extraction methods which are essentially two:

- physical extraction by pressing
- extraction with solvent.

https://lipidlibrary.aocs.org/edible-oil-processing

Extraction of fats
-> Pressing

This process is generally adopted when:

A) As a pre-extraction of seeds with a high oil content (>20%)

B) When aqueous materials have to be extracted - fruit pulp
- olive - hydraulic presses
- palm - hydraulic presses and continuous presses

C) When virgin oils have to be obtained

D) When the extraction residue should have a high fat content (e.g. cocoa)

Products typically obtained by pressing are:
- **Virgin olive oil**
- **Palm oil**
- **Cocoa butter**

Extraction of fats
-> Solvent extraction

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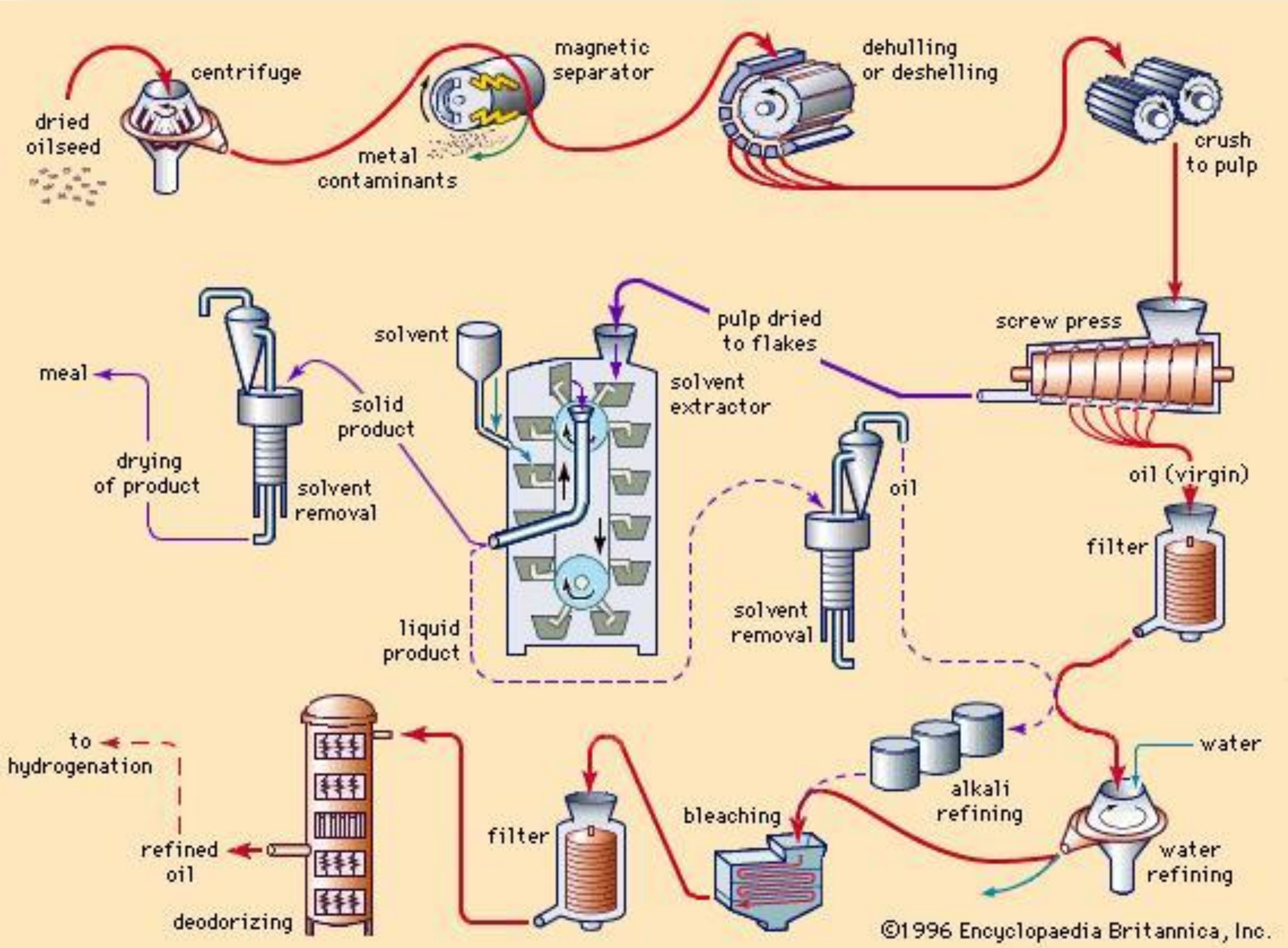

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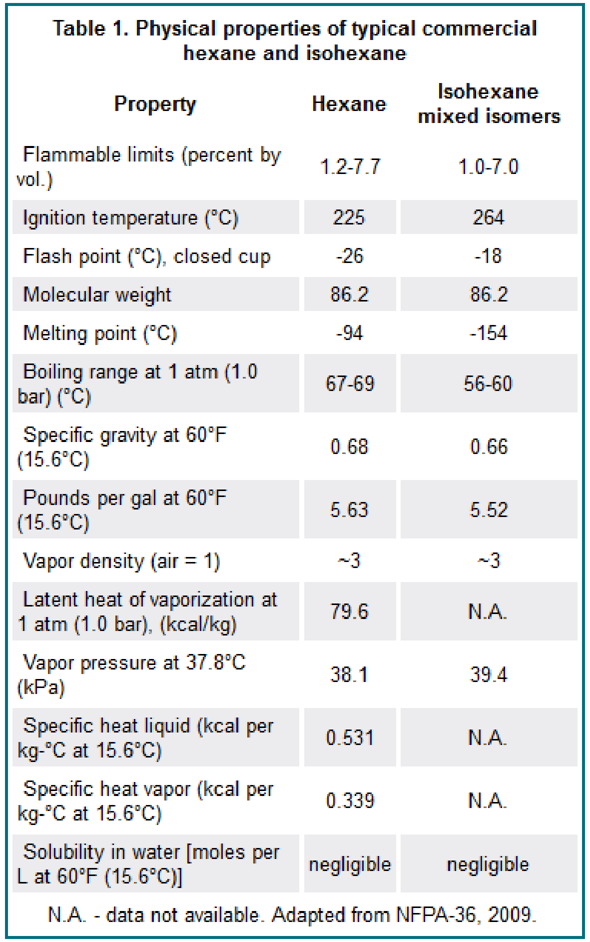


Table 1. Physical properties of typical commercial hexane and isohexane

Property	Hexane	Isohexane mixed isomers
Flammable limits (percent by vol.)	1.2-7.7	1.0-7.0
Ignition temperature (°C)	225	264
Flash point (°C), closed cup	-26	-18
Molecular weight	86.2	86.2
Melting point (°C)	-94	-154
Boiling range at 1 atm (1.0 bar) (°C)	67-69	56-60
Specific gravity at 60°F (15.6°C)	0.68	0.66
Pounds per gal at 60°F (15.6°C)	5.63	5.52
Vapor density (air = 1)	~3	~3
Latent heat of vaporization at 1 atm (1.0 bar), (kcal/kg)	79.6	N.A.
Vapor pressure at 37.8°C (kPa)	38.1	39.4
Specific heat liquid (kcal per kg-°C at 15.6°C)	0.531	N.A.
Specific heat vapor (kcal per kg-°C at 15.6°C)	0.339	N.A.
Solubility in water [moles per L at 60°F (15.6°C)]	negligible	negligible

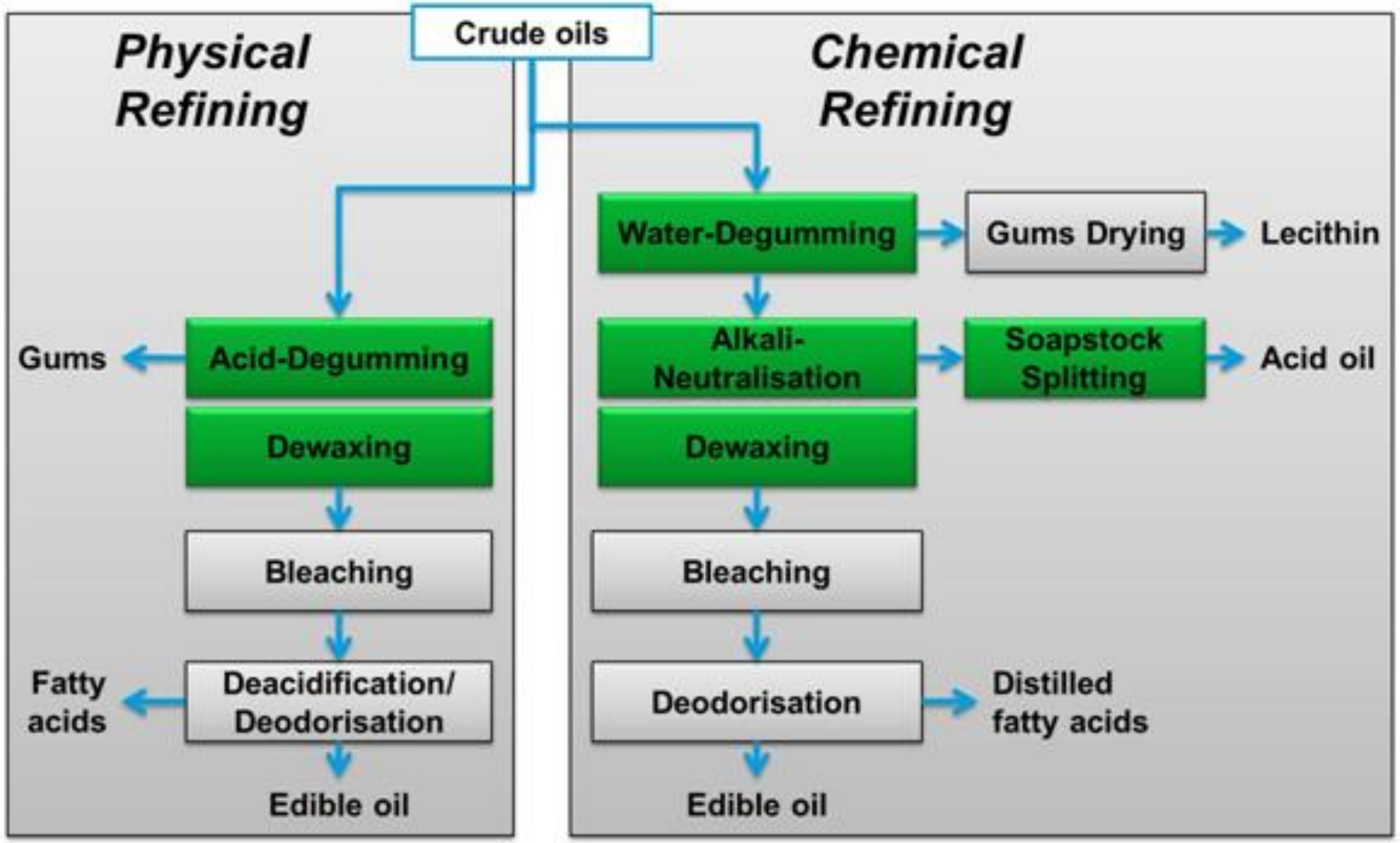
N.A. - data not available. Adapted from NFPA-36, 2009.

Extraction of fats
-> Solvent extraction

Why hexane?
Mix of isomers with very similar properties sometimes called *extraction hexane* or *commercial hexane*.

- ✓ Boiling point of 69°C it is a liquid in all but the most extreme climates of the world. Fairly high volatility and a low sensible heat of 335 kJ/kg it is relatively easy to remove from the solids and oil with low energy use.
- ✓ Azeotrope, a slightly reduced 61.6°C boiling temperature when in the presence of water or steam and resulting in a vapor coming off at about 95% by weight hexane and 5% by weight water. The azeotrope is convenient for efficient removal of the solvent from solids (or “meal”) using direct steam contact.
- ✓ It does not mix with water, allowing fairly simple processes to keep it in the system while water passes through the extraction process as moisture in the seed, meal, oil or air.
- ✓ Hexane has a good and aggressive capability to dissolve and mix with vegetable oils so that it can wash the desired oils out of a fibrous or solid material.
- ✓ Selective and leaves the proteins, sugars and some undesired gums largely undisturbed in the meal.
- ✓ Relatively ‘tolerable’ odor and a low tendency to cause discomfort when one is subjected to a brief exposure.

Fats refining



Fats refining

All vegetable oils extracted with solvent

- ✓ Degumming (avoid foaming)
- ✓ Neutralization (reduction of free acidity)
- ✓ Bleaching (removal of pigments)
- ✓ Deodorization (elimination of odorous substances)

The most drastic processes concern:
decolorization and deodorization: high temperature (up to 220-230°C) and use of adsorbent earths.
Formation of toxic compounds (process contaminants!)

☠ **Process contaminants**

Fats refining -> Degumming

Degumming removes hydratable polar lipids (phospholipids, lipoprotides, glycolipids), resins and gums.

- ✓ Sulfuric acid at various concentrations
  The process with sulfuric acid (1-2% sulfuric acid at 66% for fluid oils at 15-20°C) is the most widespread. The acid acts on the mucilage causing its coagulation by dehydration or carbonization. Subsequently it is diluted with water thus interrupting the action of the concentrated acid. The separation of the two phases is obtained through sedimentation (and subsequent washing with hot water to eliminate any acid residues) or centrifugation.
- ✓ Water or aqueous solution of electrolytes (0.5-2%)
  Causes a swelling of the lecithin (main constituents of mucilage), making them insoluble in the oil. The separation is achieved by sedimentation. The same result can be obtained by treating the oil at 50°C with diluted solutions of sodium hydroxide or sodium chloride (aqueous solutions of electrolytes) and then letting it settle;
- ✓ Adsorbents (diatomaceous earths and zeolites) applicable at low amounts of mucilage.
  They are economically viable only when the required amount of adsorbent does not exceed 1% of the oil mass. Exceeding this limit causes considerable losses of oil (retained by the earth panel or by activated carbon).

Fats refining -> Neutralization

Neutralization allows the elimination of the free fatty acids which are released by lipases.

- ✓ The most widespread process for plant engineering simplicity consists in the use of aqueous solutions (with variable concentration from 15 to 40%) of sodium hydroxide in excess of 10% with respect to the normal stoichiometric ratio.

Greater quantities of sodium hydroxide determine an increase in **losses due to saponification**, as well as the high presence of mucilages.

The refining losses are expressed through a neutralization index which expresses the total weight variation undergone by the oil upon the neutralization of 1 g of free fatty acids.

Neutralization index = (weight loss of 100 g of oil / acidity of the oil in %)

100 kg of crude oil at 3.1% acidity before treatment and 94 kg of crude oil at 0.1% acidity after treatment, the neutralization index is close to 2. This indicates that for for every gram of neutralized acids, one gram of neutral oil is entrained in the soapy part.

- ✓ If the starting oil has a high acidity (0.7-1%) it is possible to carry out a neutralization, which in this case is coupled with deodorization, by means of steam distillation under vacuum (190-230°C, 0.5-10 mbar).

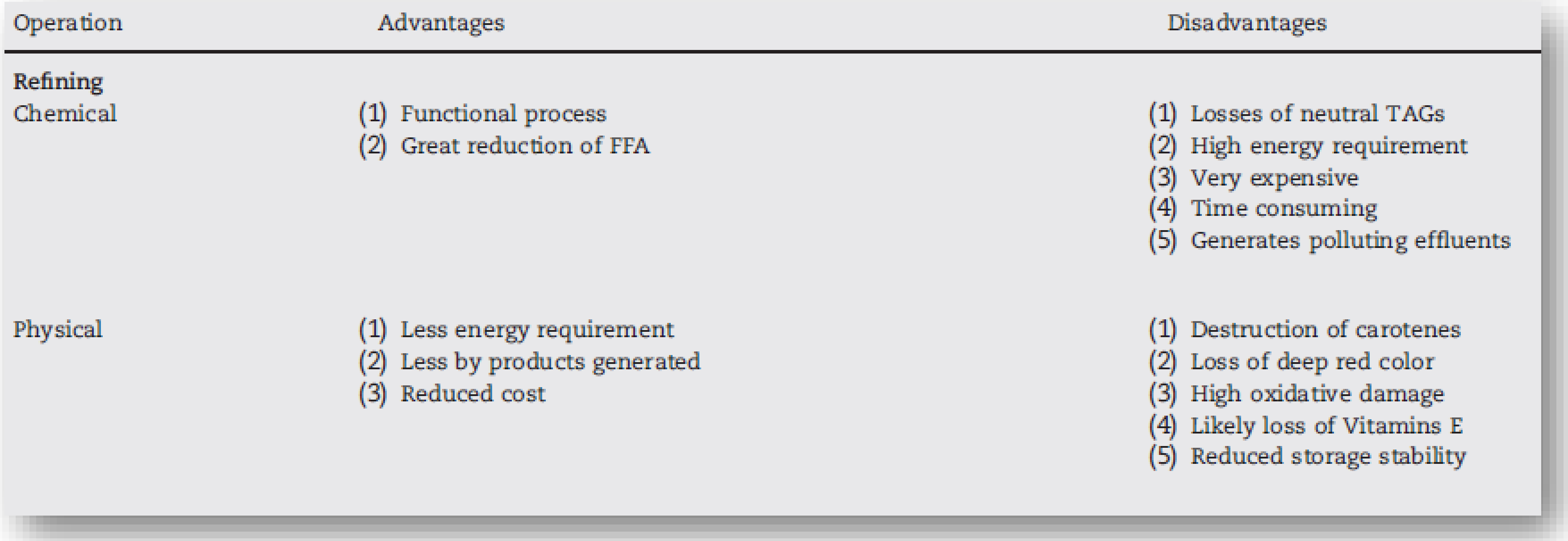
Fats refining -> Bleaching and deodorization

- ✓ The **bleaching** allows the elimination of most of the pigments (carotenoids and chlorophylls) still present in the oil.

  The oil is treated with small quantities of activated earth aluminum silicates (Fuller's bleaching earth) (0.5-4%) mixed with activated carbon (10% of the earth) at temperatures of 60-100°C for variable times between 15 and 30 minutes.
  The mass (oil + earth + carbon) is filtered through a filter press.
  The coals can be recovered, while the earths are disposed of.

- ✓ With **deodorization**, off-odorants are eliminated. These are: free fatty acids (present in soap residues); volatile compounds (aldehydes and ketones deriving from oxidation processes of unsaturated fatty acids); residual carotenes; natural toxic principles (e.g. gossypol in cotton or isothiocyanates in *Cruciferae* seeds). The treatment consists in a steam distillation under vacuum (190-230°C, 0.5-10 mbar).

Fats refining -> Process contaminants



Operation	Advantages	Disadvantages
Refining		
Chemical	(1) Functional process (2) Great reduction of FFA	(1) Losses of neutral TAGs (2) High energy requirement (3) Very expensive (4) Time consuming (5) Generates polluting effluents
Physical	(1) Less energy requirement (2) Less by products generated (3) Reduced cost	(1) Destruction of carotenes (2) Loss of deep red color (3) High oxidative damage (4) Likely loss of Vitamins E (5) Reduced storage stability

The deodorization process takes place at high temperature (> 230°C): these conditions promote the formation of glycidyl esters (GE) and 3-chloropropan-1,2-diols (3-MCPD) starting from diglycerides (DAG- diacylglycerols) present in the crude oil.

These substances have genotoxic activity in vitro and the EU recommends an upper tolerable limit of 2µg/Kg BW (body weight) for 3-MCPD.

Fats refining -> Process contaminants

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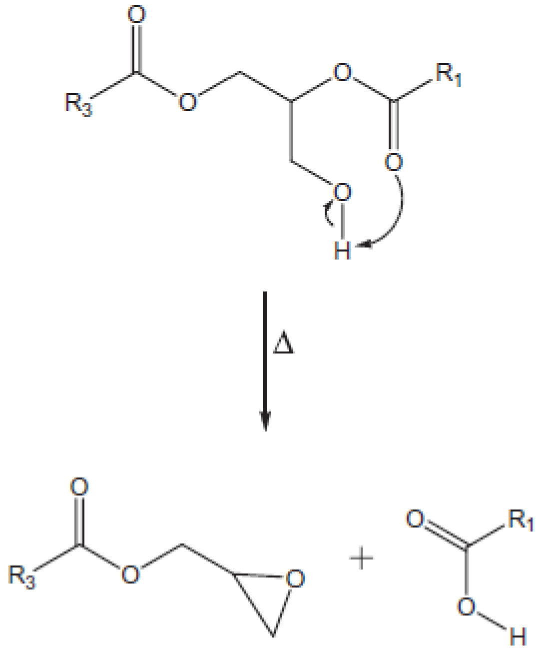
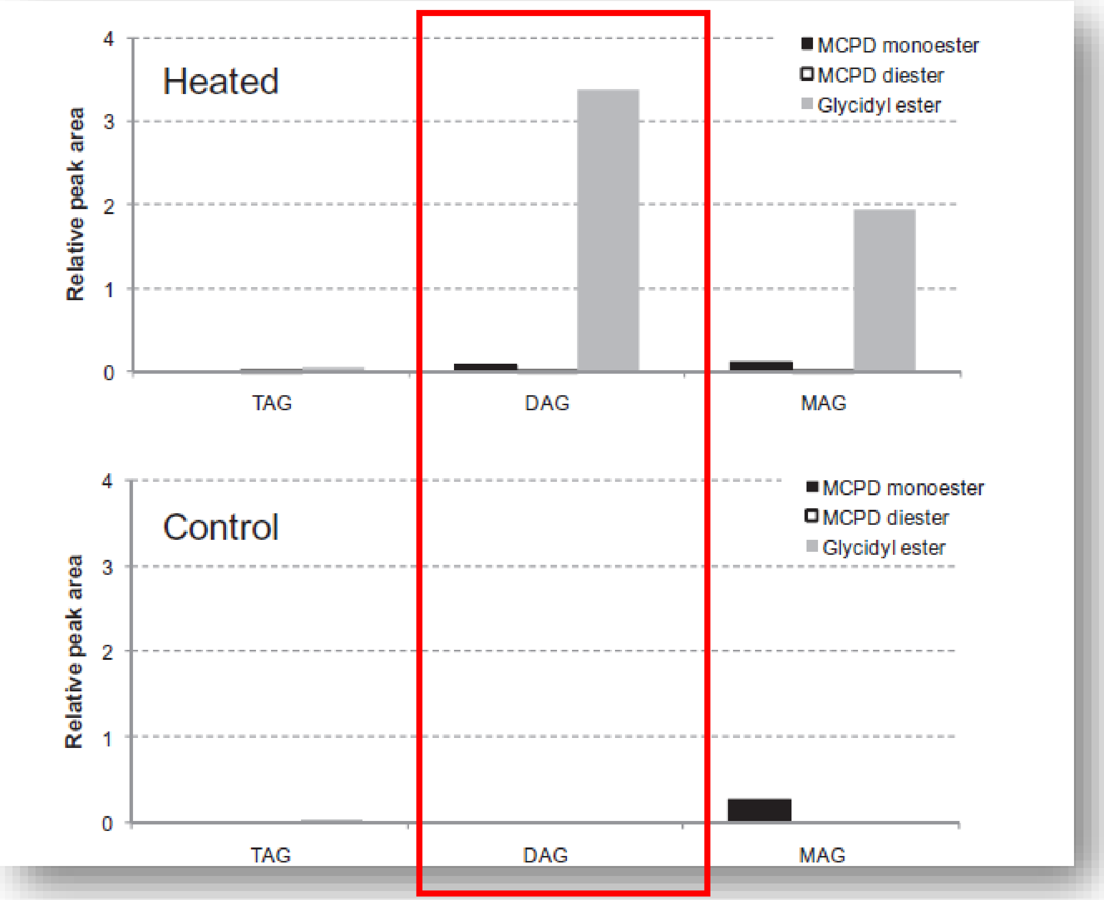


GE

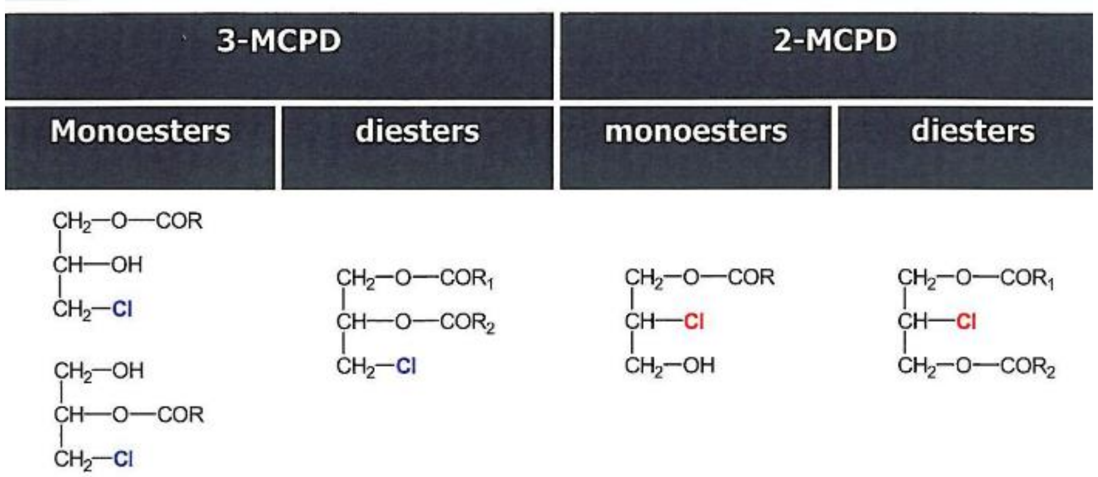
FFA

Mechanism of formation of glycidyl esters (GE) starting from DAG (diacyl glycerides) due to the effect of the process temperature



Fats refining -> Process contaminants

Your Global Fats and Oils Connection



3-MCPD		2-MCPD	
Monoesters	diesters	monoesters	diesters
$CH_2-O-COR$ $CH-OH$ CH_2-Cl CH_2-OH $CH-O-COR$ CH_2-Cl	$CH_2-O-COR_1$ $CH-O-COR_2$ CH_2-Cl	$CH_2-O-COR$ $CH-Cl$ CH_2-OH	$CH_2-O-COR_1$ $CH-Cl$ $CH_2-O-COR_2$

The mechanism of formation of 2- and 3-MCPDs has not been fully elucidated; it is probable that these compounds are formed by high temperature treatments in the presence of residues of Cl- ions. Toxicity is linked to in vitro proven genotoxicity, free 3-MCPD is classified IARC 2B - possible carcinogen for humans; the esters hydrolyze in the gastrointestinal tract and release the active form.

COMMISSION REGULATION (EU) 2020/1322

of 23 September 2020

amending Regulation (EC) No 1881/2006 as regards maximum levels of 3-monochloropropanediol (3-MCPD), 3-MCPD fatty acid esters and glycidyl fatty acid esters in certain foods

Fats refining -> Process contaminants

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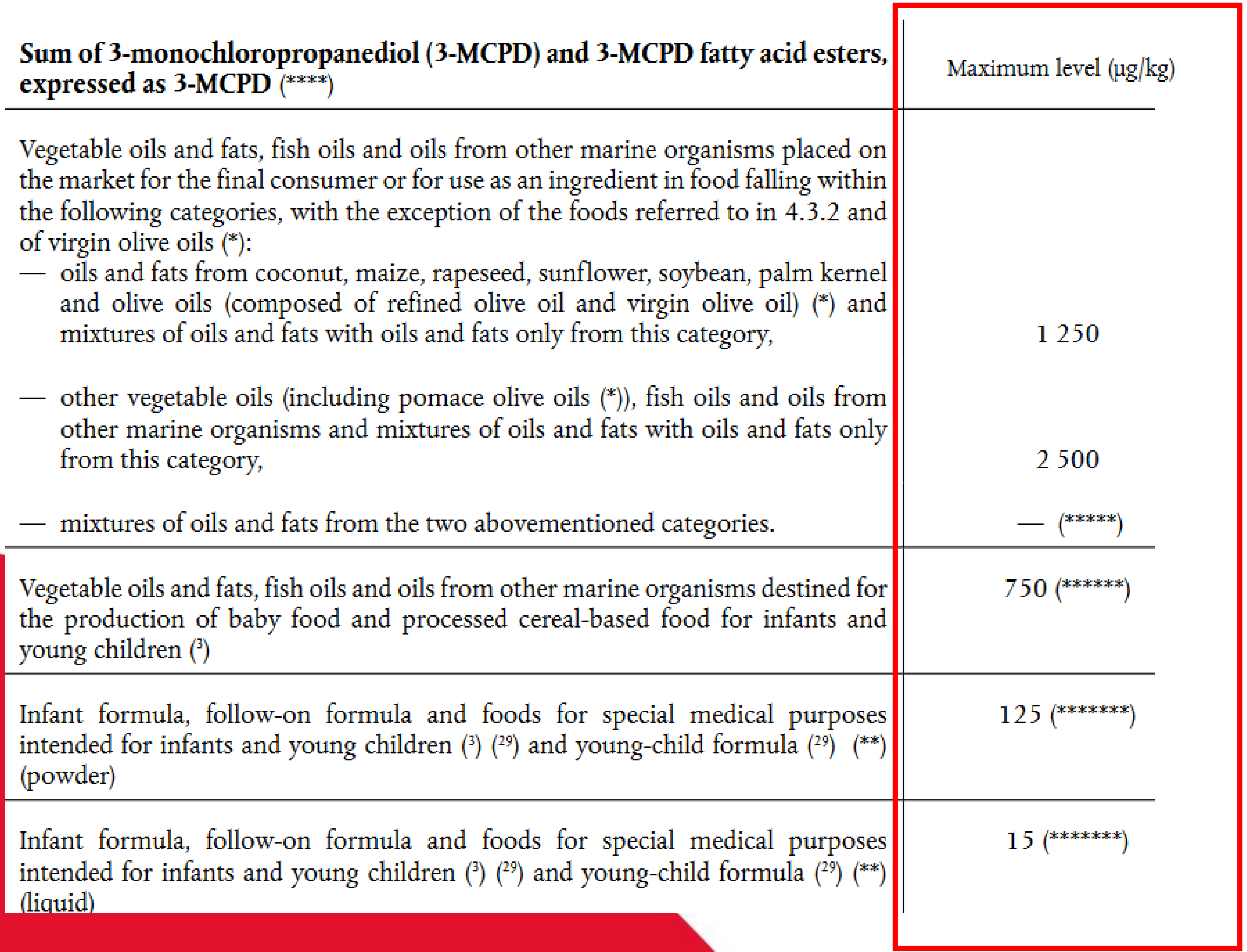
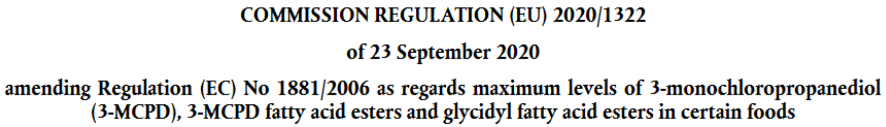


Sum of 3-monochloropropanediol (3-MCPD) and 3-MCPD fatty acid esters, expressed as 3-MCPD (****)	Maximum level (μg/kg)
Vegetable oils and fats, fish oils and oils from other marine organisms placed on the market for the final consumer or for use as an ingredient in food falling within the following categories, with the exception of the foods referred to in 4.3.2 and of virgin olive oils (*):	
— oils and fats from coconut, maize, rapeseed, sunflower, soybean, palm kernel and olive oils (composed of refined olive oil and virgin olive oil) (*) and mixtures of oils and fats with oils and fats only from this category,	1 250
— other vegetable oils (including pomace olive oils (*)), fish oils and oils from other marine organisms and mixtures of oils and fats with oils and fats only from this category,	2 500
— mixtures of oils and fats from the two abovementioned categories.	— (*****)
Vegetable oils and fats, fish oils and oils from other marine organisms destined for the production of baby food and processed cereal-based food for infants and young children (³)	750 (******)
Infant formula, follow-on formula and foods for special medical purposes intended for infants and young children (³) (²⁹) and young-child formula (²⁹) (**) (powder)	125 (*******)
Infant formula, follow-on formula and foods for special medical purposes intended for infants and young children (³) (²⁹) and young-child formula (²⁹) (**) (liquid)	15 (*******)



COMMISSION REGULATION (EU) 2020/1322

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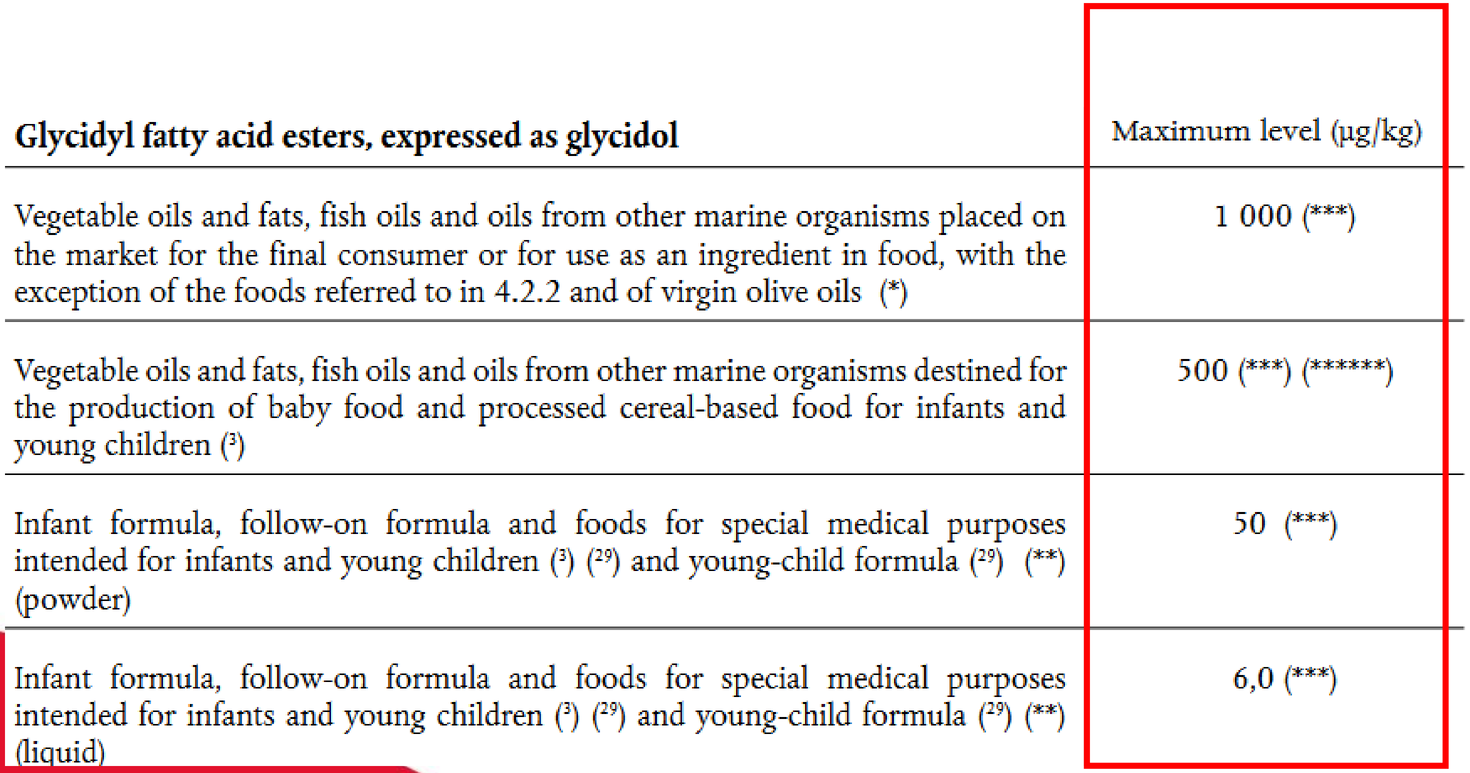
amending Regulation (EC) No 1881/2006 as regards maximum levels of 3-monochloropropanediol (3-MCPD), 3-MCPD fatty acid esters and glycidyl fatty acid esters in certain foods

Fats refining -> Process contaminants



Glycidyl fatty acid esters, expressed as glycidol	Maximum level (µg/kg)
Vegetable oils and fats, fish oils and oils from other marine organisms placed on the market for the final consumer or for use as an ingredient in food, with the exception of the foods referred to in 4.2.2 and of virgin olive oils (*)	1 000 (***)
Vegetable oils and fats, fish oils and oils from other marine organisms destined for the production of baby food and processed cereal-based food for infants and young children (3)	500 (***) (******)
Infant formula, follow-on formula and foods for special medical purposes intended for infants and young children (3) (29) and young-child formula (29) (**) (powder)	50 (***)
Infant formula, follow-on formula and foods for special medical purposes intended for infants and young children (3) (29) and young-child formula (29) (**) (liquid)	6,0 (***)

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Fats refining -> Process contaminants

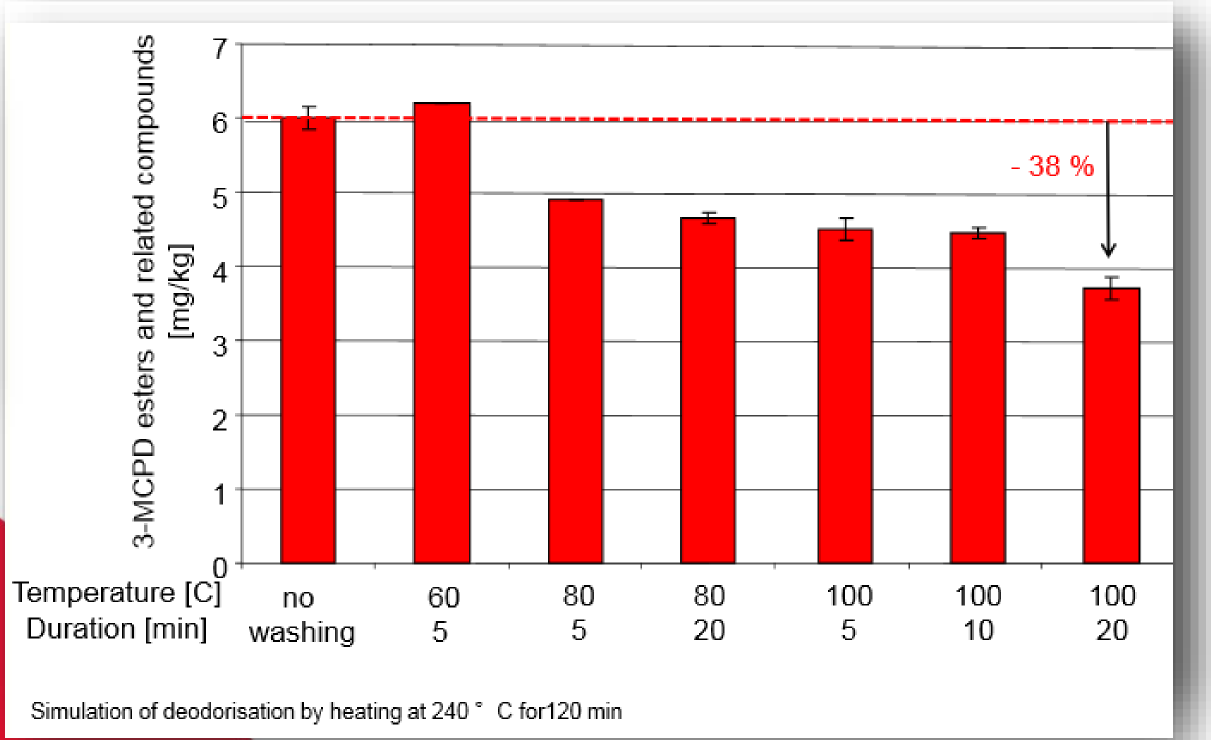
Strategies to mitigate the formation of GE and 2 and 3-MCPD derivatives:

limit the degradation of the raw material and the increase in the amount of DAG - released by the activity of the lipases during the over-ripening of the product;
subject the CPO to washings with acidified aqueous solutions (phosphoric and citric acid);
if neutralization is necessary, preferably use KOH and NaOH (by chemical route);
lowered the deodorization temperatures as much as possible
include washing the CPO

Mitigation of 3-MCPD and G Esters in refined palm oils

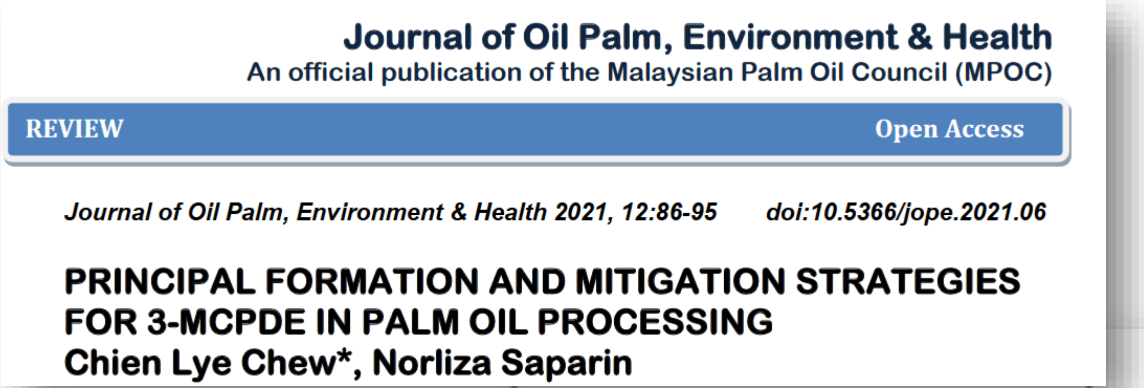
103rd AOCS Annual Meeting & Expo
April 29 – May 2, 2012, Long Beach, CA, USA

Frank Pudel, Bertrand Matthäus,
Anne Freudenstein, Tim Rudolph



Simulation of deodorisation by heating at 240 ° C for120 min

Fats refining -> Process contaminants



Journal of Oil Palm, Environment & Health
An official publication of the Malaysian Palm Oil Council (MPOC)

REVIEW Open Access

Journal of Oil Palm, Environment & Health 2021, 12:86-95 *doi:10.5366/jope.2021.06*

PRINCIPAL FORMATION AND MITIGATION STRATEGIES FOR 3-MCPDE IN PALM OIL PROCESSING

Chien Lye Chew*, Norliza Saparin

1. Optimise Harvesting Interval
2. Reduce handling
3. Clean FFB
4. Fast evacuation

1. CPO Washing
2. Hot Water Dilution
3. Separate Oil Recovery System (SORS)

1. CPO pre-treatment
2. Process modification
3. Mild refining

Modification of Triglyceride Oils

1. **Hydrogenation**
2. Interesterification
3. Fractionation

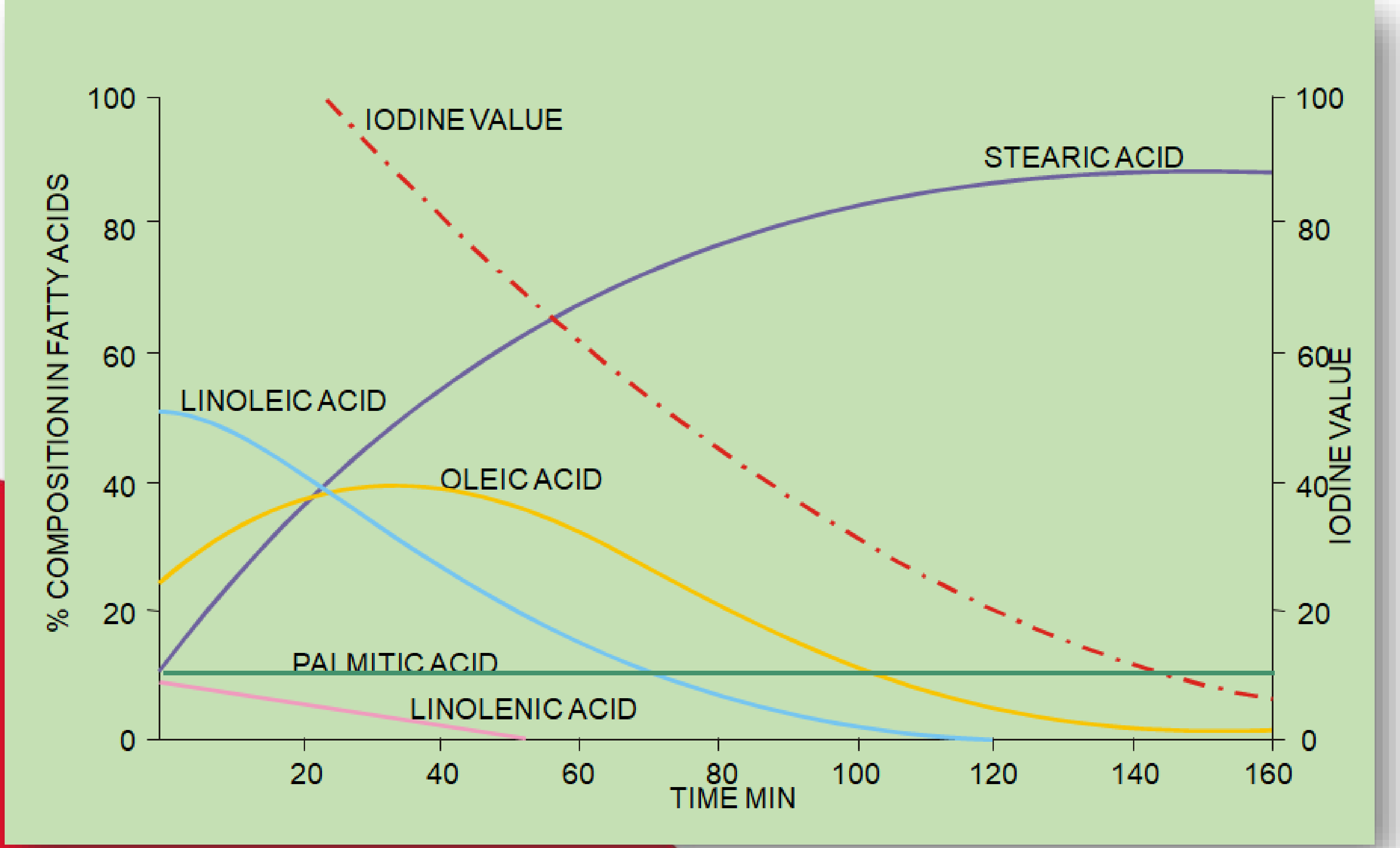
1. Hydrogenation

The hydrogenation process of edible oils was invented by Wilhelm Normann in 1902.
At that time, it was possible to follow the progress of the reaction by measuring the iodine value of the reaction product. Measuring its melting point also provided a way of characterization and measuring both soon revealed that when a certain oil was partially hydrogenated to a certain melting point, its iodine value could vary. This led to the concept of selectivity, be it as yet poorly defined.

It is now commonly accepted that the nickel-catalysed hydrogenation of unsaturated fatty acids follows the Horiuti-Polanyi mechanism. According to this mechanism, molecular hydrogen is adsorbed onto the nickel surface and dissociated into two hydrogen atoms. Fatty acids are also adsorbed onto this nickel surface by their double bond or bonds and in a first step, a hydrogen atom is added to this bond to form a half-hydrogenated intermediate. If a second hydrogen atom is then added to this intermediate, the original double bond has been saturated but because the first addition is reversible, the intermediate can also dissociate.

Modification of Triglyceride Oils

1. Hydrogenation



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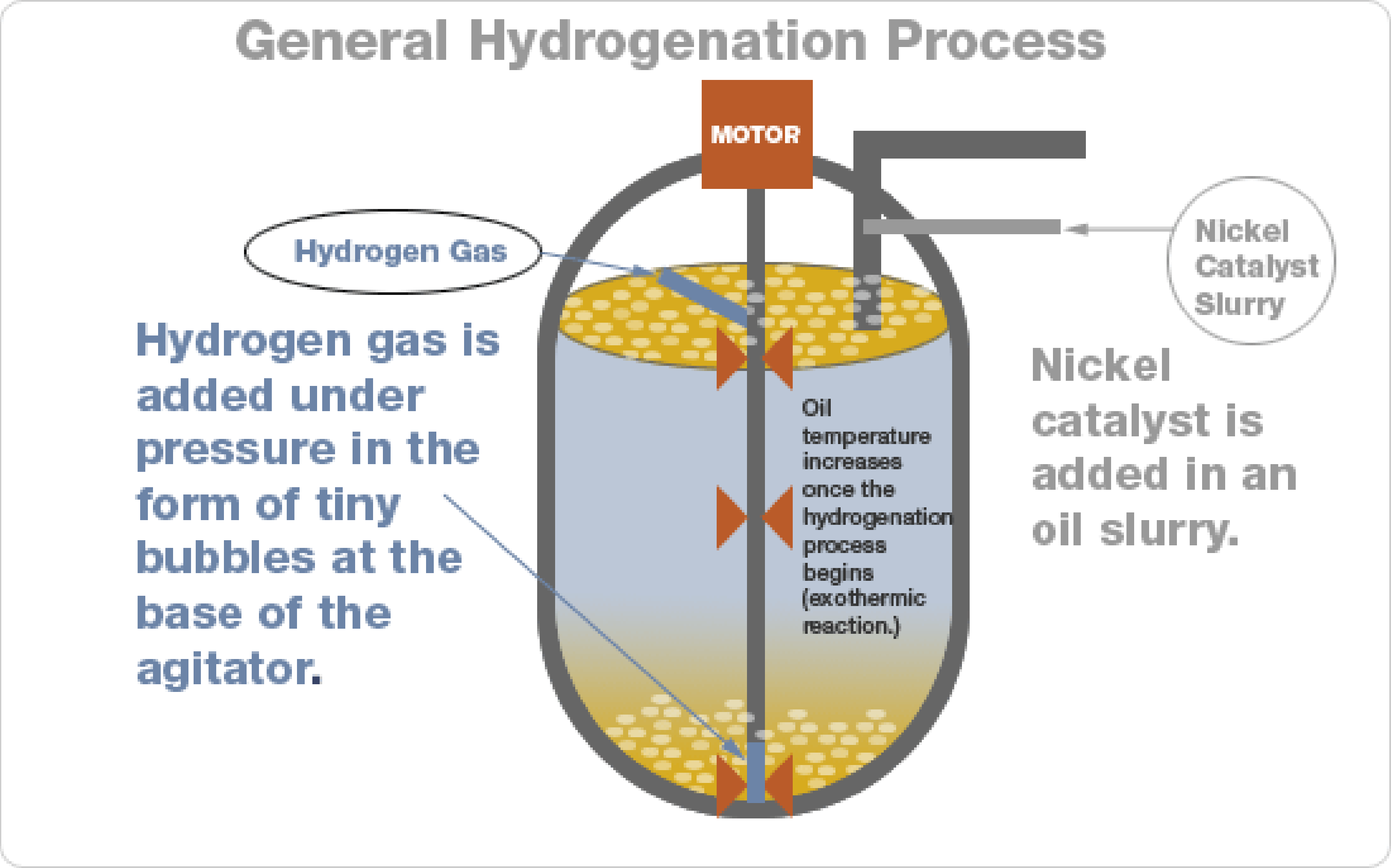
1. Hydrogenation

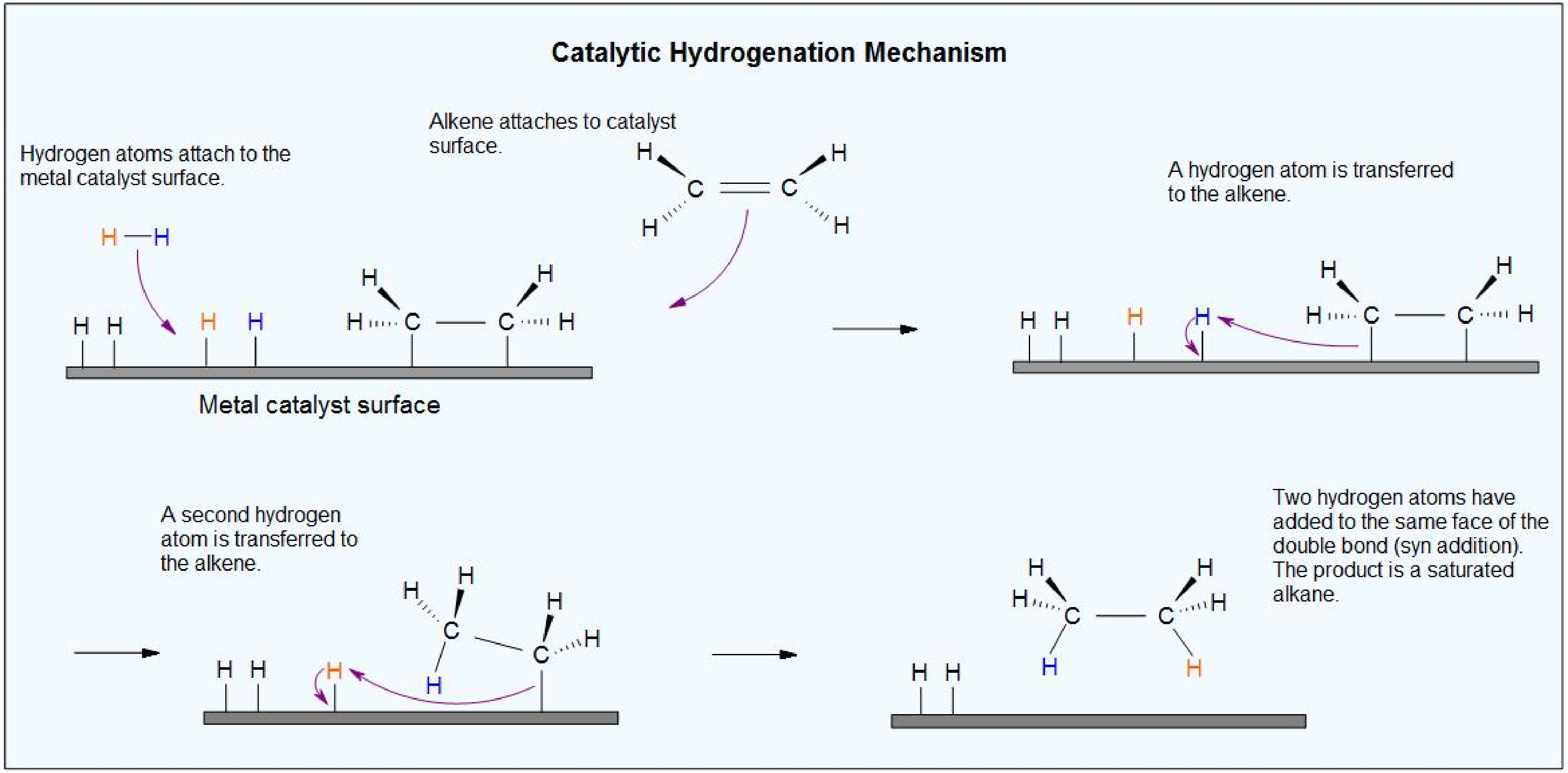


Hydrogen gas is added under pressure in the form of tiny bubbles at the base of the agitator.

Nickel catalyst is added in an oil slurry.

Modification of Triglyceride Oils

1. Hydrogenation



Catalytic Hydrogenation Mechanism

Hydrogen atoms attach to the metal catalyst surface.

Alkene attaches to catalyst surface.

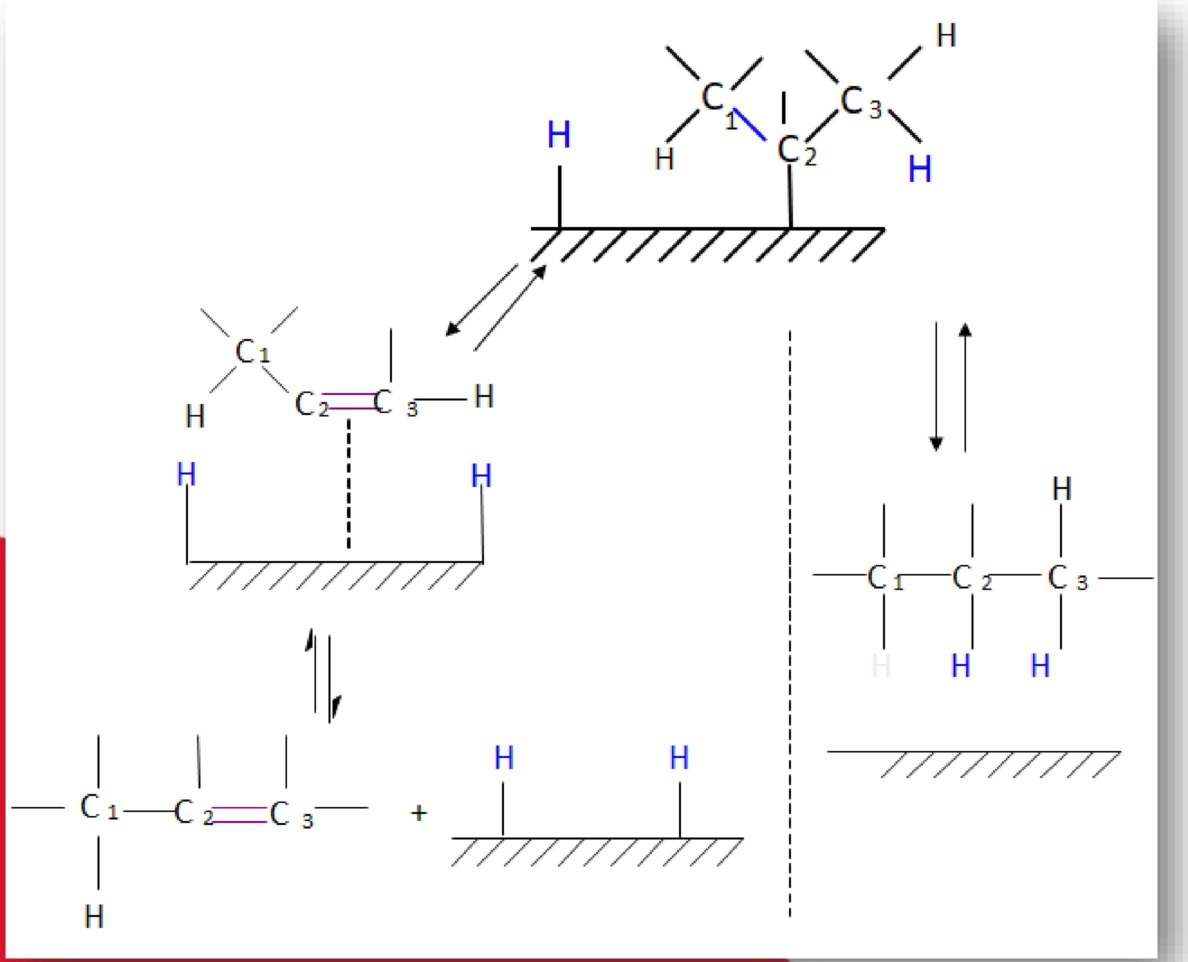
A hydrogen atom is transferred to the alkene.

A second hydrogen atom is transferred to the alkene.

Two hydrogen atoms have added to the same face of the double bond (syn addition). The product is a saturated alkane.

Modification of Triglyceride Oils

1. Hydrogenation



The most common catalysts for the catalytic hydrogenation process in heterogeneous phase are:

- ✓ Nickel
- ✓ Nickel supported
- ✓ Copper
- ✓ Other Noble Metals

The choice is usually guided by:

- ✓ Specificity
- ✓ Degree of *trans*-isomers
- ✓ Duration and costs of the process

Modification of Triglyceride Oils

1. Hydrogenation

To determine the specificity of a catalyst, the reaction rate of each step of the process is evaluated, which can be summarized as follows:

Triene-AR $\xrightarrow{k_3}$ Diene-AR $\xrightarrow{k_2}$ Monoene-AR $\xrightarrow{k_1}$ Saturated-AR

AR= Acyl Residue

For the hydrogenation yield to be considered satisfactory, it is necessary that $k_3>k_2>k_1$

Therefore the Specificity (S) of a catalyst can be defined as follows:

$S_{32}= k_3/k_2$ $S_{21}= k_2/k_1$ $S_{31}= k_3/k_1$

This means that the higher the S value, the faster the hydrogenation process will be.

Modification of Triglyceride Oils

1. Hydrogenation

$S_{32} = k_3/k_2$ $S_{21} = k_2/k_1$ $S_{31} = k_3/k_1$

Nickel, although less efficient than the noble metals, is the cheapest, and can be reused up to 50 consecutive hydrogenation cycles.

The support on which the nickel is deposited is made up of zeolite or kieselguhr.

Costy

Catalyst	Specificity		*trans*-isomers (% weight)
	S_{32}	S_{21}	
Nichel-contact	2-3	40	40
Ni_3S_2-contact	1-2	75	90
Copper -contact	10-12	50	10

Modification of Triglyceride Oils

1. Hydrogenation

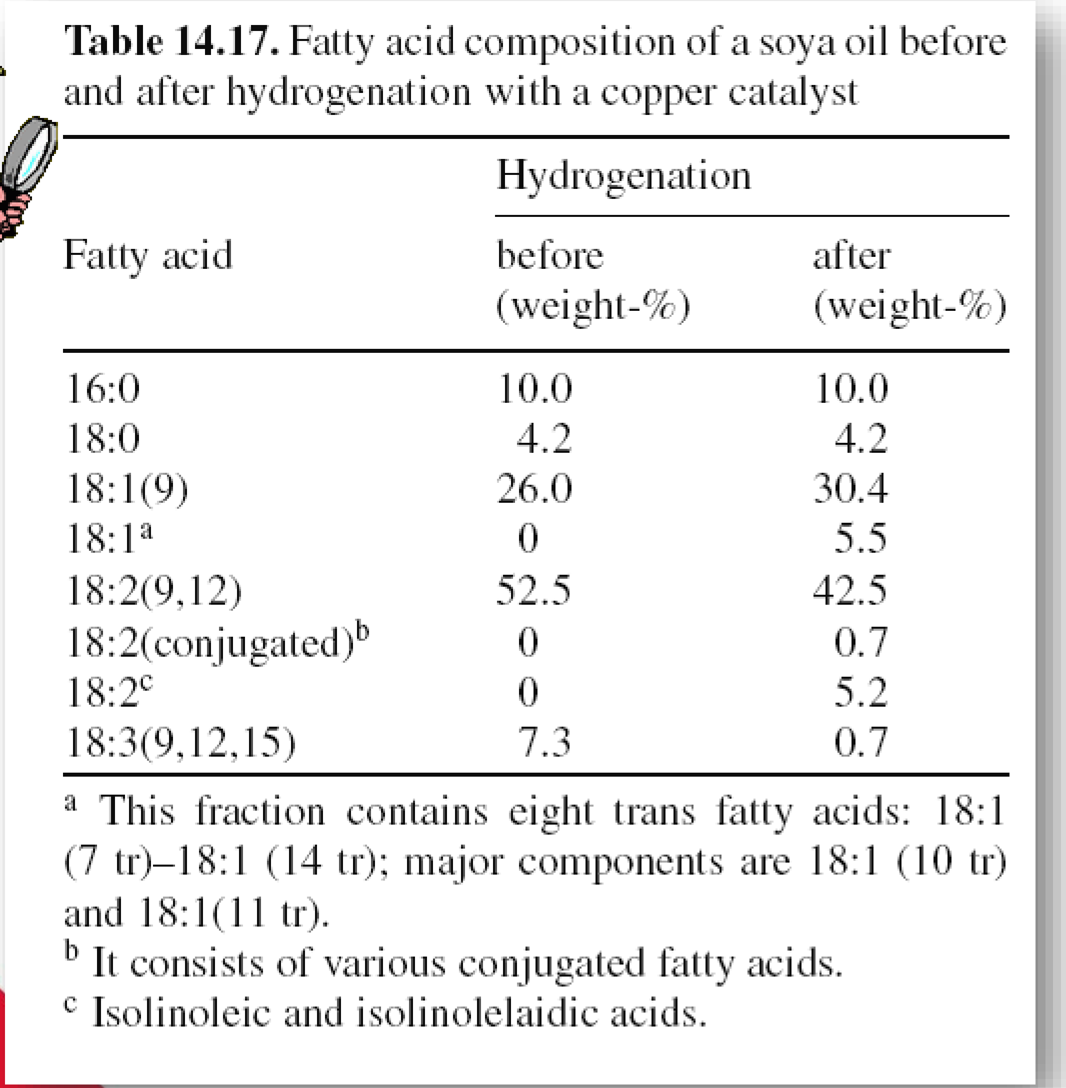


Table 14.17. Fatty acid composition of a soya oil before and after hydrogenation with a copper catalyst

Fatty acid	Hydrogenation before (weight-%)	Hydrogenation after (weight-%)
16:0	10.0	10.0
18:0	4.2	4.2
18:1(9)	26.0	30.4
18:1[a]	0	5.5
18:2(9,12)	52.5	42.5
18:2(conjugated)[b]	0	0.7
18:2[c]	0	5.2
18:3(9,12,15)	7.3	0.7

[a] This fraction contains eight trans fatty acids: 18:1 (7 tr)–18:1 (14 tr); major components are 18:1 (10 tr) and 18:1(11 tr).

[b] It consists of various conjugated fatty acids.

[c] Isolinoleic and isolinolelaidic acids.

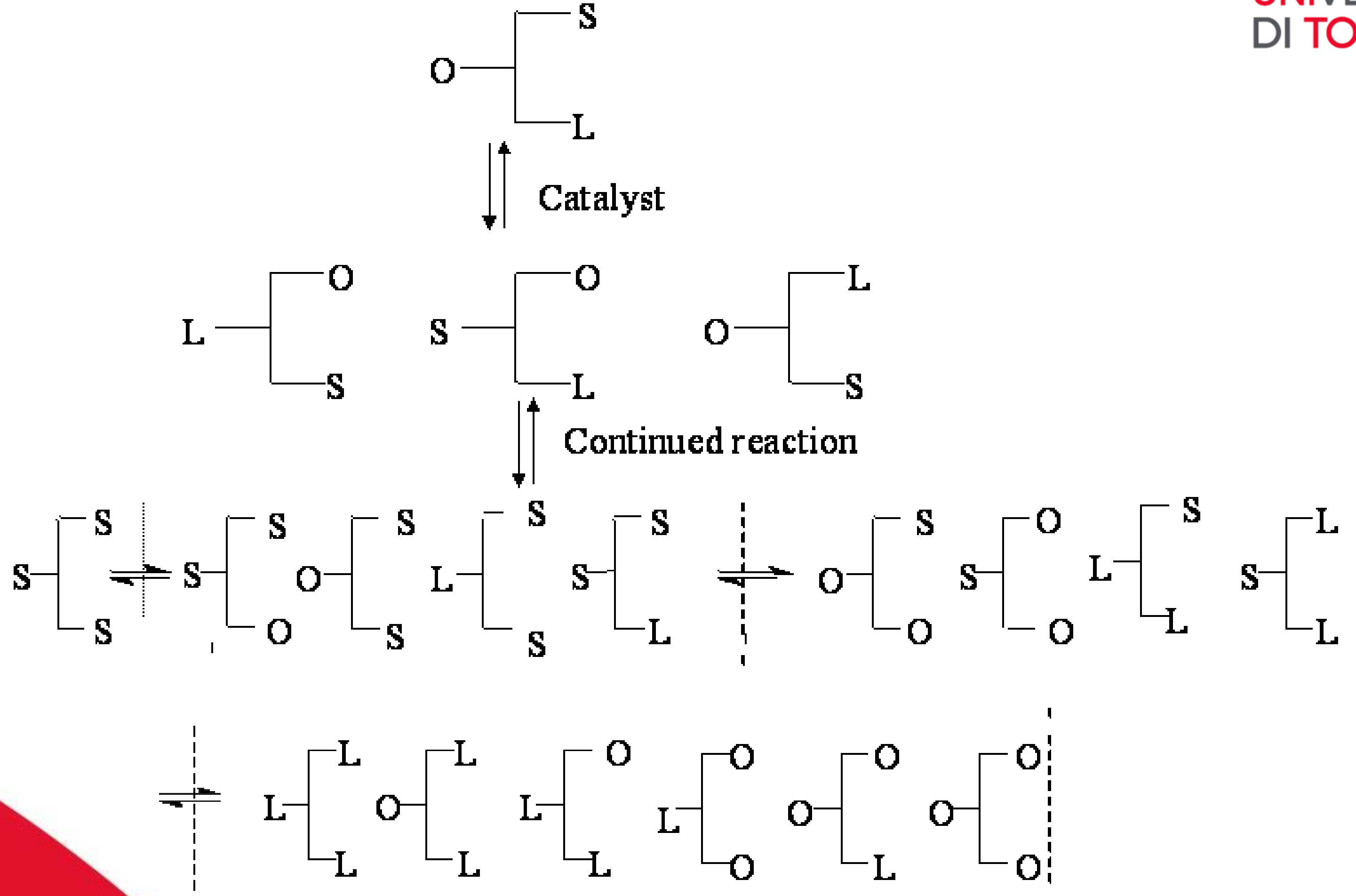
Modification of Triglyceride Oils

1. Hydrogenation
2. **Interesterification**
3. Fractionation

2. Interesterification
can be defined as a redistribution of the fatty acid moieties present in a triglyceride oil over its glycerol moieties. This can be random when the reaction is carried out in a single, liquid phase. When during the reaction higher-melting triglycerides are allowed to crystallise, their mainly saturated fatty acids are withdrawn from the liquid phase so that the distribution of the fatty acids still present in the liquid phase will no longer be random. It will continue to redistribute these residual fatty acids and thereby form further higher-melting triglycerides that then also crystallize. This is called 'directed interesterification'. Directed interesterification processes are no longer practiced industrially.

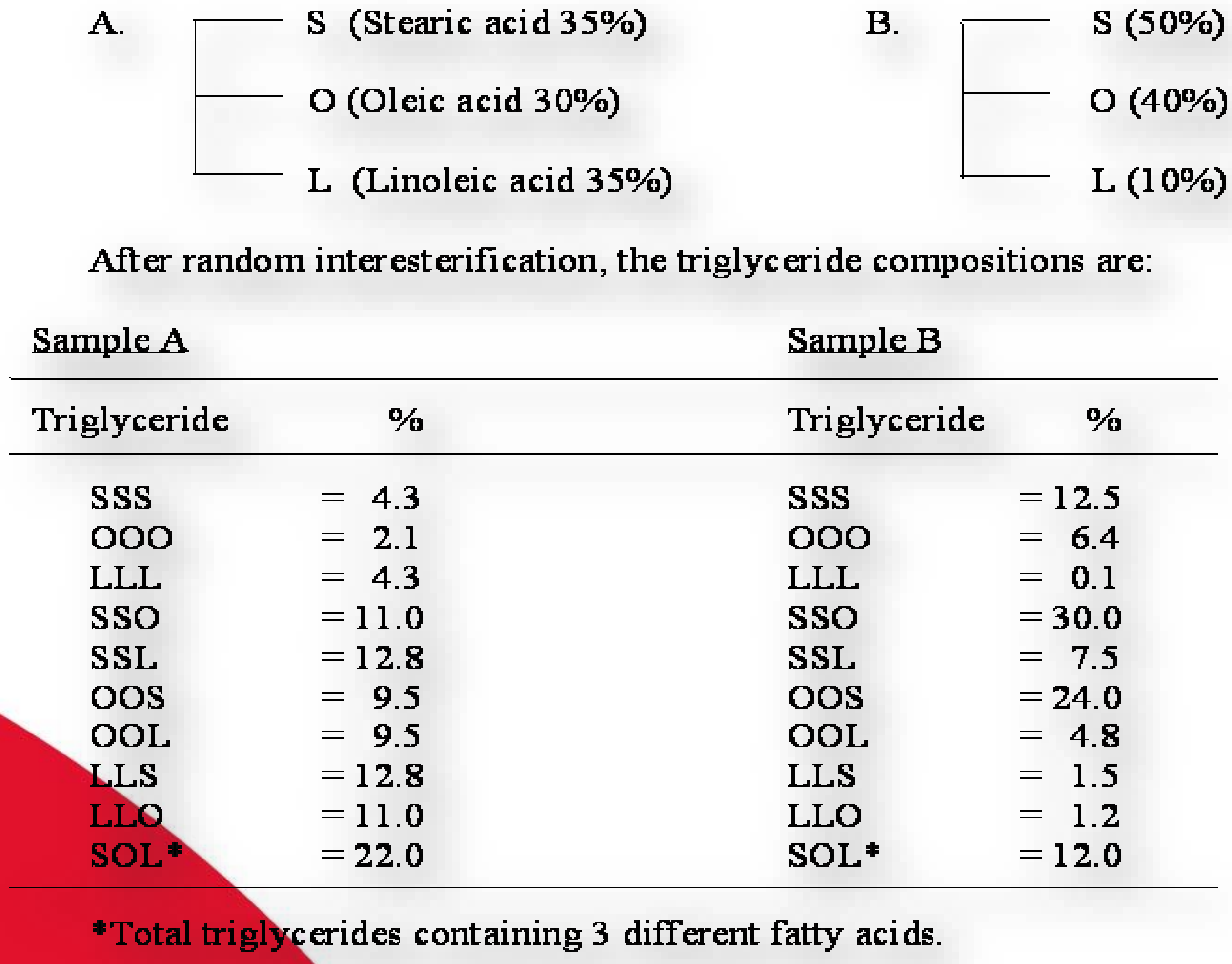
Modification of Triglyceride Oils

2. Interesterification



Modification of Triglyceride Oils

2. Random-end interesterification



A.
S (Stearic acid 35%)
O (Oleic acid 30%)
L (Linoleic acid 35%)

B.
S (50%)
O (40%)
L (10%)

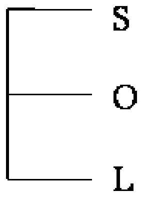
After random interesterification, the triglyceride compositions are:

Sample A Triglyceride	%	Sample B Triglyceride	%
SSS	= 4.3	SSS	= 12.5
OOO	= 2.1	OOO	= 6.4
LLL	= 4.3	LLL	= 0.1
SSO	= 11.0	SSO	= 30.0
SSL	= 12.8	SSL	= 7.5
OOS	= 9.5	OOS	= 24.0
OOL	= 9.5	OOL	= 4.8
LLS	= 12.8	LLS	= 1.5
LLO	= 11.0	LLO	= 1.2
SOL*	= 22.0	SOL*	= 12.0

*Total triglycerides containing 3 different fatty acids.

Modification of Triglyceride Oils

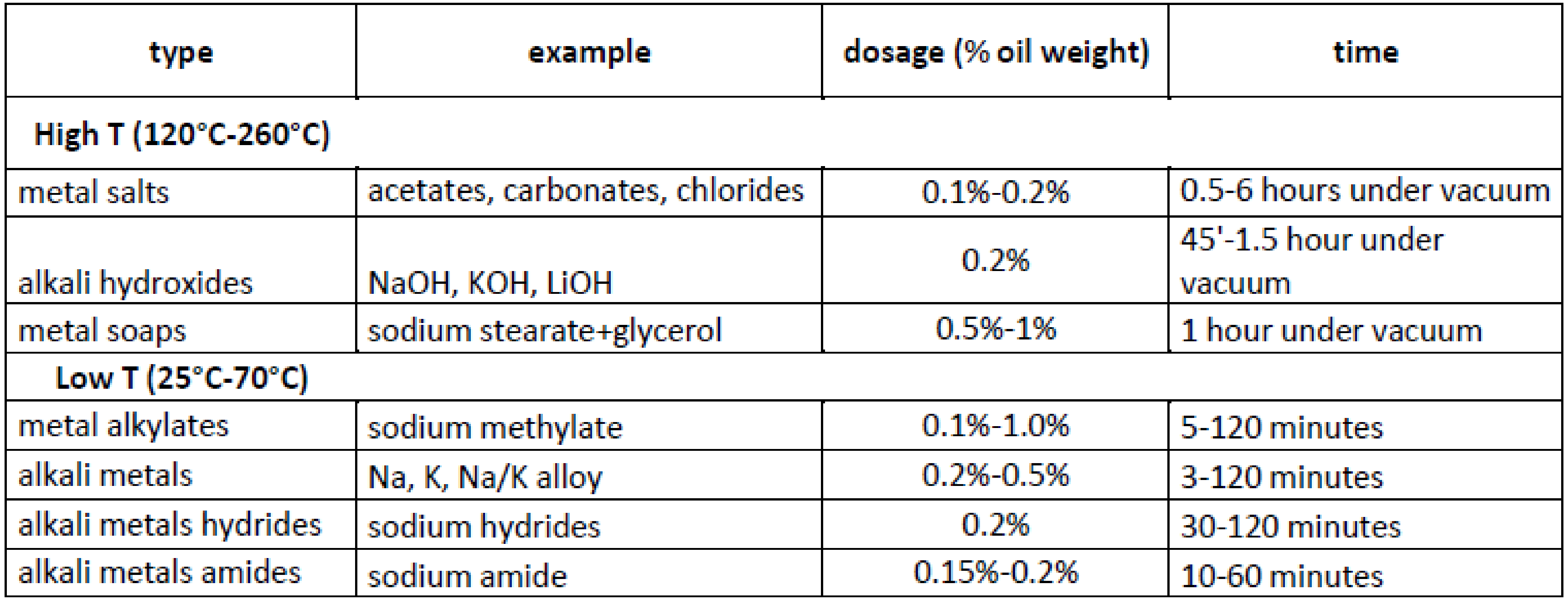
2. Directed interesterification



1. Stearic-Stearic-Stearic	33.3 mole % solid
2. Oleic-Oleic-Oleic	8.3 mole % liquid
3. Linoleic-Linoleic-Linoleic	8.3 mole % liquid
4. Oleic-Oleic-Linoleic	24.9 mole % liquid
5. Oleic-Linoleic-Linoleic	24.9 mole % liquid

Modification of Triglyceride Oils

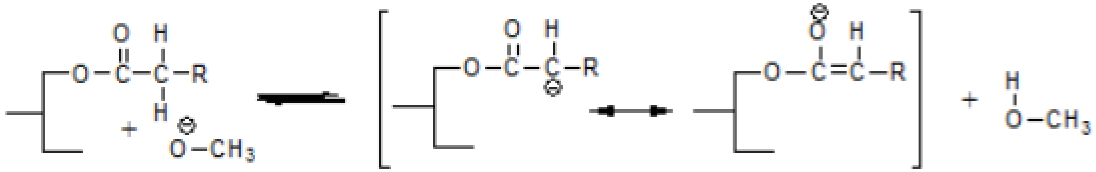
2. Interesterification -> catalysts



type	example	dosage (% oil weight)	time
High T (120°C-260°C)			
metal salts	acetates, carbonates, chlorides	0.1%-0.2%	0.5-6 hours under vacuum
alkali hydroxides	NaOH, KOH, LiOH	0.2%	45'-1.5 hour under vacuum
metal soaps	sodium stearate+glycerol	0.5%-1%	1 hour under vacuum
Low T (25°C-70°C)			
metal alkylates	sodium methylate	0.1%-1.0%	5-120 minutes
alkali metals	Na, K, Na/K alloy	0.2%-0.5%	3-120 minutes
alkali metals hydrides	sodium hydrides	0.2%	30-120 minutes
alkali metals amides	sodium amide	0.15%-0.2%	10-60 minutes

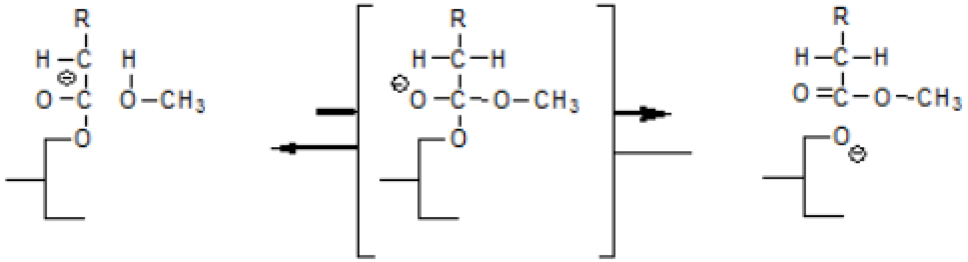
Modification of Triglyceride Oils

2. Interesterification -> reaction mechanism



the sodium methanolate that is added to the oil to be interesterified can react in various ways giving rise to a number of different anions, one of which is a glycerolate anion. However, if the concentration of free hydroxyl groups in the oil is low, enol formation according to:

This reaction liberates methanol and just like methanol that has been added to the reaction mixture this methanol can react to form a fatty acid methyl ester and a glycerolate anion according to:



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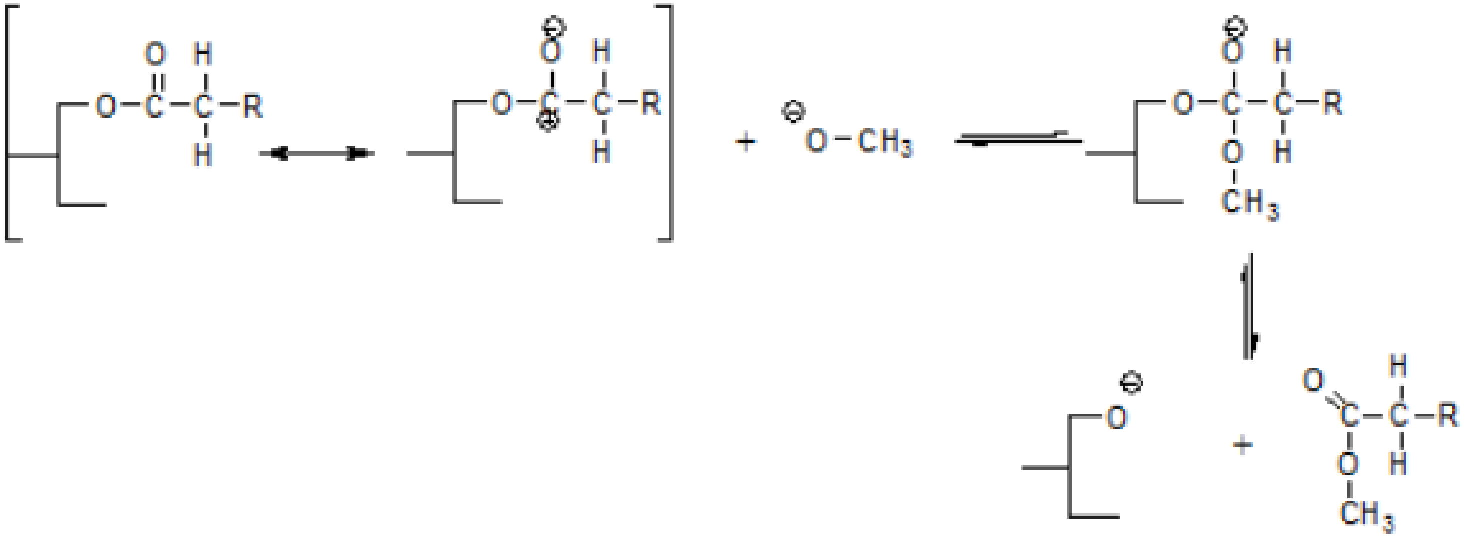
2. Interesterification -> reaction mechanism

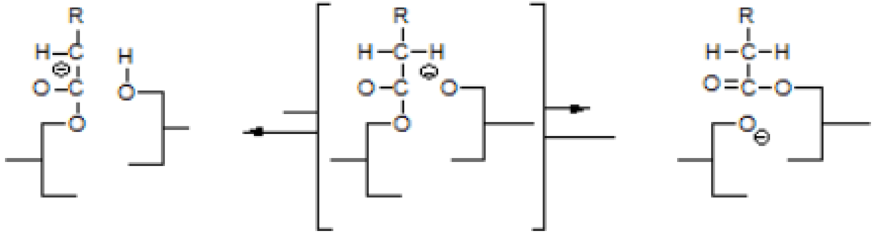
This reaction explains that interesterification reaction mixtures contain an amount of fatty acid methyl esters (FAME) that is equivalent to the amount of sodium methoxide added. It also explains that further methanol added to the reaction mixture eventually ends up as FAME. Perhaps some FAME are also formed on addition of the sodium methoxide according to:



Modification of Triglyceride Oils

2. Interesterification -> reaction mechanism

When the enolate anion reacts with the free hydroxyl group in a partial glyceride, this leads to interesterification according to:



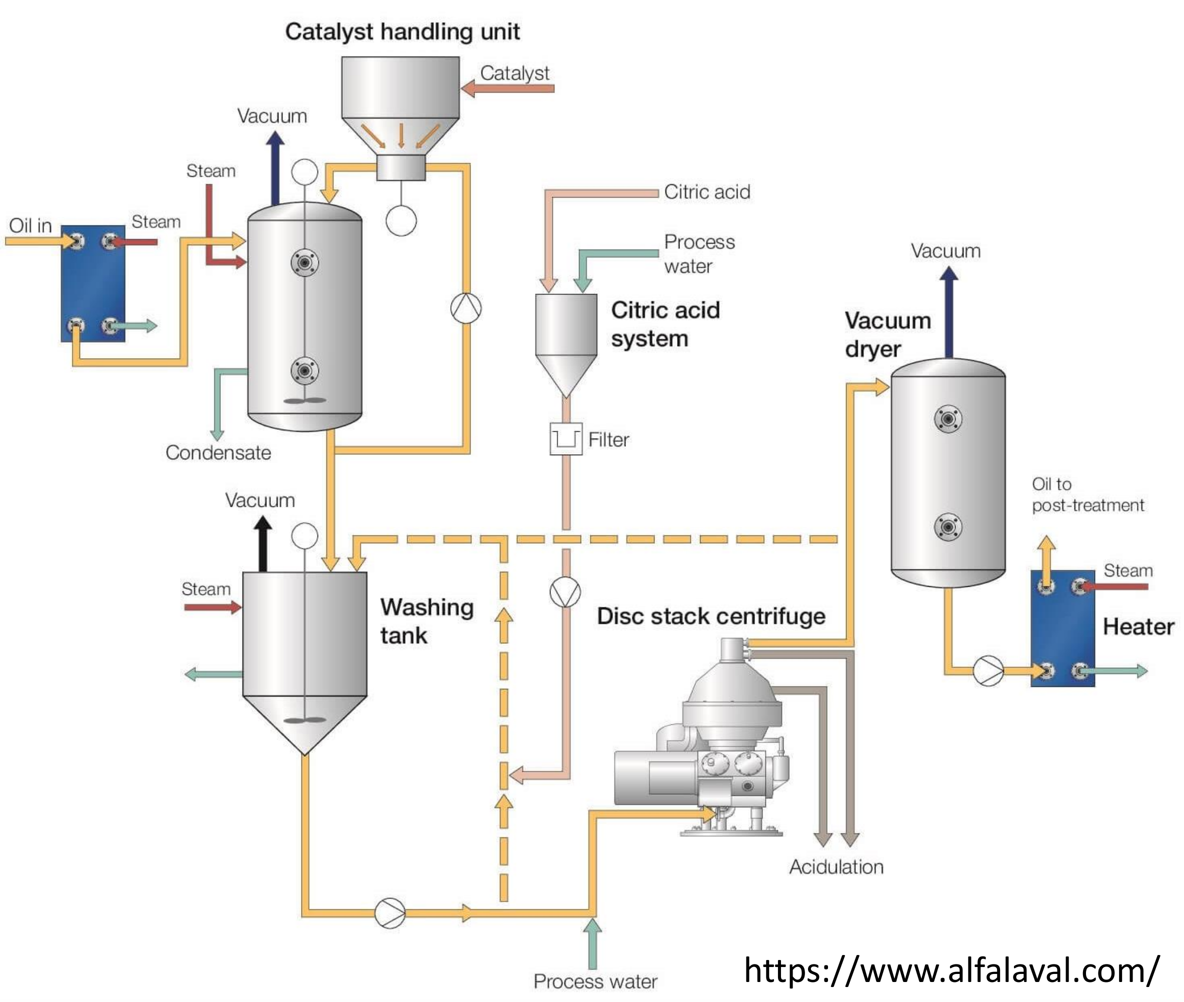
Modification of Triglyceride Oils

2. Interesterification -> reaction mechanism

The mixture of oils and fats is pumped from the mixing tank to a steam heater and then to the reactor under vacuum conditions for drying. To improve drying efficiency, the oil is pumped through a recirculation section.

After drying the oil, a catalyst is introduced into the oil recirculation stream, using the special catalyst dosing device. When the catalyst reaction is completed, the oil is discharged to the post-treatment reactor. Here, the catalyst is deactivated with acid and the oil is treated using bleaching earth.

Interesterification does not affect the degree of saturation of the fat, nor the location of the cis-trans chemical bonds. It is largely done to control the consistency of the oil or fat at different temperatures, a parameter that is crucial for your customers in the food industry.



https://www.alfalaval.com/

Modification of Triglyceride Oils

2. Interesterification -> bio-catalysts

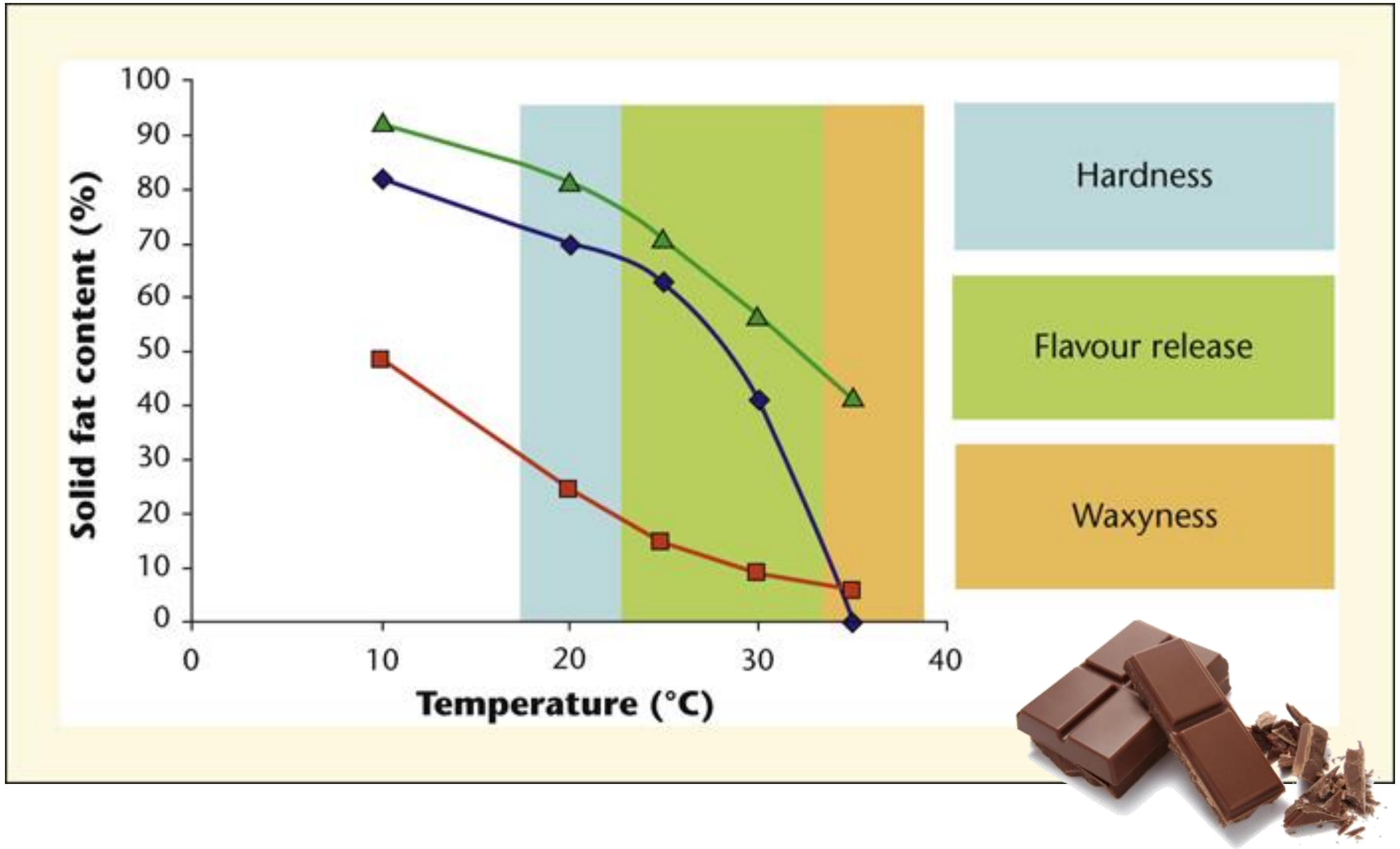
Two are the enzymes most used for interesterification and these are commercialized by Novozymes:

1. Lypozyme TL IM, aspecific enzyme, immobilized on silica support, derived from *Thermomyces lanuginosus* and obtained by submerged fermentation of *Asperigillus oryzae*
2. Lypozyme RM IM, specific enzyme, immobilized of phenolic resins and also obtained by submerged fermentation of *Asperigillus oryzae*

Modification of Triglyceride Oils

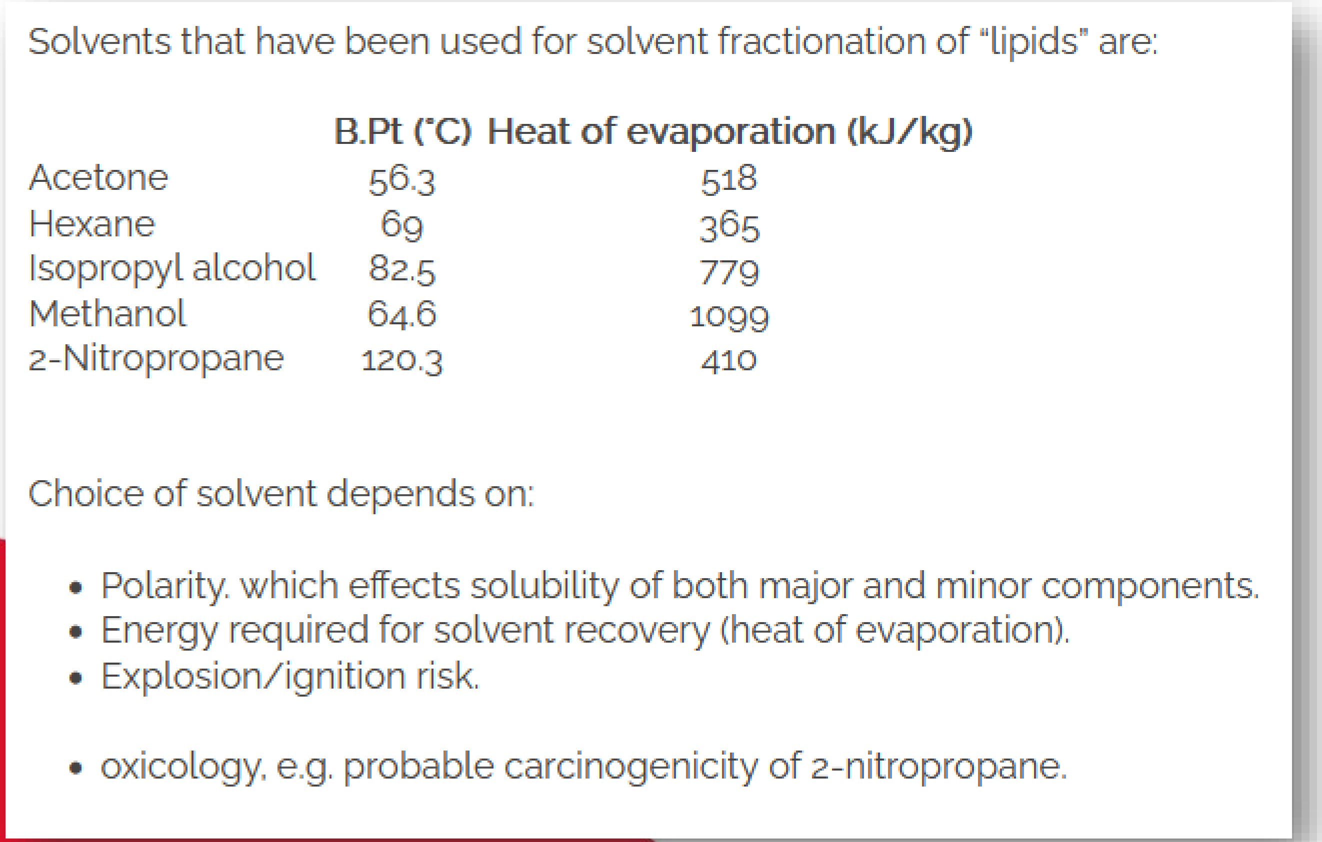
1. Hydrogenation
2. Interesterification
3. **Fractionation**

3. Fractionation
If there is an oil or fat with triglycerides with a range of melting points present, it is possible to separate them by fractional crystallisation. This can then enable products with more specific solid/liquid characteristics to be produced with better functionality in the product and therefore of a higher value. The process "trick" is to crystallise and separate these various triglycerides. The quality of separation of crystals from any remaining liquid oil is called the separation efficiency (SE), where 100% SE means perfect removal of all liquid oil from the crystals.



Modification of Triglyceride Oils

3. Fractionation with solvent



Solvents that have been used for solvent fractionation of "lipids" are:

	B.Pt (°C)	Heat of evaporation (kJ/kg)
Acetone	56.3	518
Hexane	69	365
Isopropyl alcohol	82.5	779
Methanol	64.6	1099
2-Nitropropane	120.3	410

Choice of solvent depends on:

- Polarity. which effects solubility of both major and minor components.
- Energy required for solvent recovery (heat of evaporation).
- Explosion/ignition risk.

- oxicology, e.g. probable carcinogenicity of 2-nitropropane.

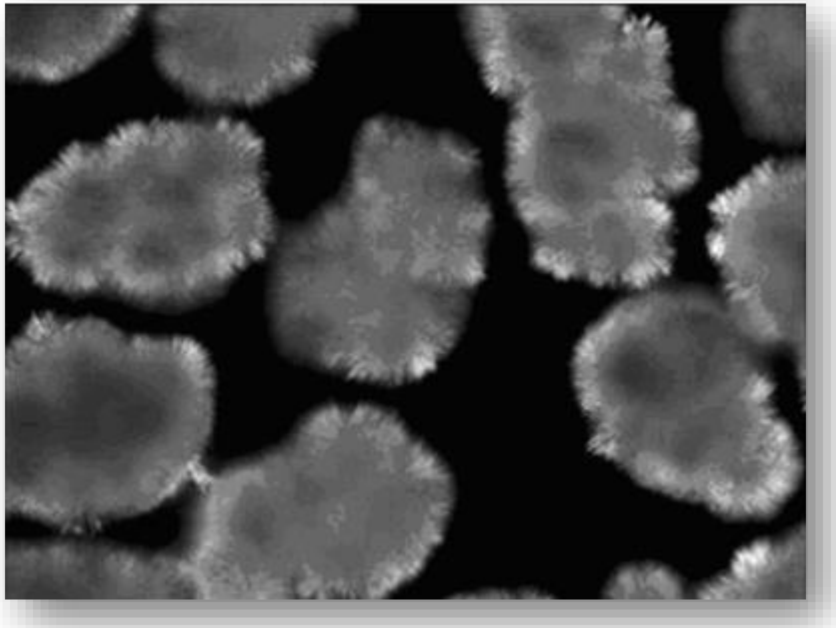
Is the most used because it is more discriminating (e.g. «cis» fatty acids separable from the «trans» form)
Most commonly used solvents: acetone and hexane

Very expensive plant for the recovery of the solvent and for the explosion proof system

Modification of Triglyceride Oils

3. Fractionation without solvent -> DRY FRACTIONATION OR WINTERING

Dry fractionation, also known as crystallization from the melt, is fractional crystallization in its most simple form, and the economy of the technology allows it to be used for production of commodity fats. Dry fractionation has long been regarded as an unpredictable, tedious and labor-intensive process. However, the relatively cheap dry fractionation technique has evolved to the modification technology of the 21st century, as without additives, polluting effluents or post-refining involved, the sustainability and safety of the process are second to none.



Polarized light microscopic picture of typical spherulitic crystals developing in palm oil fractions.

Modification of Triglyceride Oils

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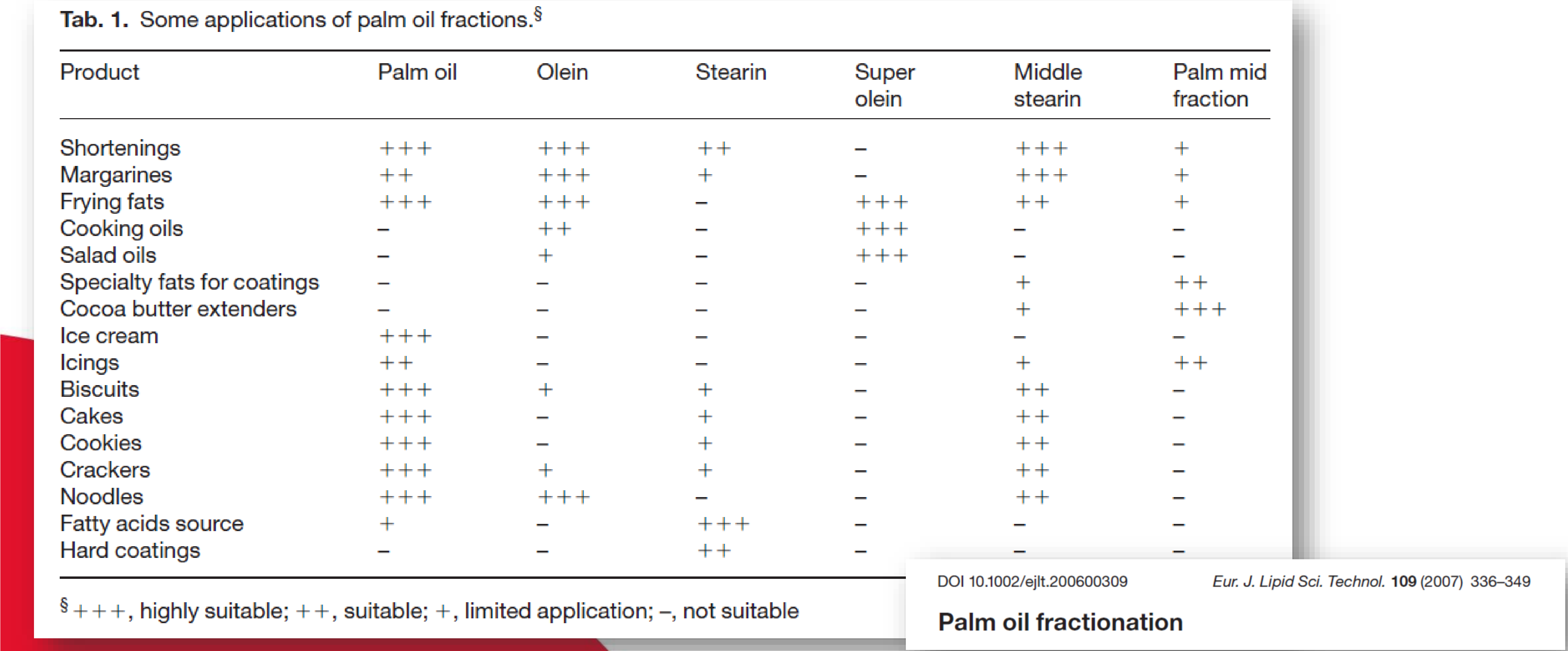
3. Fractionation without solvent -> DRY FRACTIONATION OR WINTERING



Tab. 1. Some applications of palm oil fractions.[§]

Product	Palm oil	Olein	Stearin	Super olein	Middle stearin	Palm mid fraction
Shortenings	+++	+++	++	–	+++	+
Margarines	++	+++	+	–	+++	+
Frying fats	+++	+++	–	+++	++	+
Cooking oils	–	++	–	+++	–	–
Salad oils	–	+	–	+++	–	–
Specialty fats for coatings	–	–	–	–	+	++
Cocoa butter extenders	–	–	–	–	+	+++
Ice cream	+++	–	–	–	–	–
Icings	++	–	–	–	+	++
Biscuits	+++	+	+	–	++	–
Cakes	+++	–	+	–	++	–
Cookies	+++	–	+	–	++	–
Crackers	+++	+	+	–	++	–
Noodles	+++	+++	–	–	++	–
Fatty acids source	+	–	+++	–	–	–
Hard coatings	–	–	++	–	–	–

[§] +++, highly suitable; ++, suitable; +, limited application; –, not suitable

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Palm oil fractionation

Modification of Triglyceride Oils

3. Fractionation without solvent -> DRY FRACTIONATION OR WINTERING

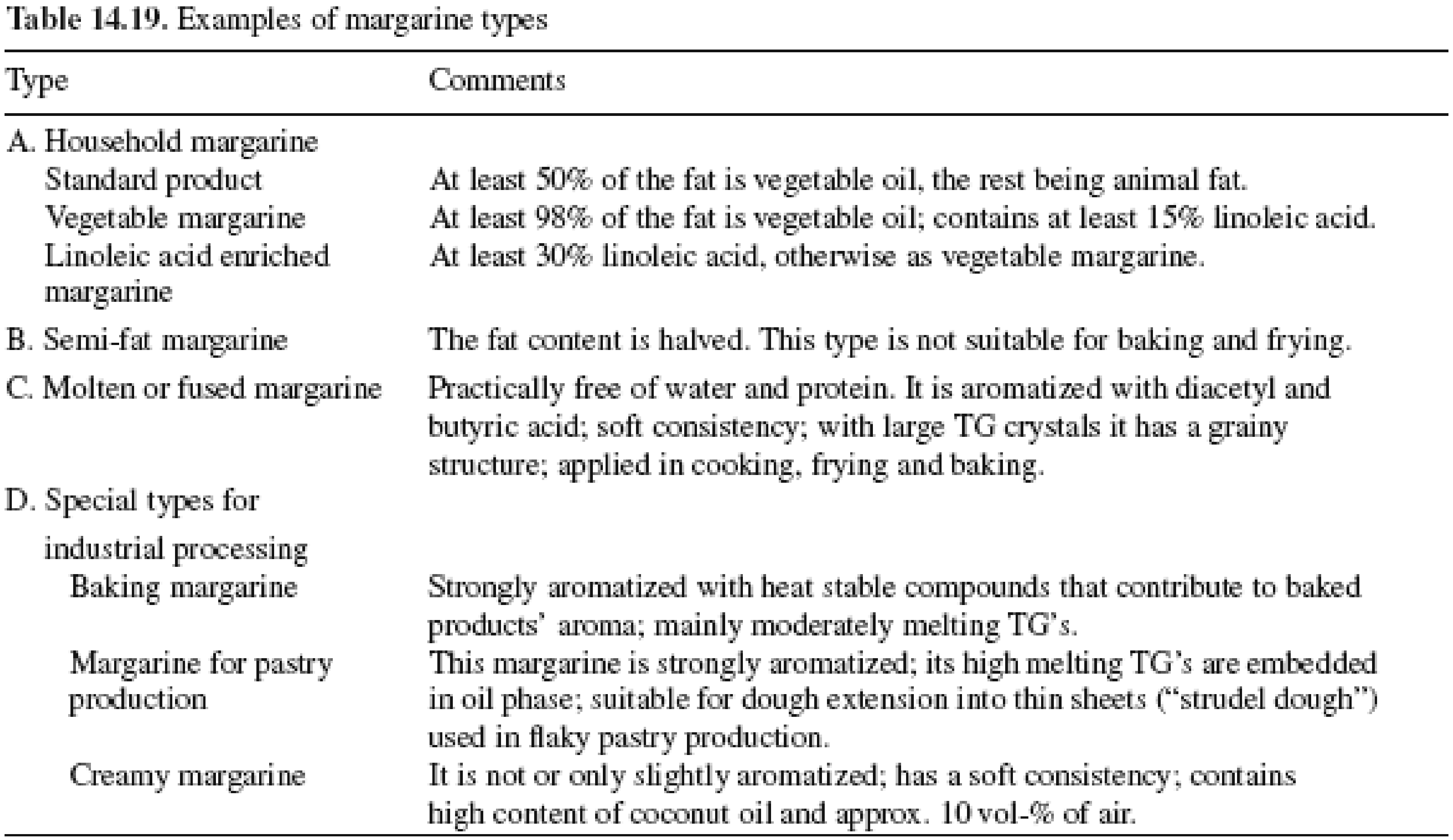
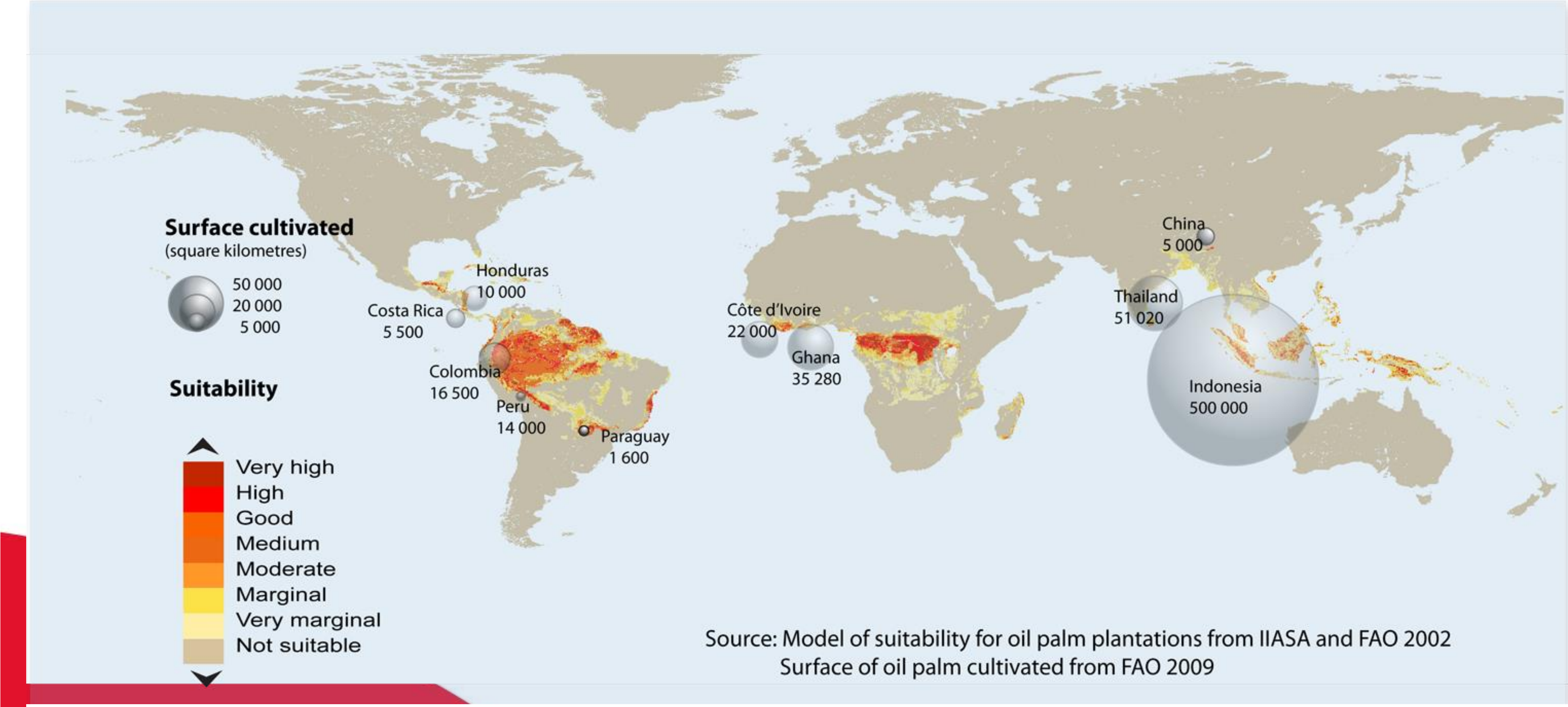


Table 14.19. Examples of margarine types

Type	Comments
A. Household margarine	
Standard product	At least 50% of the fat is vegetable oil, the rest being animal fat.
Vegetable margarine	At least 98% of the fat is vegetable oil; contains at least 15% linoleic acid.
Linoleic acid enriched margarine	At least 30% linoleic acid, otherwise as vegetable margarine.
B. Semi-fat margarine	The fat content is halved. This type is not suitable for baking and frying.
C. Molten or fused margarine	Practically free of water and protein. It is aromatized with diacetyl and butyric acid; soft consistency; with large TG crystals it has a grainy structure; applied in cooking, frying and baking.
D. Special types for industrial processing	
Baking margarine	Strongly aromatized with heat stable compounds that contribute to baked products' aroma; mainly moderately melting TG's.
Margarine for pastry production	This margarine is strongly aromatized; its high melting TG's are embedded in oil phase; suitable for dough extension into thin sheets ("strudel dough") used in flaky pastry production.
Creamy margarine	It is not or only slightly aromatized; has a soft consistency; contains high content of coconut oil and approx. 10 vol-% of air.

Learn more about palm oil



Source: Model of suitability for oil palm plantations from IIASA and FAO 2002
Surface of oil palm cultivated from FAO 2009

Surface cultivated and estimated **tropical forested** area suitable for **oil palm plantations**.

Fonte: United Nations Environment Programme UNEP

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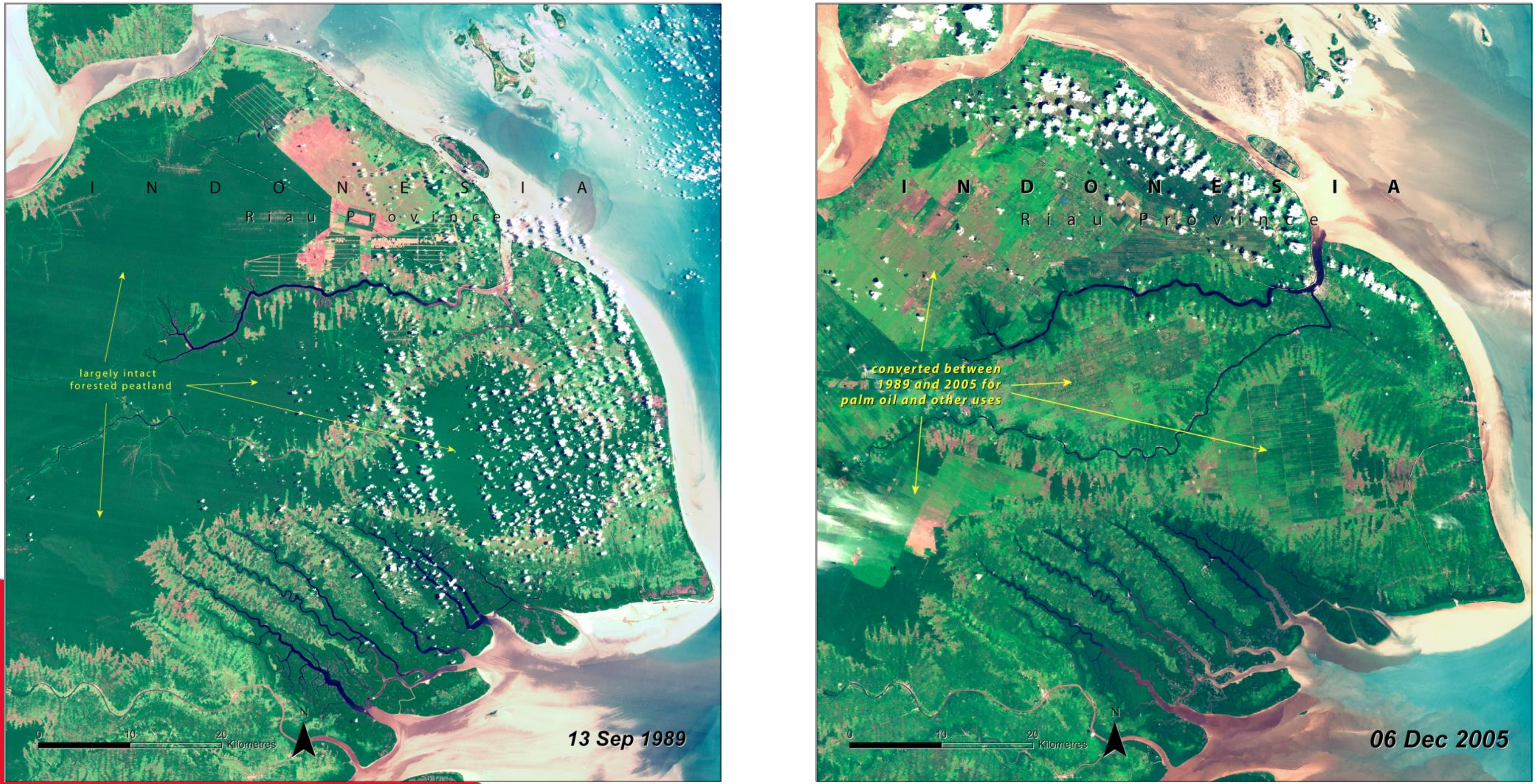
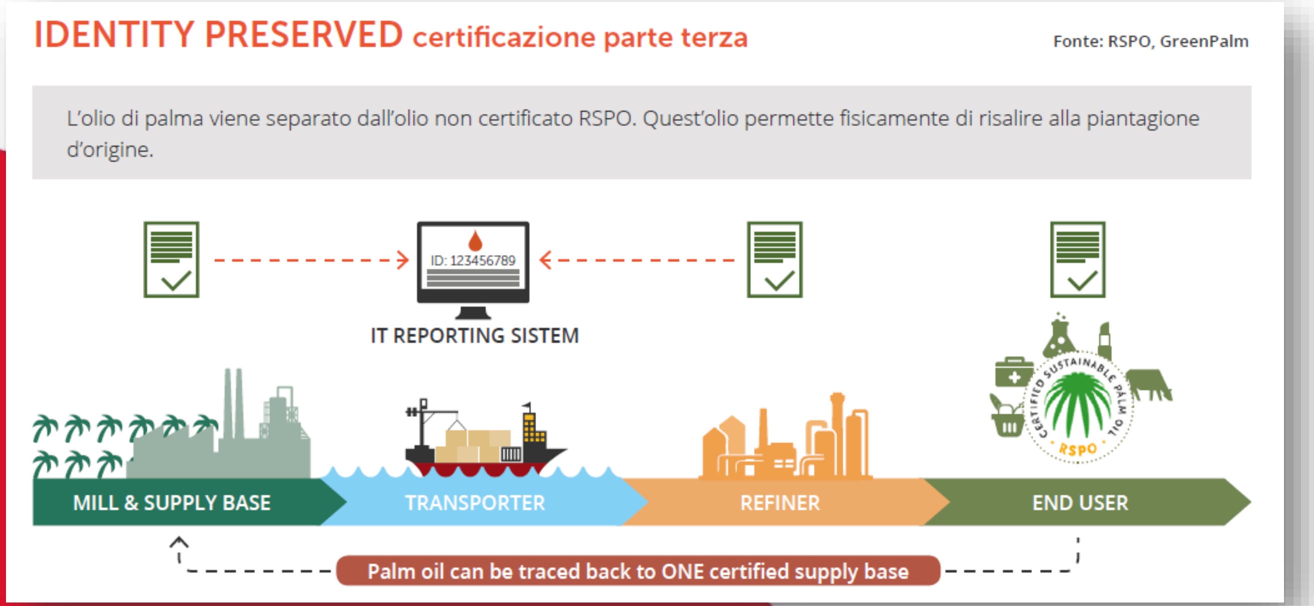


Satellite images from the southeastern corner of **Indonesia's Raui Province** showing loss in tropical forest to palm oil plantations between 1989 and 2005. The tropical forests are on peat formations up to 40 metres in depth (dark green = primary forest, light green = palm plantations).

Learn more about palm oil

Sustainable Palm Oil

In 2004, the Roundtable on Sustainable Palm Oil - RSPO was formed
Organization uniting growers, processors, traders, users, banks, investors, NGOs committed to environmental conservation and human rights defense
It has developed a global certification standard and aims to safeguard environmental sustainability in the growing production of palm oil.
According to RSPO, 11.6 million tonnes of palm oil were certified worldwide in 2014, accounting for 18% of global production.



IDENTITY PRESERVED certificazione parte terza

Fonte: RSPO, GreenPalm

L'olio di palma viene separato dall'olio non certificato RSPO. Quest'olio permette fisicamente di risalire alla piantagione d'origine.

Learn more about palm oil

MASS BALANCE certificazione parte terza

Olio di palma certificato sostenibile viene miscelato con olio di palma che non è stato certificato. L'olio può essere miscelato da diverse fonti ma la percentuale di olio di palma certificato è nota.

SEGREGATED certificazione parte terza

Olio di palma certificato sostenibile proveniente da diverse tenute viene miscelato nei lotti/partite. L'olio commercializzato secondo tale modello non consente di risalire alla specifico impianto o piantagione, ma viene garantito fisicamente tracciabile da una fonte sostenibile.

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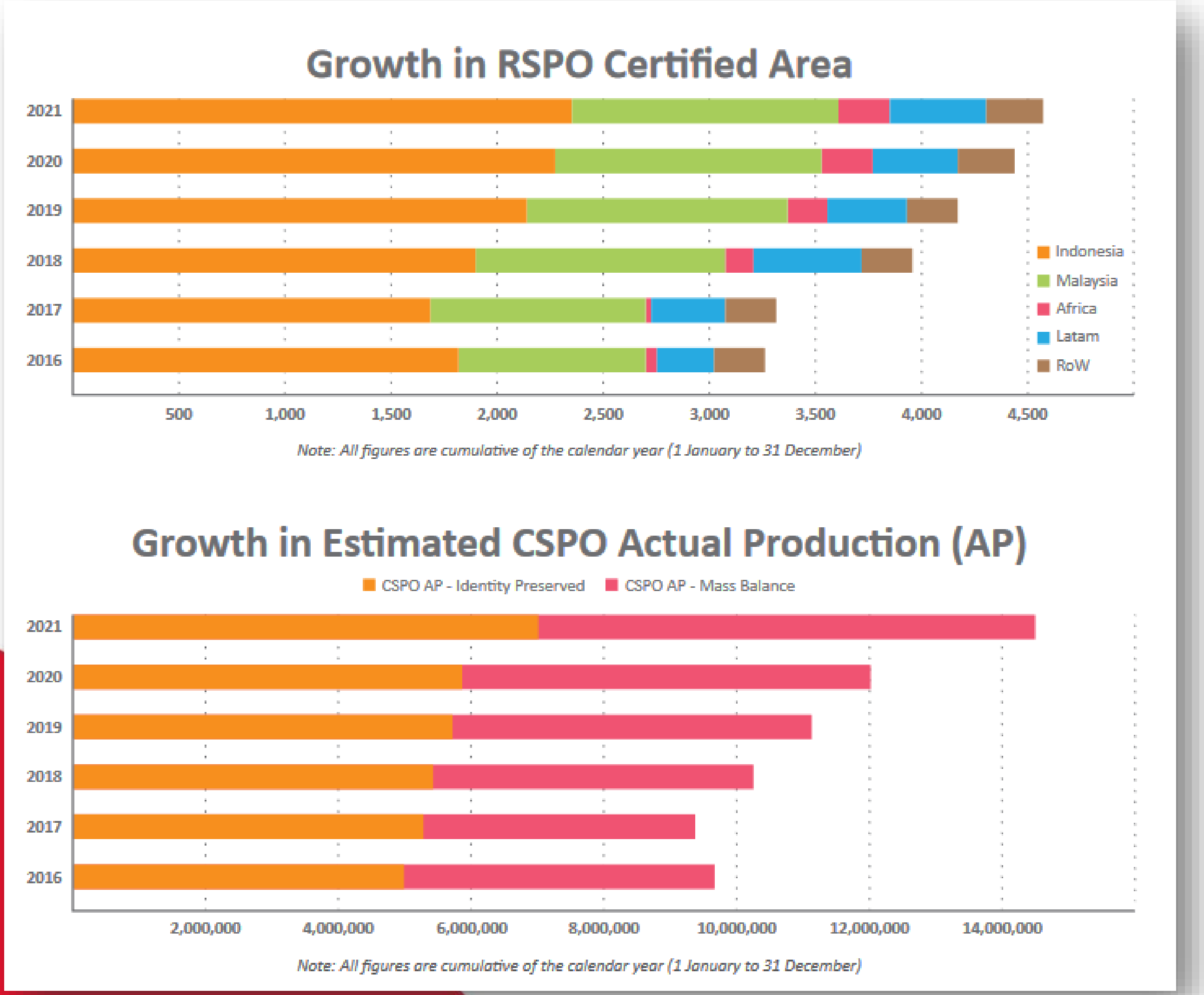
RSPO-Impact-Report-2022.pdf



Growth in RSPO Certified Area

Note: All figures are cumulative of the calendar year (1 January to 31 December)

Growth in Estimated CSPO Actual Production (AP)

Note: All figures are cumulative of the calendar year (1 January to 31 December)

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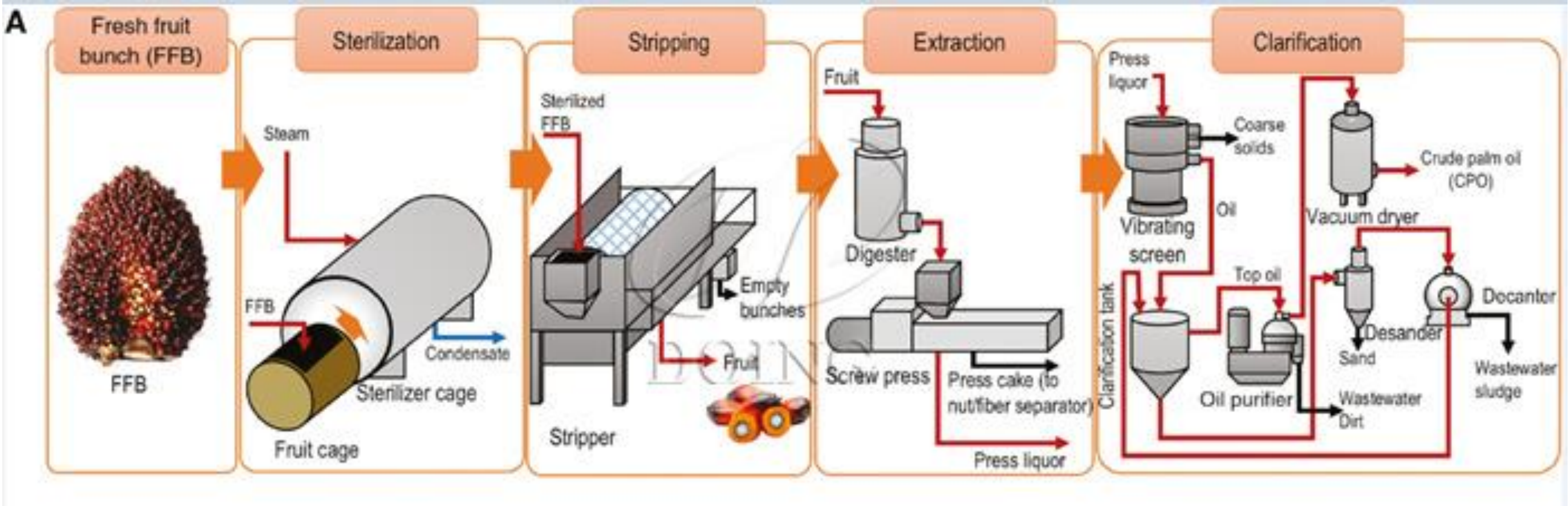

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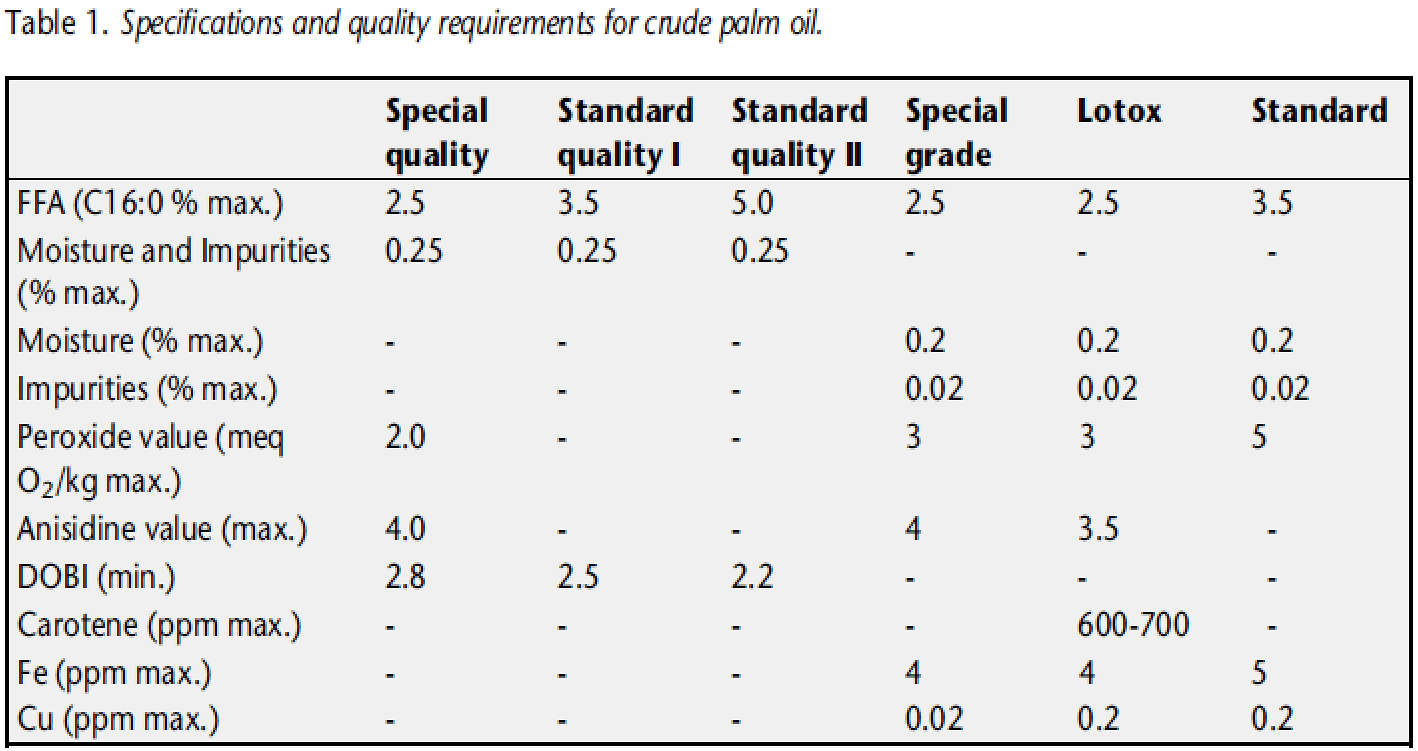

Table 1. *Specifications and quality requirements for crude palm oil.*

	Special quality	Standard quality I	Standard quality II	Special grade	Lotox	Standard
FFA (C16:0 % max.)	2.5	3.5	5.0	2.5	2.5	3.5
Moisture and Impurities (% max.)	0.25	0.25	0.25	-	-	-
Moisture (% max.)	-	-	-	0.2	0.2	0.2
Impurities (% max.)	-	-	-	0.02	0.02	0.02
Peroxide value (meq O_2/kg max.)	2.0	-	-	3	3	5
Anisidine value (max.)	4.0	-	-	4	3.5	-
DOBI (min.)	2.8	2.5	2.2	-	-	-
Carotene (ppm max.)	-	-	-	-	600-700	-
Fe (ppm max.)	-	-	-	4	4	5
Cu (ppm max.)	-	-	-	0.02	0.2	0.2

FFA: Free fatty acids in % w/w of palmitic acid
Moisture: residual moisture
Peroxide value: level of primary oxidation status (hydroperoxides)
DOBI: ration between carotenoids and peroxide value (if > 3 high quality)

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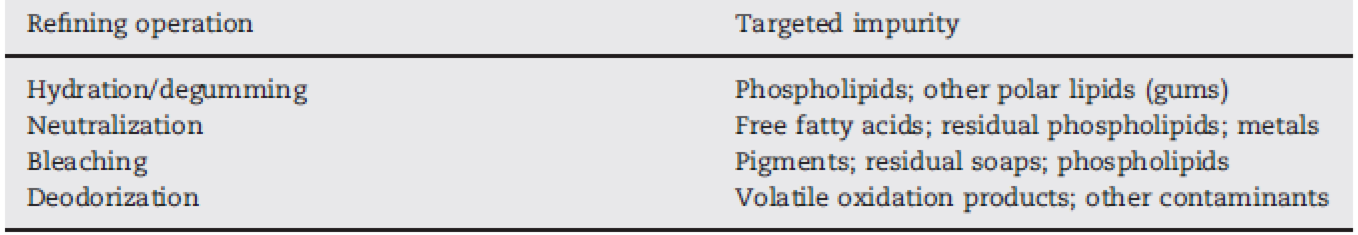
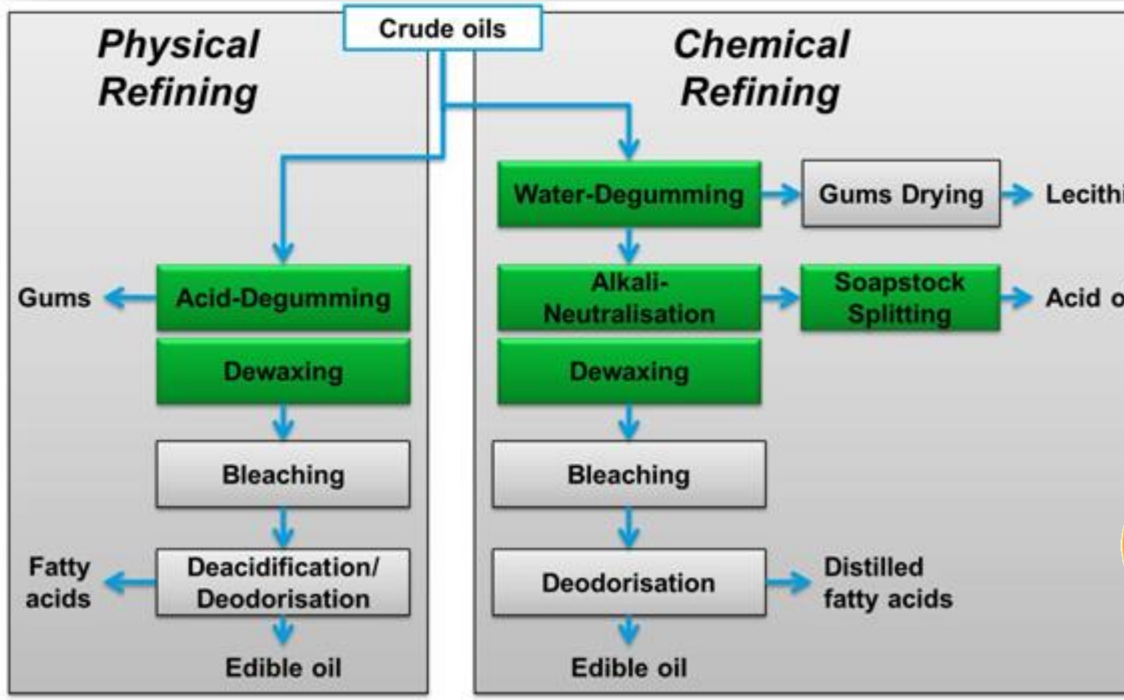


Refining operation	Targeted impurity
Hydration/degumming	Phospholipids; other polar lipids (gums)
Neutralization	Free fatty acids; residual phospholipids; metals
Bleaching	Pigments; residual soaps; phosphoplipids
Deodorization	Volatile oxidation products; other contaminants



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Grazie