Food Safety Information: Understanding 3-MCPDE & GE

Assoc. Prof. Ts ChM Dr Raseetha Siva
Universiti Teknologi MARA
Shah Alam, MALAYSIA

PORAM Annual Forum
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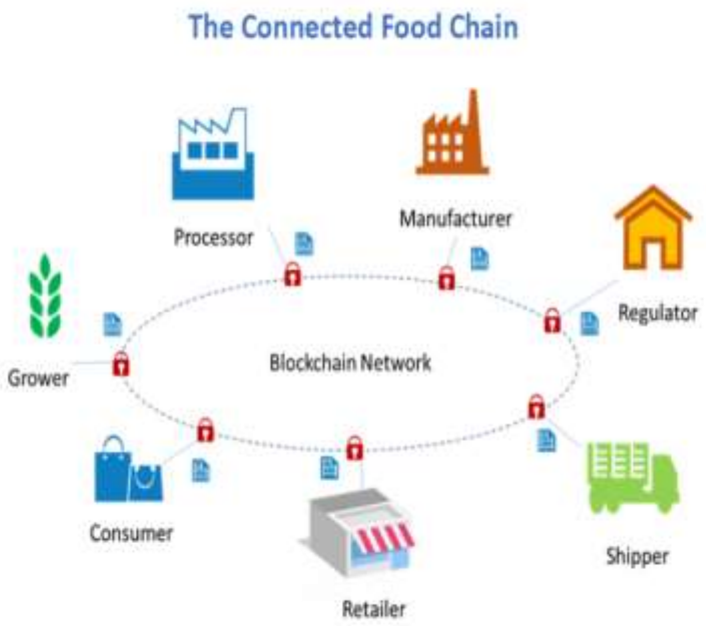
One World Hotel, Petaling Jaya

Outline

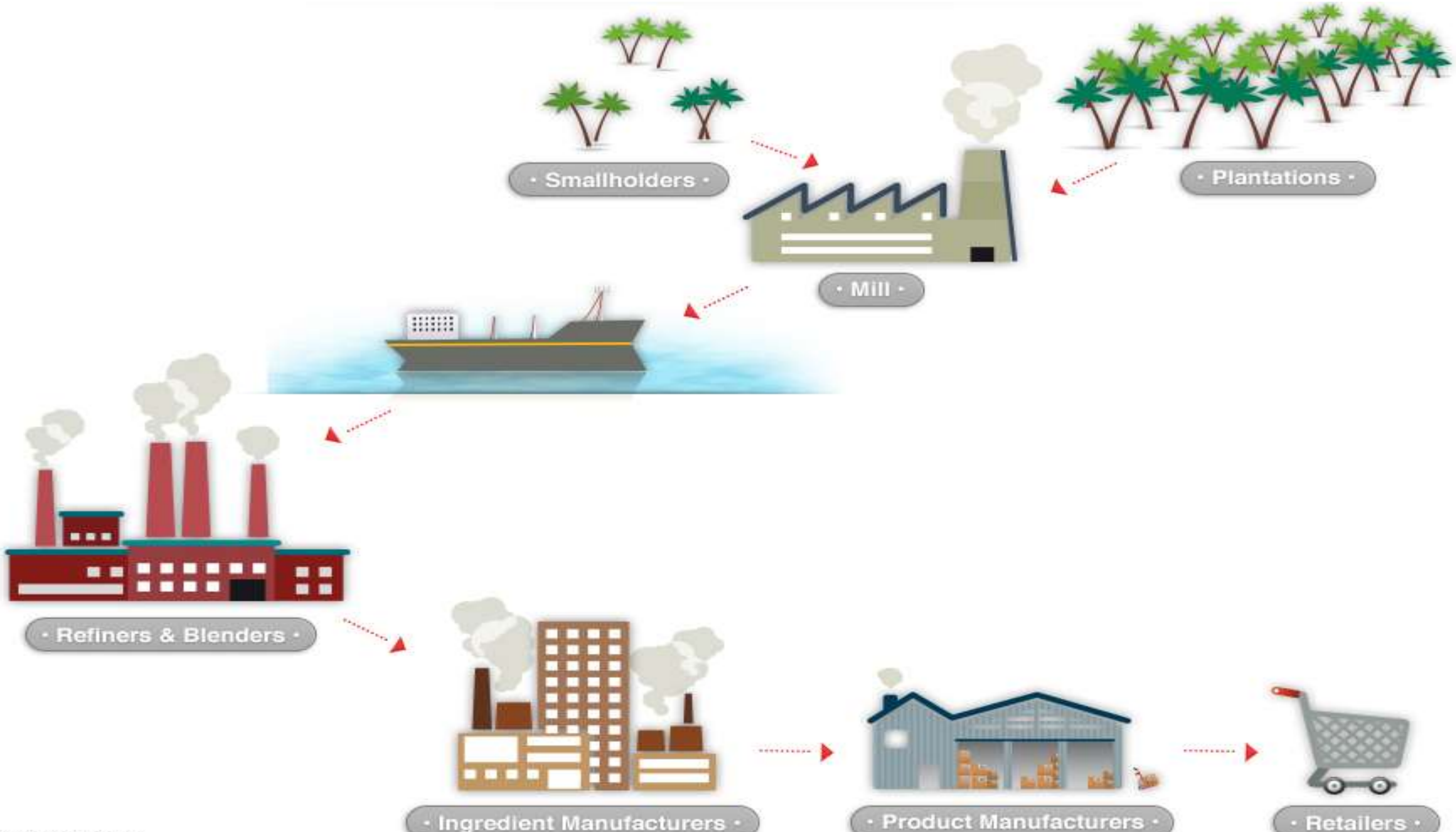
- Food Safety
- Background
- Occurrence
- Way Forward

Food Safety

- Food safety, nutrition & security are **linked**
- Ensure **food is safe** from farm to fork
- Good **milling practices**
- No compromises



Supply Chain in Palm Oil Industry



Source: Bureau Veritas, 2013

Figure 1: Supply chain in palm oil industry

What is Food Safety?

Food safety is described as the **preparation of food that shall not cause any harm** to the consumer when it is eaten according to its intended use [1].

It can also be described as the **handling, preparation, and storage of food** which can best lower the risk of sickness caused by foodborne illnesses [2].

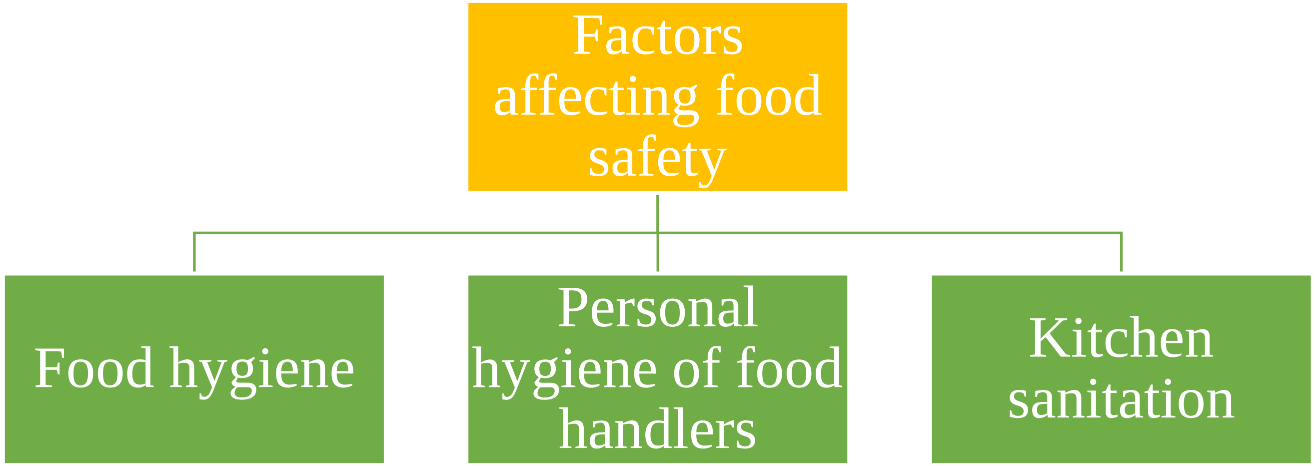
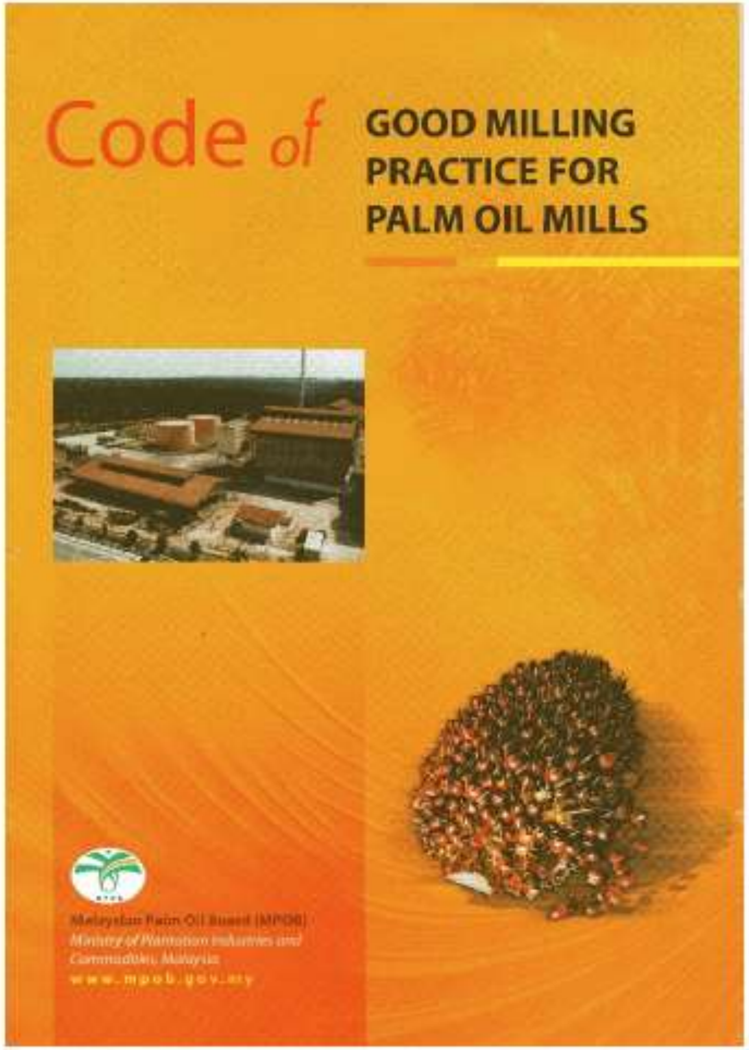


Figure 2: Factors affecting food safety [1].

[1] Uçar, A., Yilmaz, M. V., and Çakiroglu, F. P. (2016). Food safety–problems and solutions. *IntechOpen*. 1, 1–25. doi: 10.5772/63176
[2] Australian Institute of Food Safety (2019). *What is Food Safety?* Available online at: https://www.foodsafety.com.au/blog/what-is-food-safety.

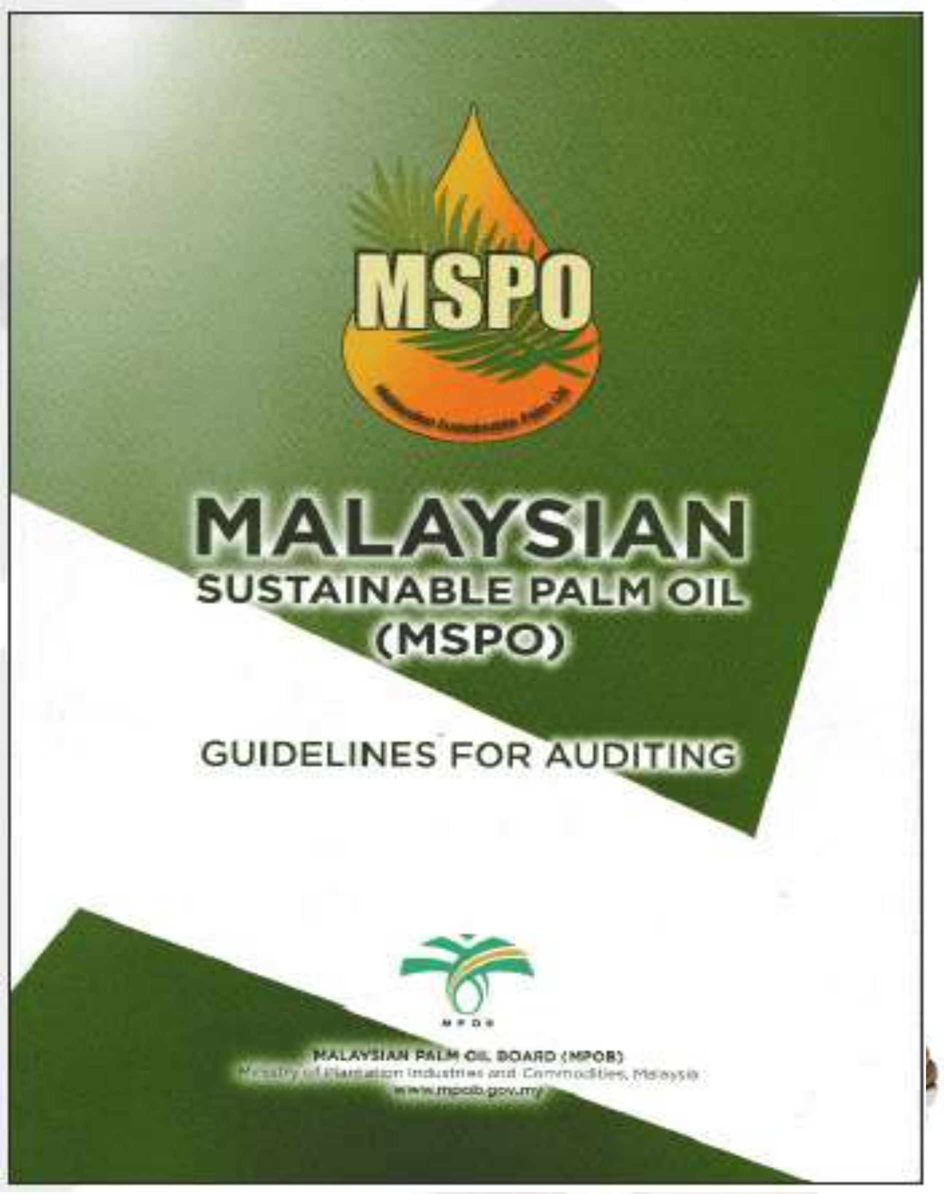
Food Safety in Mills

- Suggests **hygiene and process control**
- Ensure safe and **good quality products** to consumers
- Part of supply chain in palm oil industry



Food Safety in Mills

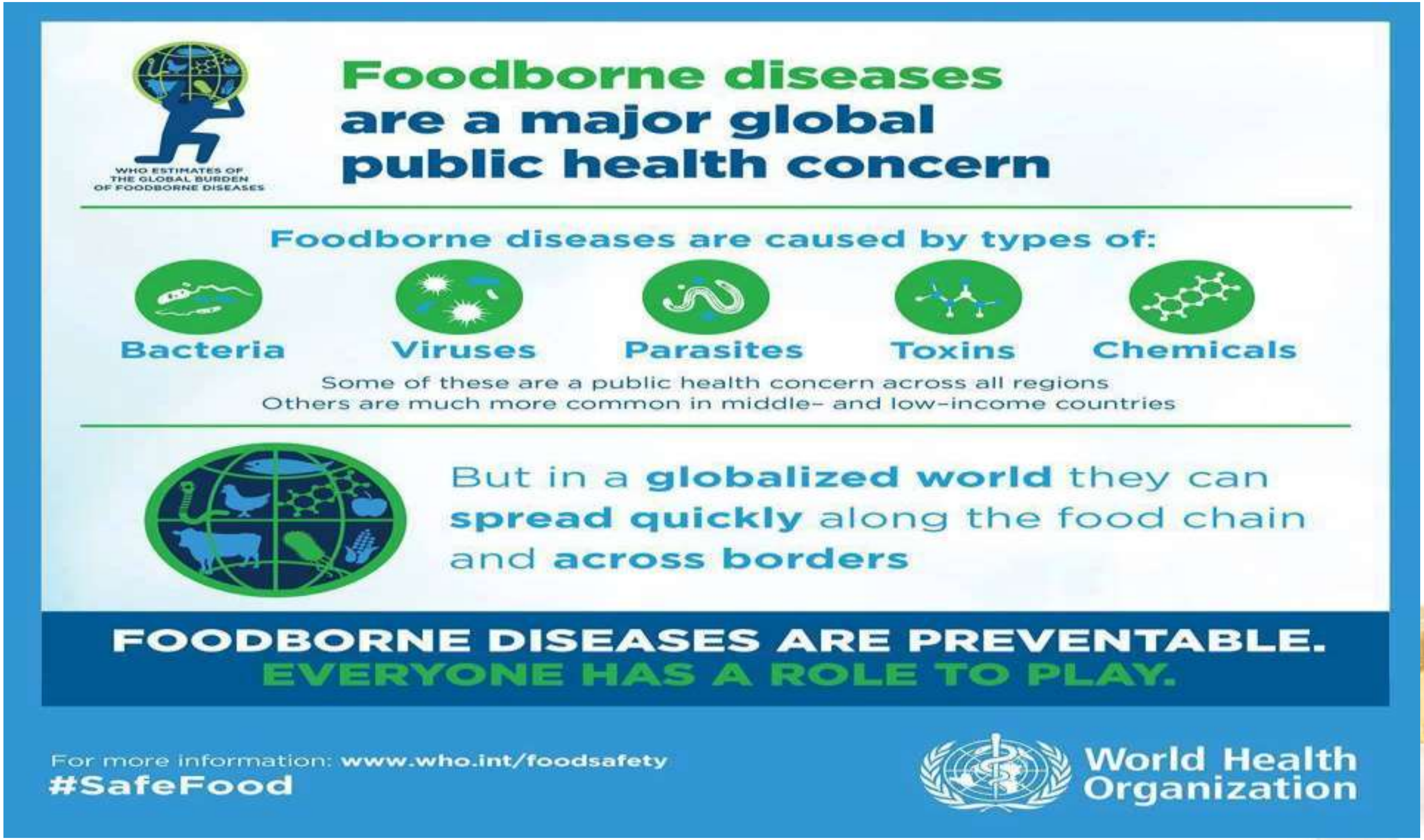
- **MSPO Certification scheme**
- Supply chain traceability requirement
- There is a **standard** to be met



SDG (United Nations)

Figure 3: Sustainable development goals approach

Food Safety


WHO ESTIMATES OF THE GLOBAL BURDEN OF FOODBORNE DISEASES
Foodborne diseases are a major global public health concern
Foodborne diseases are caused by types of:
Bacteria
Viruses
Parasites
Toxins
Chemicals
Some of these are a public health concern across all regions
Others are much more common in middle- and low-income countries
But in a globalized world they can spread quickly along the food chain and across borders
FOODBORNE DISEASES ARE PREVENTABLE.
EVERYONE HAS A ROLE TO PLAY.
For more information: www.who.int/foodsafety
#SafeFood
World Health Organization

Food Safety

Key foodborne diseases and hazards

WHO ESTIMATES OF THE GLOBAL BURDEN OF FOODBORNE DISEASES

Bacteria:

- *Listeria* can result in blood poisoning and meningitis, and is usually spread by consuming contaminated raw vegetables, ready-to-eat meals, processed meats, smoked fish or soft cheeses.
- *Brucella*, commonly from unpasteurized milk or cheese of infected goats or sheep, can cause fever, muscle pain or more severe arthritis, chronic fatigue, neurologic symptoms and depression.
- Cholera can be caused by consuming food contaminated with *Vibrio cholerae*. It causes watery diarrhoea that can be fatal within hours if left untreated.

Virus:

- Hepatitis A is a liver disease caused by the hepatitis A virus, transmitted through food contaminated by the faeces of an infected person. It causes jaundice, nausea, anorexia, fever, malaise and abdominal pain.

Parasites:

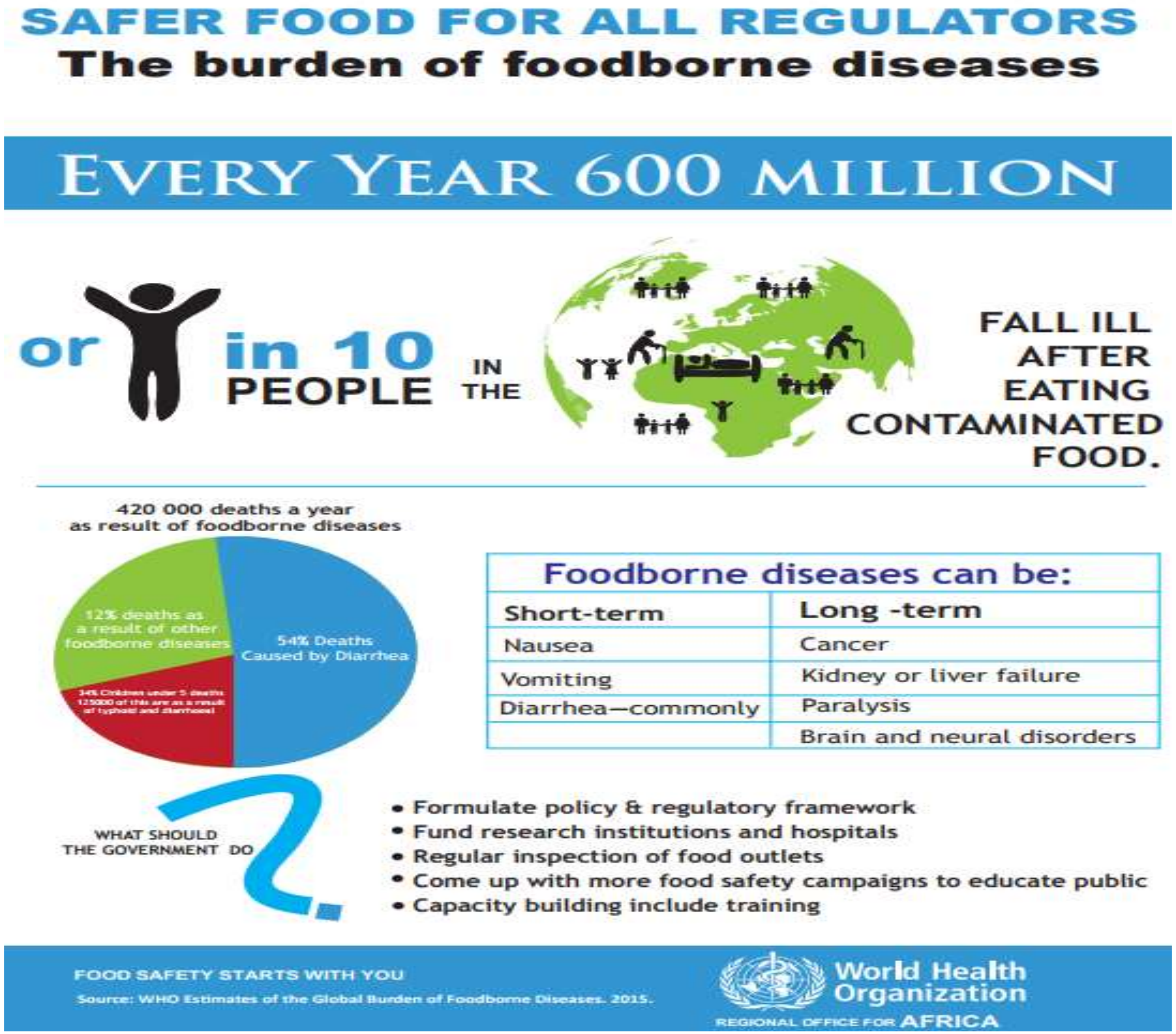
- Toxoplasmosis, caused by *Toxoplasma gondii*, spread through undercooked or raw meat and fresh produce, can result in impaired vision and neurological conditions.
- Pork tapeworm (*Taenia solium*) can cause cysts to develop in the brain (cysticercosis), which is the most frequent preventable cause of epilepsy worldwide.
- *Echinococcus* tapeworms can infect humans through food contaminated with dog or fox faeces. They can cause tumours to form in the liver, lungs and brain.
- Chinese liver fluke (*Clonorchis sinensis*) commonly contracted through raw and incorrectly processed or cooked fish, can cause bile duct inflammation and cancer.

Chemicals and toxins:

- Aflatoxin is a toxin produced by mould that grows on grain that has been stored inappropriately, and can cause liver cancer, one of the most deadly forms of cancer.
- Cyanide poisoning occurs when inappropriately processed cassava is consumed.

FOODBORNE DISEASES ARE PREVENTABLE.
EVERYONE HAS A ROLE TO PLAY.

Food Safety


SAFER FOOD FOR ALL REGULATORS
The burden of foodborne diseases
EVERY YEAR 600 MILLION
or
in 10
PEOPLE
IN THE
FALL ILL AFTER EATING CONTAMINATED FOOD.
420 000 deaths a year
as result of foodborne diseases
12% deaths as a result of other foodborne diseases
54% Deaths Caused by Diarrhea
Foodborne diseases can be:
Short-term
Long -term
Nausea
Cancer
Vomiting
Kidney or liver failure
Diarrhea—commonly
Paralysis
Brain and neural disorders
WHAT SHOULD THE GOVERNMENT DO
• Formulate policy & regulatory framework
• Fund research institutions and hospitals
• Regular inspection of food outlets
• Come up with more food safety campaigns to educate public
• Capacity building include training
FOOD SAFETY STARTS WITH YOU
Source: WHO Estimates of the Global Burden of Foodborne Diseases. 2015.
World Health Organization
REGIONAL OFFICE FOR AFRICA

Food Safety Hazard

Chemical Hazards in Food

Table 1: Major chemical hazards in food and their examples [3]

Chemical Hazards	Examples
Inherent (natural) toxin	**Lectins** in kidney beans, glycoalkaloids in potatoes
Natural and environmental contaminants	**Mycotoxin** (Aspergillus, Penicillium and Fusarium) affecting nuts, dried fruits and cereals **Dioxins/Polychlorinated biphenyls (PCBs)** found in soil, water, sediment, plants and animal tissue present in virtually all foods, which is the main route to human exposure
Process and storage-derived contaminants	**3-MCPD** occur in foods/ingredients at low levels as a result of processing, migration from packaging materials during storage, or domestic cooking Acrylamide is formed in food by traditional cooking methods such as baking, frying and roasting (i.e. high temperatures)
Deliberately added contaminants	**Melamine** (chemical found in plastics) fraudulently added to wheat gluten and rice protein from China
Pesticides and veterinary residue	The use of **medicines** used to treat animals raised for food is regulated in a similar manner to that for **pesticides** used on food crops.

[3] Julian South, Mike Edwards and Tim Hutton (2011). Chemical Hazards in Food, IUFoST Scientific Information Bulletin (SIB)

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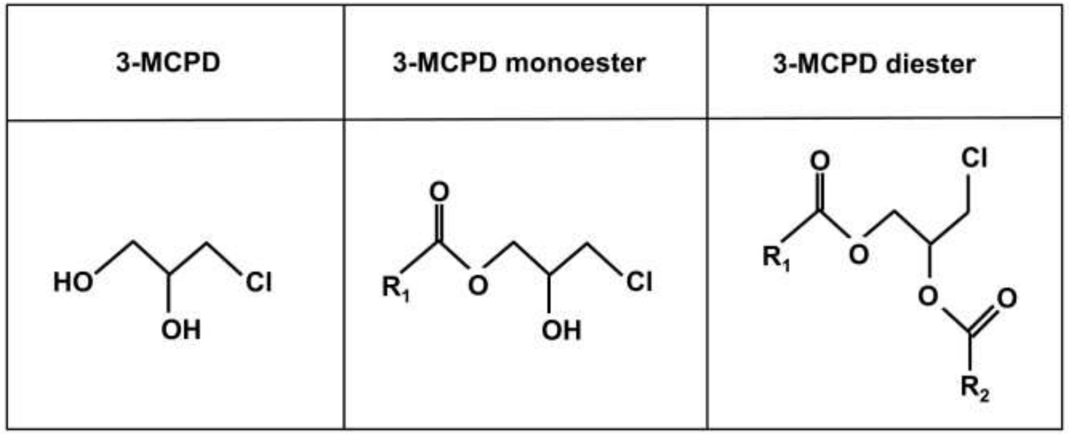
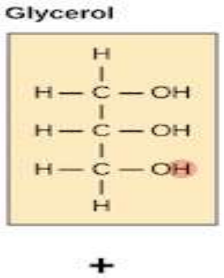
Process contaminant (3-MCPD)

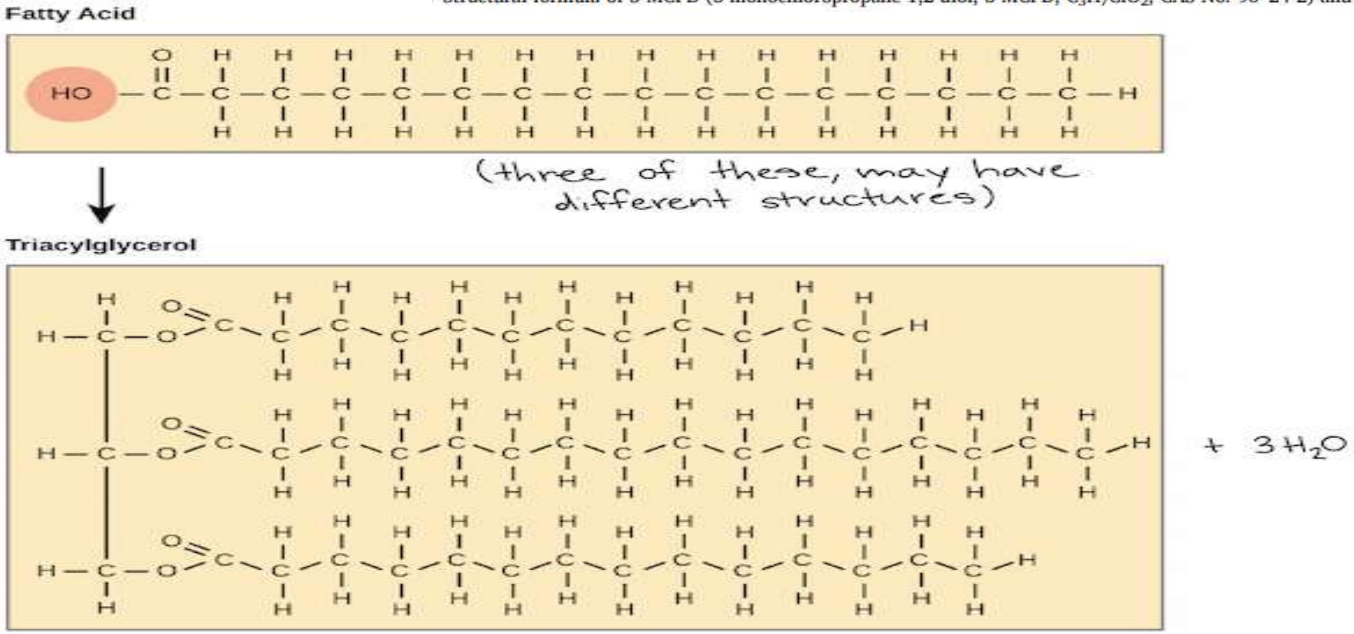
- 3-monochloropropane-1,2-diol (3-MCPD) is a type of process contaminant

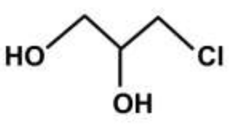
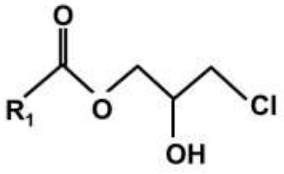
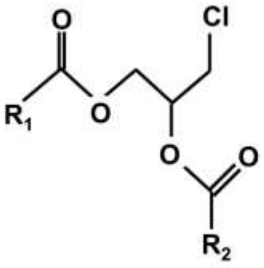


Structural formula of 3-MCPD (3-monochloropropane-1,2-diol, 3-MCPD; $C_3H_7ClO_2$; CAS No. 96–24-2) and its mono- and diesters. R_1, R_2 = residues.

Structure of 3-MCPD





3-MCPD	3-MCPD monoester	3-MCPD diester
		

Structural formula of 3-MCPD (3-monochloropropane-1,2-diol, 3-MCPD; $C_3H_7ClO_2$; CAS No. 96–24-2) and its mono- and diesters. R_1, R_2 = residues.

Production of 3-MCPD

- Precursor is **chloride ion** (cultivation) and **high temperature**
- **Refining**: Cl^- reacts with glycerol backbone (lipids) --> 3-MCPD
- **Deodorisation**: high temperature (>210 ˚C) used to remove undesirables (by-products, impurities)
- Mitigation strategies in refined palm oil

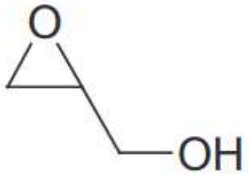
Production of 3-MCPD

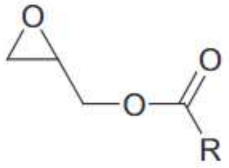
- Found in food with high level of fats & oil
- Produced during **heat treatments** (baking, frying, roasting)
- Much of the 3-MCPD found in food is present as 3-MCPD fatty acid esters (3-MCPDE) and are found in a **wide range of food**

Process contaminant (GE)

- Glycidyl ester (GE) is a type of process contaminant

Glycidol has the IUPAC name oxiranylmethanol [CAS Number 556-52-5].





glycidyl ester

[4] EU Commission Food Safety Authority (2016). Risks for human health related to the presence of 3- and 2-monochloropropanediol (MCPD), and their fatty acid esters, and glycidyl fatty acid esters in food. *EFSA Journal*, 14(5), e04426. https://doi.org/10.2903/j.efsa.2016.4426

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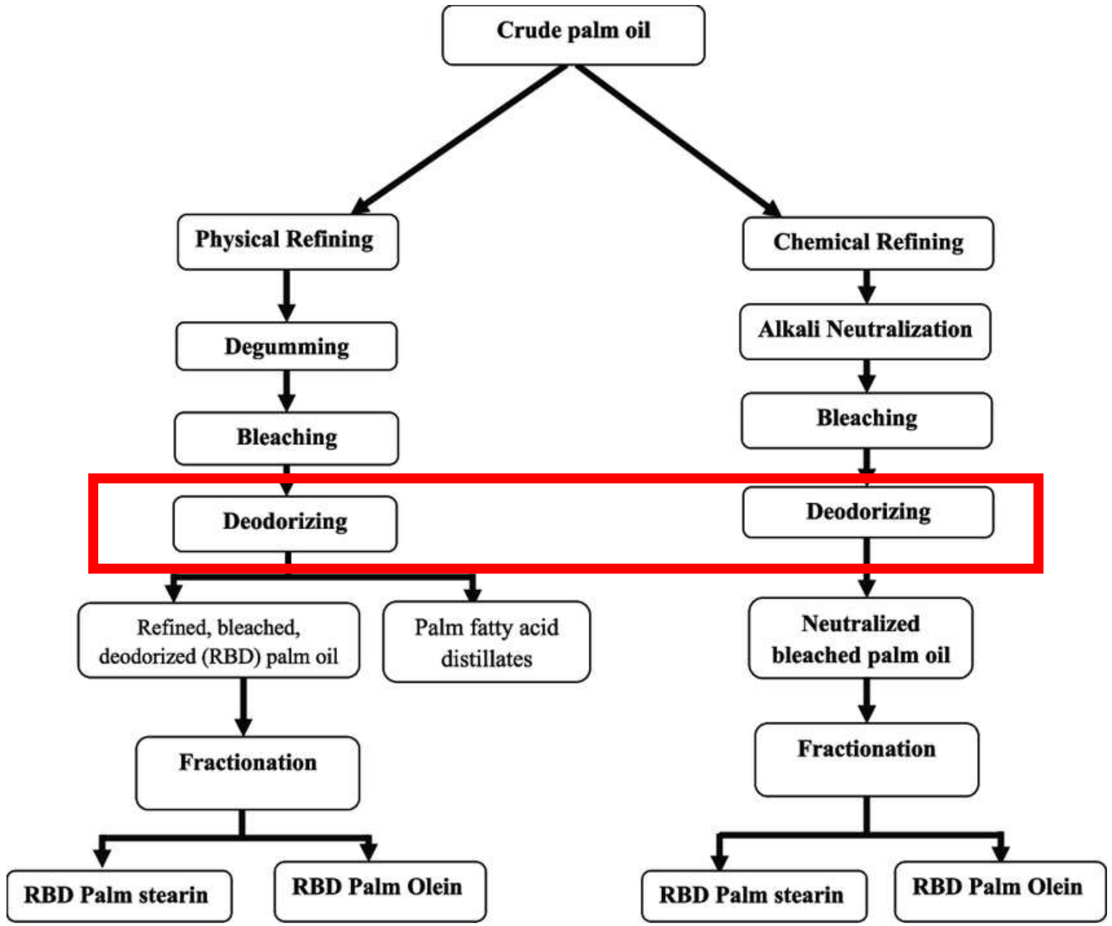
Occurrence (3-MCPD)

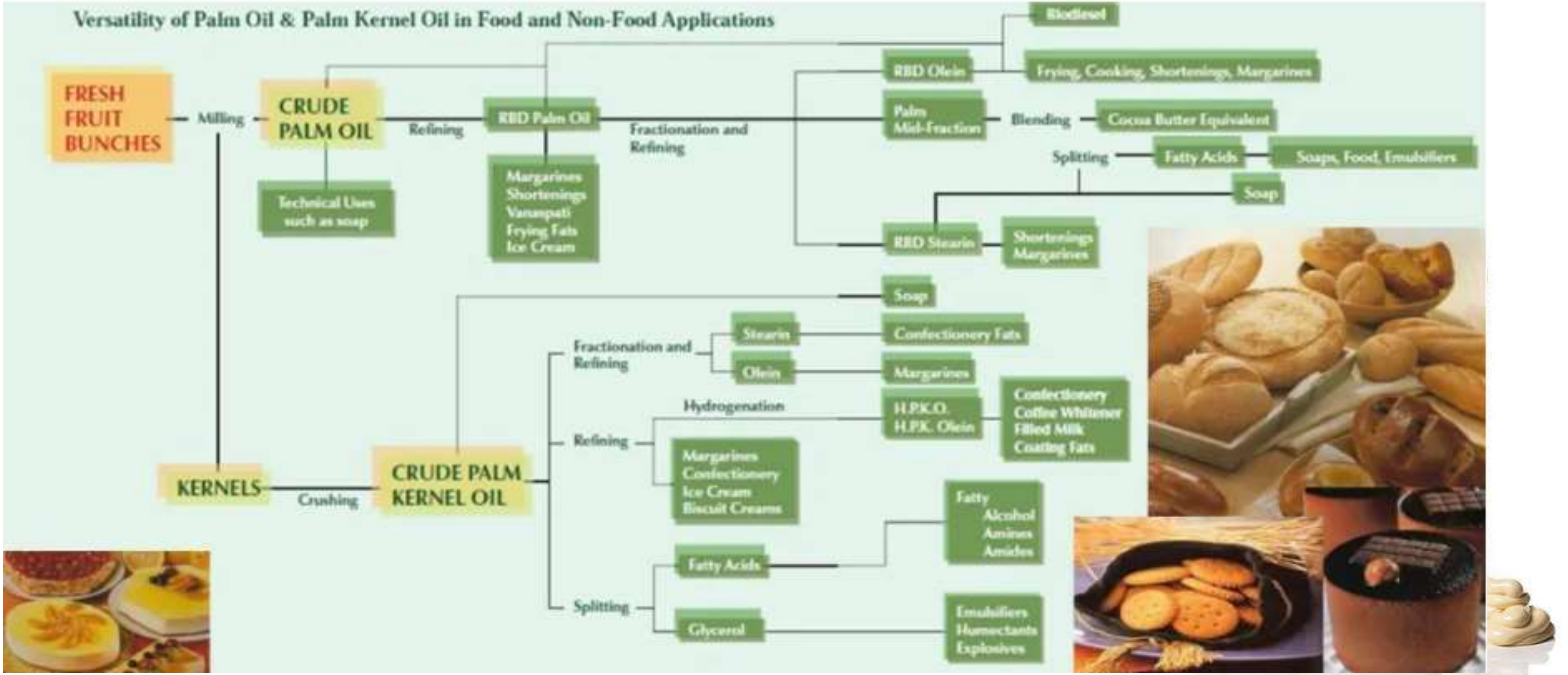
- Palm oil extraction process



Occurrence (3-MCPD)

- **Limited data** of 3-MCPD for food products
- Refined fats and oils or as substituted in food products susceptible to contain 3-MCPD

3-MCPD & GE in various food products



Occurrence (3-MCPD)

- Exact mechanism on the formation of 3-MCPD is **still being explored**
- Formed when **fat- and salt-** containing food are processed at **high temperatures** during production
- **Possibly available** in refined vegetables oils and fats and also infant milk powders

Occurrence (3-MCPD)

- Low temperature resulted in lower 3-MCPDE and GE

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Formation of 3-MCPD and glycidyl esters in biscuits produced using soybean oil-based diacylglycerol stearin-shortening blends: Impacts of different baking temperatures and blending ratios

Nur Shafika Abdul Kadir [a], Yih Phing Khor [b], Yi Jane Lee [a], Dongming Lan [a], Suijian Qi [a], Yonghua Wang [a], Chin Ping Tan [b,c,*]

[a] School of Food Science and Engineering, South China University of Technology, Guangzhou, 510640, China
[b] Department of Food Technology, Faculty of Food Science and Technology, Universiti Putra Malaysia, 43400 Serdang, Selangor, Malaysia
[c] Laboratory of Processing and Product Development, Institute of Plantation Studies, Universiti Putra Malaysia, 43400 Serdang, Selangor, Malaysia

ARTICLE INFO

Keywords:
Fat blending
Diacylglycerol
Glycidyl ester
3-monochloropropane-1,2-diol ester
Baking
Cookie

ABSTRACT

Diacylglycerol (DAG) is commonly known as one of the precursors for 3-monochloropropane-1,2-diol esters (3-MCPDE) and glycidyl esters (GE) formation. Besides, 3-MCPDE and GE are heat-induced contaminants which can be formed in fat-containing baked products during the baking process. This study attempted to replace the conventional palm-based shortening (SH) with a healthier fat, namely soybean oil-based diacylglycerol stearin (SDAG) in producing biscuits. The effects of different baking temperatures (200, 210 and 220 °C) and SDAG:SH fat blend ratios (0:100, 60:40 (D64S), 80:20 (D82S), 100:0, w/w) towards the biscuits' physical properties were evaluated. Moreover, the oxidative stability, 3-MCPDPE and GE formation in the fats extracted from the biscuits were also investigated. SDAG-produced biscuit showed slight reductions in the spread ratio compared to the SH-produced biscuit. The elevated baking temperatures resulted in biscuits with increased hardness and low moisture content. Pure SDAG and the other fat blends exhibited significant ($p < 0.05$) poorer oxidative stability than SH. However, D64S was found to be more oxidative stable compared to SDAG and D82S. The D64S fat blend exhibited the lowest 3-MCPDE and GE formation rates among all fat samples with the increasing baking temperatures. Furthermore, the amount of 3-MCPDE and GE detected in the fats extracted from the biscuits baked at highest temperature (220 °C) were still within the safety limit. In overall, better quality biscuits were produced when lower baking temperature (200 °C) was used as all biscuits baked with different fats showed similar textural properties (hardness and cohesiveness), higher oxidative stability and lower formation of 3-MCPDE and GE compared to biscuits baked at higher temperatures. The findings justified the potential of D64S fat blend in replacing the conventional SH in producing healthier biscuits.

Occurrence (3-MCPD)

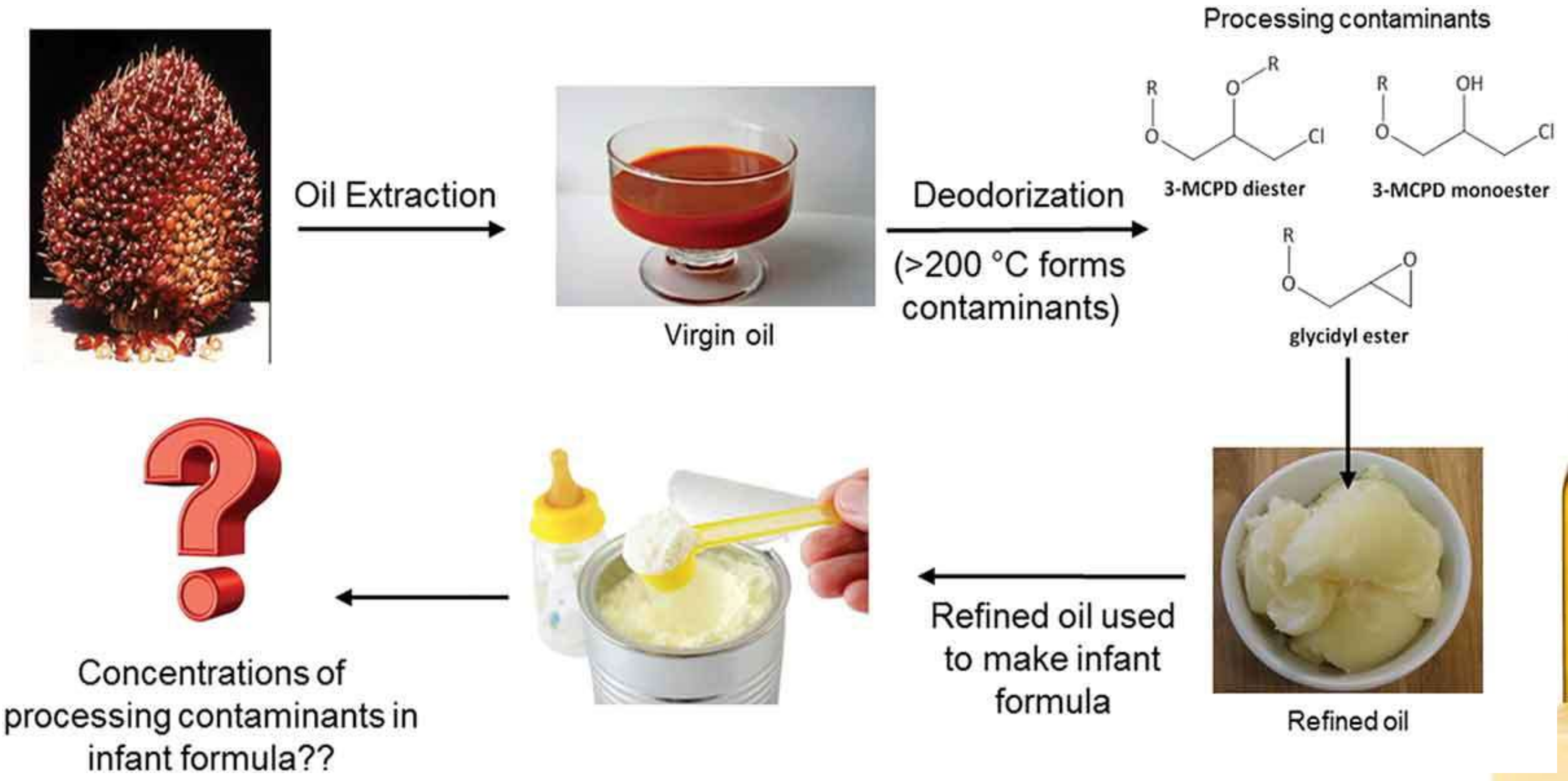
Table 2: Conventional palm-based shortening (SH), soybean oil-based diacylglycerol stearin (SDAG) to produce biscuits. The effects of different baking temperatures (200, 210 and 220 ◦C) and SDAG:SH fat blend ratios (0:100, 60:40 (D64S), 80:20 (D82S), 100:0, w/w) were explored [5]

3-MCPDE and glycidyl esters content of extracted fats from biscuits baked at 200, 210 and 220 °C.

	Temperature(°C)	SH	D64S	D82S	SDAG
3-MCPDE (mg/kg)	Control	1.93 ± 0.01^{aA}	1.39 ± 0.05^{aB}	1.19 ± 0.01^{aB}	1.13 ± 0.14^{aB}
	200	1.55 ± 0.04^{cA}	1.29 ± 0.02^{aB}	1.08 ± 0.01^{bC}	0.94 ± 0.02^{aD}
	210	1.76 ± 0.01^{bA}	1.29 ± 0.10^{aB}	1.09 ± 0.01^{bC}	0.96 ± 0.03^{aD}
	220	1.77 ± 0.03^{bA}	1.30 ± 0.03^{aB}	1.10 ± 0.00^{bcC}	1.01 ± 0.03^{aC}
GE (mg/kg)	Control	1.68 ± 0.17^{aA}	0.44 ± 0.01^{bB}	0.51 ± 0.01^{aB}	0.34 ± 0.03^{aB}
	200	1.13 ± 0.03^{bA}	0.74 ± 0.01^{aB}	0.56 ± 0.05^{aC}	0.37 ± 0.02^{aD}
	210	1.88 ± 0.04^{aA}	0.78 ± 0.04^{aB}	0.58 ± 0.04^{aC}	0.40 ± 0.01^{aD}
	220	1.88 ± 0.16^{aA}	0.74 ± 0.02^{aB}	0.61 ± 0.03^{aB}	0.41 ± 0.06^{aB}

3-MCPDE: LOD = 0.01 mg/kg, LOQ = 0.05 mg/kg; GE: LOD = 0.04 mg/kg, LOQ = 0.14 mg/kg.
Values are expressed as mean ± standard deviation (n = 4). Mean$^{a\text{-}c}$ values in the same column with different small letter superscripts are significantly different at $p < 0.05$. Mean$^{A\text{-}C}$ values in the same row with different capital letter superscripts are significantly different at $p < 0.05$. Abbreviations: 3-MCPDE = 3-monochloropropanediol esters; GE = glycidyl esters; LOD: limit of detection and LOQ = limit of quantification.

3-MCPD & GE in various food products



Why 3-MCPD and GE considered harmful?

- In 2016, European Food Safety Authority (EFSA)'s expert panel on contaminants in food chain (**CONTAM**) evaluated potential risk
- 3-MCPDE and GE found in **highest level in palm oil/fats**
- Potential health **concern** for certain target consumers e.g **infants**

Why 3-MCPD and GE are considered harmful?

SCIENTIFIC OPINION

EFSA Journal

ADOPTED: 3 March 2016

doi: 10.2903/j.efsa.2016.4426

Risks for human health related to the presence of 3- and 2-monochloropropanediol (MCPD), and their fatty acid esters, and glycidyl fatty acid esters in food

EFSA Panel on Contaminants in the Food Chain (CONTAM)

Abstract

EFSA was asked to deliver a scientific opinion on free and esterified 3- and 2-monochloropropane-1, 2-diol (MCPD) and glycidyl esters in food. Esters of 3- and 2-MCPD and glycidol are contaminants of processed vegetable oils; free MCPDs are formed in some processed foods. The Panel on Contaminants in the Food Chain (CONTAM Panel) evaluated 7,175 occurrence data. Esters of 3- and 2-MCPD and glycidyl esters were found at the highest levels in palm oil/fat, but most vegetable oil/fats contain substantial quantities. Mean middle bound (MB) dietary exposure values to total 3-MCPD, 2-MCPD and glycidol, respectively, across surveys and age groups in μg/kg body weight (bw) per day were 0.2–1.5, 0.1–0.7 and 0.1–0.9; high exposure (P95) values were 0.3–2.6, 0.2–1.2 and 0.2–2.1.

Why 3-MCPD and GE are considered harmful?

- In 2018, **CONTAM panel** updated TDI 3-MCPDE to 2 µg/kg body weight per day
- Joint FAO/WHO Expert Committee on Food Additives (JECFA) proposed provisional maximum TDI (PMTDI) = 4 µg/kg body weight per day
- Estimation of dietary exposure:
  - 0.1-0.6 µg/kg body weight per day (general population)
  - 3.8 µg/kg body weight per day (high demand)
  - 10 µg/kg body weight per day (infants)

Why 3-MCPD and GE are considered harmful?

International Agency for Research on Cancer

World Health Organization

IARC MONOGRAPHS ON THE IDENTIFICATION OF CARCINOGENIC HAZARDS TO HUMANS

Agents Classified by the IARC Monographs, Volumes 1–132

Group 1	Carcinogenic to humans	122 agents
Group 2A	Probably carcinogenic to humans	93 agents
Group 2B	Possibly carcinogenic to humans	319 agents
Group 3	Not classifiable as to its carcinogenicity to humans	501 agents

Why 3-MCPD and GE are considered contaminants?

- "Possibly carcinogenic to humans"
- There is some evidence that it can cause cancer in humans but at present it is far from conclusive.

Agents Classified by the IARC Monographs, Volumes 1–132

CAS No.	Agent	Group	Volume	Year	Additional information
96-24-2	3-Monochloro-1,2-propanediol	2B	101	2013	

Last updated: 2022-09-07 10.34am (CEST)

- "Probably carcinogenic to humans"
- There is strong evidence that it can cause cancer in humans, but at present it is not conclusive.

Agents Classified by the IARC Monographs, Volumes 1–132

CAS No.	Agent	Group	Volume	Year	Additional information
556-52-5	Glycidol	2A	77	2000	NB Overall evaluation upgraded to Group 2A with supporting evidence from other relevant data

Last updated: 2022-09-07 10.34am (CEST)

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- **Additional Licensing Conditions**
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Additional Licensing Conditions: Pk EL MPOB 03/2020

MF, PX and PM:

(POSTPONED)

- FFA (as palmitics), max %: 5.0
- Moisture & Impurities (M&I), max %: 0.25
- DOBI, min: 2.31
- Chlorine (Cl): 2.0 ppm

RF, PX and PM:

(1 JANUARY 2023)

- 3-MCPDE, max: 2.5 ppm
- GE, max: 1 ppm

Additional Licensing Conditions

- Abrupt
- Preparation of **457 mills+50 refineries**
- **Huge cost** up to RM2 billion capital expenditure(refinery) to comply
- Operation & maintenance cost: RM100 million/annum
- Analysis cost: RM120 million/annum

Outline

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Way Forward

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Chemical refining methods effectively mitigate 2-MCPD esters, 3-MCPD esters, and glycidyl esters formation in refined vegetable oils

Sergio B. Oey [a], H.J. van der Fels-Klerx [a], Vincenzo Fogliano [b], Stefan P.J. van Leeuwen [a,*]

[a] *Wageningen Food Safety Research (WFSR), Wageningen University & Research, Akkermaalsbos 2, 6708 WB Wageningen, the Netherlands*
[b] *Department of Food Quality and Design, Wageningen University & Research, P.O. Box 17, 6700 AA Wageningen, the Netherlands*

A R T I C L E I N F O

Keywords:
3-Monochloropropanediol
Glycidol
Processing Contaminants
Refined Edible Oils
Pilot Plant Refining
Mitigation Strategies

A B S T R A C T

Esters of 3-monochloro-1,2-propanediol (3-MCPDE), 2-monochloro-1,3-propanediol (2-MCPDE), and glycidyl esters (GE) are processing contaminants that can be found in refined edible fats and oils. Recently, the European Commission has implemented maximum limits for the presence of free and bound 3-MCPDE in vegetable fats and oils and in marine and fish oils. This boosted the necessity of oil producers to develop refining methods to limit the concentration of both 3-MCPDE and GE in their final products. Physical refining may lack the potential to mitigate the formation of 2- and 3-MCPDE. Therefore, in this study, the chemical refining method were explored to provide a viable mitigation strategy aimed at industrial application. Several pilot plant treatments with organic palm oil were performed. The investigated refining methods included a neutralization, a water washing process, reduced deodorization temperature, and a combination of them. The best performing chemical refining treatment achieved a final concentration of 0.42 (−49%), 0.78 (−52%), and 0.99 (−73%) mg/kg for 2-MCPDE, 3-MCPDE, and GE in organic palm oil, respectively. Results thus showed chemical refining has great potential for the simultaneous mitigation of 2-, 3-MCPDE, and GE.

Way Forward

Journal of
Food Processing and Preservation
Institute of Food Science + Technology ifst

ORIGINAL ARTICLE

Effects of herb (mint, ginger, and cinnamon) addition on the formation of 3-monochloropropanediol esters in the refined olive oil

Farzaneh Kamandloo, Karamatollah Rezaei, Ali Aghakhani

First published: 05 August 2022 | https://doi-org.ezaccess.library.uitm.edu.my/10.1111/jfpp.16974

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Abstract

The inhibitory effects of using extracts and leaf powders from mint (*Mentha spicata*), ginger (*Zingiber officinale*), and cinnamon (*Cinnamomum verum*) were investigated on the formation of 3-monochloropropanediol esters (3-MCPD esters) in the refined olive oil at temperatures 100–200°C using Taguchi's experimental design. The initial concentration of 3-MCPD esters in the refined olive oil before the treatment was 0.33 mg/100 g of oil. The greatest reducing effect was found for mint powder (0.16 mg/100 g of oil). The inhibitory effects of extracts and powders were similar. Based on the Taguchi's approach for the analysis of the data, the best level for the extract and/or the powder of mint or ginger was 0.04 mg for 100 g refined olive oil. During the storage of refined olive oil for 1 and 2 months, mint and ginger as both dry extract and plant powder reduced the formation of 3-MCPD esters.

Practical applications

In the current study, during 1 and 2 months of storage of refined olive oil, decreases in the production of 3-monochloropropanediol esters were observed in samples containing mint and ginger (as a powder or in their extract forms). Therefore, to avoid the production of this toxic chemical in olive oil after it is packaged, mint and ginger can be combined with the oil immediately after its refining stage. Results from the current study can encourage manufacturers to use these natural antioxidants for inhibiting the formation of 3-monochloropropanediol esters.

Way Forward

Journal of Food Composition and Analysis 106 (2022) 104272

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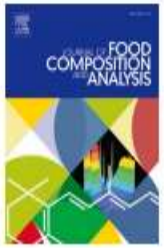

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Original Research Article

Occurrence and dietary intake of food processing contaminants (FPCs) in Catalonia, Spain

Neus González [a], Montse Marquès [a], Josep Calderón [b], Roger Collantes [b], Lidia Corraliza [b], Isabel Timoner [c], Jaume Bosch [c], Victòria Castell [c], José L. Domingo [a], Martí Nadal [a,*]

[a] *Laboratory of Toxicology and Environmental Health, School of Medicine, IISPV, Universitat Rovira i Virgili, Sant Llorenç 21, 43201, Reus, Catalonia, Spain*
[b] *Laboratory of the Public Health Agency of Barcelona, Chemistry, Avda. Drassanes 13-15, 08001, Barcelona, Catalonia, Spain*
[c] *Catalan Food Safety Agency, Department of Health, Generalitat de Catalunya, Roc Boronat 81-95, 08005 Barcelona, Catalonia, Spain*

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ABSTRACT

Food processing contaminants (FPCs) form a wide group of chemicals that are generated during different cooking practices. This study was aimed at determining the levels of a number of FPCs (i.e., acrylamide, furans, monochloropropanediols (MCPDs) and glycidyl esters (GEs)) in foodstuffs purchased in Catalonia (Spain), and assessing the human exposure for different population groups. The dietary intake of acrylamide for the adult population was estimated in 2.91 μg/day, while that of furan, 2-methylfurans and 3-methylfurans was 4.32, 7.35 and 0.439 μg/day, respectively. Finally, the exposure to 3-MCPD, 2-MCPD, 3-MCPD esters, 2-MCPD esters and GEs through food consumption was estimated in 0.657, 0.529, 10.7, 5.15 and 8.81 μg/day, respectively. The risk assessment showed that there is a health concern for developing neoplastic effects derived from the intake of acrylamide for all the population groups. In addition, toddlers and infants would exceed the threshold values of 3-MCDP and GEs. The global analysis of these results indicates that a special attention should be paid to the youngest population groups in Catalonia, reinforcing the need of conducting periodical monitoring studies and developing policy measures, especially focused on foodstuffs highly consumed by toddlers, infants and children.

Way Forward

Table 3: Food processing contaminants (FPCs) for food products in Catalonia, Spain [8]

Concentrations of FPCs (μg/kg) in different foodstuffs purchased from Catalonia (Spain).

Food samples	Acrylamide	Furan	2-methylfurans	3-methylfurans	3-MCPD	2-MCPD	3-MCPD ester	2-MCPD ester	GE
Potato chips (n = 24)	435 ± 110	n.a.	n.a.	n.a.	<10	<10	102 ± 40	50.7 ± 25	68 ± 5.3
Potato snacks (n = 24)	248 ± 140	n.a.	n.a.	n.a.	<10	<10	389 ± 190	152 ± 69	138 ± 44
Sliced bread (n = 24)	14.7 ± 4.2	n.a.	n.a.	n.a.	15.1 ± 1.5	<10	21 ± 9.2	5 ± 2	1 ± 1.7
Toasts and crackers (n = 24)	43.4 ± 17	n.a.	n.a.	n.a.	4.67 ± 0.58	<10	68.3 ± 37	24.3 ± 24	61.7 ± 31
White bread (n = 24)	9.6 ± 8	n.a.	n.a.	n.a.	4.87 ± 0.23	<10	0.67 ± 1.2	1 ± 1	3 ± 0
Breakfast cereals (wheat) (n = 24)	86 ± 21	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Breakfast cereals (other) (n = 24)	59.7 ± 6	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Roasted coffee (n = 24)	202 ± 76	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Instant coffee*	594 ± 160	380 ± 330	869 ± 640	62.1 ± 40	n.a.	n.a.	n.a.	n.a.	n.a.
Margarine (n = 24)	<40	n.a.	n.a.	n.a.	<20	<20	287 ± 38	174 ± 32	294 ± 160
Cereal-based baby food*	11.3 ± 3.1	4.70 ± 6.5	2.65 ± 1.4	<1	<10	<10	2.33 ± 1.5	1.17 ± 0.76	<1
Cookies (n = 24)	209 ± 49	n.a.	n.a.	n.a.	4.47 ± 0.7	<10	191 ± 95	91.3 ± 42	305 ± 110
Baby food*	9.27 ± 6.9	1.13 ± 0.36	<1	<1	n.a.	n.a.	n.a.	n.a.	n.a.
Ground coffee (n = 8)	n.a.	1670 ± 170	5210 ± 1100	261 ± 32	n.a.	n.a.	n.a.	n.a.	n.a.
Coffee beans (n = 8)	n.a.	2410 ± 260	7130 ± 1100	373 ± 29	n.a.	n.a.	n.a.	n.a.	n.a.
Coffee substitutes (n = 8)	n.a.	257 ± 190	380 ± 230	12.6 ± 8.5	n.a.	n.a.	n.a.	n.a.	n.a.
Fruit juices (n = 8)	n.a.	<1	<1	<1	n.a.	n.a.	n.a.	n.a.	n.a.
Breakfast cereals (n = 8)	n.a.	21.6 ± 29	8.13 ± 9.6	1.26 ± 0.73	n.a.	n.a.	n.a.	n.a.	n.a.
Sunflower oil (n = 24)	n.a.	n.a.	n.a.	n.a.	<10	<10	617 ± 190	321 ± 100	407 ± 140
Pomace oil (n = 24)	n.a.	n.a.	n.a.	n.a.	<10	<10	2270 ± 210	733 ± 220	737 ± 400
Refined olive oil (n = 24)	n.a.	n.a.	n.a.	n.a.	<10	<10	397 ± 210	198 ± 130	267 ± 29
Infant formula (n = 24)	n.a.	n.a.	n.a.	n.a.	<10	<10	304 ± 180	101 ± 61	<68
Follow-on formulae (n = 24)	n.a.	n.a.	n.a.	n.a.	<10	<10	171 ± 120	73 ± 36	<54
Cereals and milk (n = 24)	n.a.	n.a.	n.a.	n.a.	<20	<20	<6	1.83 ± 1.3	<7
Mayonnaise (n = 24)	n.a.	n.a.	n.a.	n.a.	34.1 ± 20	5.7 ± 0.58	245 ± 96	102 ± 47	246 ± 37
Soy sauce (n = 24)	n.a.	n.a.	n.a.	n.a.	18.8 ± 7.6	46 ± 71	n.a.	n.a.	n.a.
Salad sauce (n = 24)	n.a.	n.a.	n.a.	n.a.	12.3 ± 1.2	12.3 ± 1.2	229 ± 130	97.3 ± 58	95.3 ± 21
Bakery products (n = 24)	n.a.	n.a.	n.a.	n.a.	7.23 ± 3.9	<10	388 ± 310	107 ± 110	265 ± 380
Chocolate spreads (n = 24)	n.a.	n.a.	n.a.	n.a.	<10	<10	457 ± 160	207 ± 49	617 ± 140
Palm oil cookies (n = 24)	n.a.	n.a.	n.a.	n.a.	4.50 ± 0.87	<10	297 ± 15	114 ± 13	343 ± 15
Frying oil (mixture) (n = 24)	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	727 ± 58	313 ± 32	700 ± 53

n.a.: not analyzed; *different number of analyzed samples, depending on the target chemicals: n = 24 for acrylamide, 3-MCPD, 2-MCPD, 3-MCPD ester, 2-MCPD ester and GE, and n = 8 for furan, 2-methylfutran and 3-methylfuran.

Way Forward

Table 3: Food processing contaminants (FPCs) for food products in Catalonia, Spain [8]

Concentrations of FPCs (µg/kg) in different foodstuffs purchased from Catalonia (Spain).

Food samples	Acrylamide	Furan	2-methylfurans	3-methylfurans	3-MCPD	2-MCPD	3-MCPD ester	2-MCPD ester	GE
Potato chips (n = 24)	435 ± 110	n.a.	n.a.	n.a.	<10	<10	102 ± 40	50.7 ± 25	68 ± 5.3
Potato snacks (n = 24)	243 ± 140	n.a.	n.a.	n.a.	<10	<10	389 ± 190	152 ± 69	138 ± 44
Sliced bread (n = 24)	14.7 ± 4.2	n.a.	n.a.	n.a.	15.1 ± 1.5	<10	21 ± 9.2	5 ± 2	1 ± 1.7
Toasts and crackers (n = 24)	43.4 ± 17	n.a.	n.a.	n.a.	4.67 ± 0.58	<10	68.3 ± 37	24.3 ± 24	61.7 ± 31
White bread (n = 24)	9.6 ± 8	n.a.	n.a.	n.a.	4.87 ± 0.23	<10	0.67 ± 1.2	1 ± 1	3 ± 0
Breakfast cereals (wheat) (n = 24)	86 ± 21	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Breakfast cereals (other) (n = 24)	59.7 ± 6	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Roasted coffee (n = 24)	202 ± 76	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Instant coffee*	594 ± 160	380 ± 330	869 ± 640	62.1 ± 40	n.a.	n.a.	n.a.	n.a.	n.a.
Margarine (n = 24)	<40	n.a.	n.a.	n.a.	<20	<20	287 ± 38	174 ± 32	294 ± 160
Cereal-based baby food*	11.3 ± 3.1	4.70 ± 6.5	2.65 ± 1.4	<1	<10	<10	2.33 ± 1.5	1.17 ± 0.76	<1
Cookies (n = 24)	209 ± 49	n.a.	n.a.	n.a.	4.47 ± 0.7	<10	191 ± 95	91.3 ± 42	305 ± 110
Baby food*	9.27 ± 6.9	1.13 ± 0.36	<1	<1	n.a.	n.a.	n.a.	n.a.	n.a.
Ground coffee (n = 8)	n.a.	1670 ± 170	5210 ± 1100	261 ± 32	n.a.	n.a.	n.a.	n.a.	n.a.
Coffee beans (n = 8)	n.a.	2410 ± 260	7130 ± 1100	373 ± 29	n.a.	n.a.	n.a.	n.a.	n.a.
Coffee substitutes (n = 8)	n.a.	257 ± 190	380 ± 230	12.6 ± 8.5	n.a.	n.a.	n.a.	n.a.	n.a.
Fruit juices (n = 8)	n.a.	<1	<1	<1	n.a.	n.a.	n.a.	n.a.	n.a.
Breakfast cereals (n = 8)	n.a.	21.6 ± 29	8.13 ± 9.6	1.26 ± 0.73	n.a.	n.a.	n.a.	n.a.	n.a.
Sunflower oil (n = 24)	n.a.	n.a.	n.a.	n.a.	<10	<10	617 ± 190	321 ± 100	407 ± 140
Pomace oil (n = 24)	n.a.	n.a.	n.a.	n.a.	<10	<10	2270 ± 210	733 ± 220	737 ± 400
Refined olive oil (n = 24)	n.a.	n.a.	n.a.	n.a.	<10	<10	397 ± 210	198 ± 130	267 ± 29
Infant formula (n = 24)	n.a.	n.a.	n.a.	n.a.	<10	<10	304 ± 180	101 ± 61	<68
Follow-on formulae (n = 24)	n.a.	n.a.	n.a.	n.a.	<10	<10	171 ± 120	73 ± 36	<54
Cereals and milk (n = 24)	n.a.	n.a.	n.a.	n.a.	<20	<20	<6	1.83 ± 1.3	<7
Mayonnaise (n = 24)	n.a.	n.a.	n.a.	n.a.	34.1 ± 20	5.7 ±	245 ± 96	102 ± 47	246 ± 37

Way Forward

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Monochloropropanediol and glycidyl esters in infant formula and baby food products on the Danish market: Occurrence and preliminary risk assessment

Khanh Hoang Nguyen*, Arvid Fromberg

National Food Institute, Technical University of Denmark, 2800, Kgs. Lyngby, Denmark

ARTICLE INFO

Keywords:
MCPD esters
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ABSTRACT

A GC/MS-MS method for determination of monochloropropanediol (MCPDEs) and glycidol (GEs) was developed, validated, and applied to analyze 60 infant formula and baby food products commercially available on the Danish market. The contaminants were quantifiable in almost all sample categories with the exception of fruit or vegetable based purees. The highest concentrations of 3-MCPDEs and 2-MCPDEs were found in a baby biscuit product at 102.6 μg/kg and 52.8 μg/kg, respectively. Meanwhile, a baby puff item contained GEs as high as 149 μg/kg. MCPDEs and GEs concentrations are well correlated with each other in all sample types except puffs and biscuits. Occurrence data suggested that GEs formation might have taken place during production of baby puffs by unknown mechanisms. Preliminary exposure and risk assessment showed no apparent risk of Danish infants to these chemicals in formula and baby foods. However, special attention should be paid when feeding babies with puffs or similar items due to their relatively high level of GEs.

Way Forward

Table 4: The content of 3-MCPDE and GE for infant related items in Denmark [13]

Concentrations of 2-MCPDEs, 3-MCPDEs and GEs in infant formula and baby food products purchased in Denmark.

Item	Sample type	Oil composition[a]	Brand	Intended age of use (months)	Fat content (%)[a]	2-MCPDEs (μg/kg)	3-MCPDEs (μg/kg)	GEs (μg/kg)	Ratio 2-/3-MCPDEs
	Biscuits								
1		palm, sunflower	E	12	12.7	28.6	59.6	35.0	0.48
2		palm	E	10	11.2	44.7	96.3	16.2	0.46
3		palm	E	10	12.9	52.8	102.6	23.9	0.51
4		palm, sunflower	F	10	13.5	34.8	71.7	24.6	0.49
	Liquid formula								
34		palm, rapeseed, coconut, sunflower	A	0	3.5	1.5	3.7	0.6	0.41
35		palm, sunflower, rapeseed, coconut, fish	A	6	2.9	2.3	5.3	0.9	0.44
36		palm, sunflower, rapeseed, coconut, fish	C	0	3.6	2.2	5.9	1.5	0.37
37		palm, sunflower, rapeseed, coconut, fish	C	6	3.6	1.2	3.4	0.7	0.35
38		palm, rapeseed, soybean, coconut	B	0	3.6	3.0	6.9	1.6	0.44
39		palm, rapeseed, soybean, coconut	B	6	3.1	3.7	8.5	1.2	0.43
	Powder formula								
40		sunflower, rapeseed, coconut, fish	C	0	28	18.6	50.2	8.7	0.37
41		palm, palm kernel, sunflower, rapeseed, fish	A	0	19	20.1	46.5	17.3	0.43
42		palm, palm kernel, sunflower, rapeseed, fish	A	6	19	11.1	26.9	9.4	0.41
43		palm, sunflower, rapeseed, coconut, fish	A	12	20	12.4	28.8	8.8	0.43
44		palm, canola, coconut, soybean	B	0	23	29.0	65.0	31.2	0.45
45		palm, canola, coconut, soybean	B	6	22.5	16.1	40.2	10.3	0.40
46		sunflower, rapeseed, fish	C	6	24	1.3	8.6	3.1	0.15
	Puffs								
47		no added oil	F	6	3.4	< LOQ	< LOQ	< LOQ	NA
48		sunflower	F	6	14.4	3.4	7.4	27.5	0.46
49		sunflower	E	6	13.8	7.6	20.9	128	0.36
50		sunflower	E	6	15.8	8.7	21.8	149	0.40
51		sunflower	E	6	14	8.4	26.5	58.0	0.32

Way Forward

- Conduct proper study on Malaysian edible oils and food products
- Establish Tolerable Daily Intake (TDI) for Malaysian population
- Identify mitigation steps for whole supply chain (plantation, mills and refinery)

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Thank you