Formation of 3-MCPD esters and Glycidyl esters during food preparation - What happens during frying, baking and barbecuing?

Bertrand Matthäus

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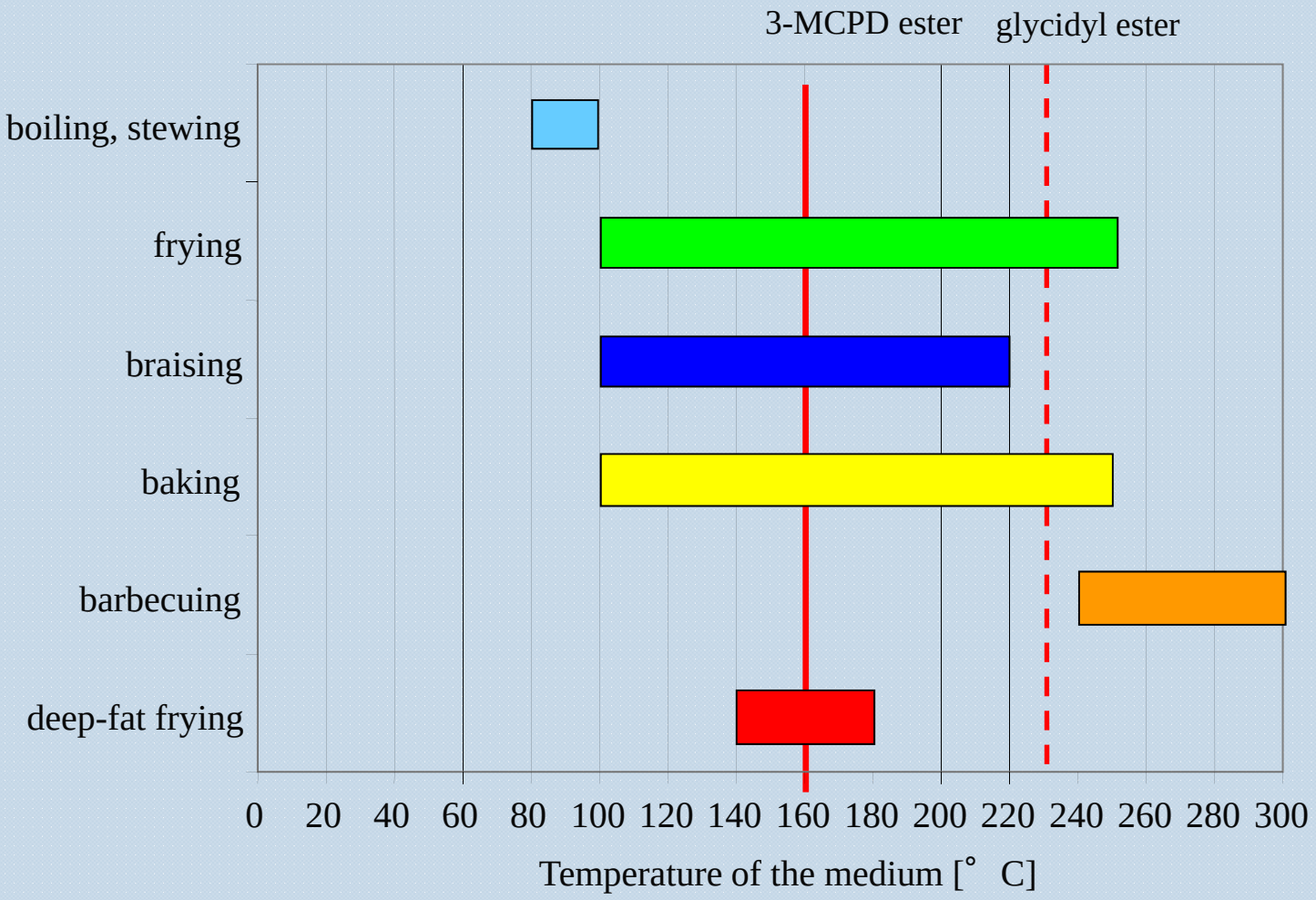
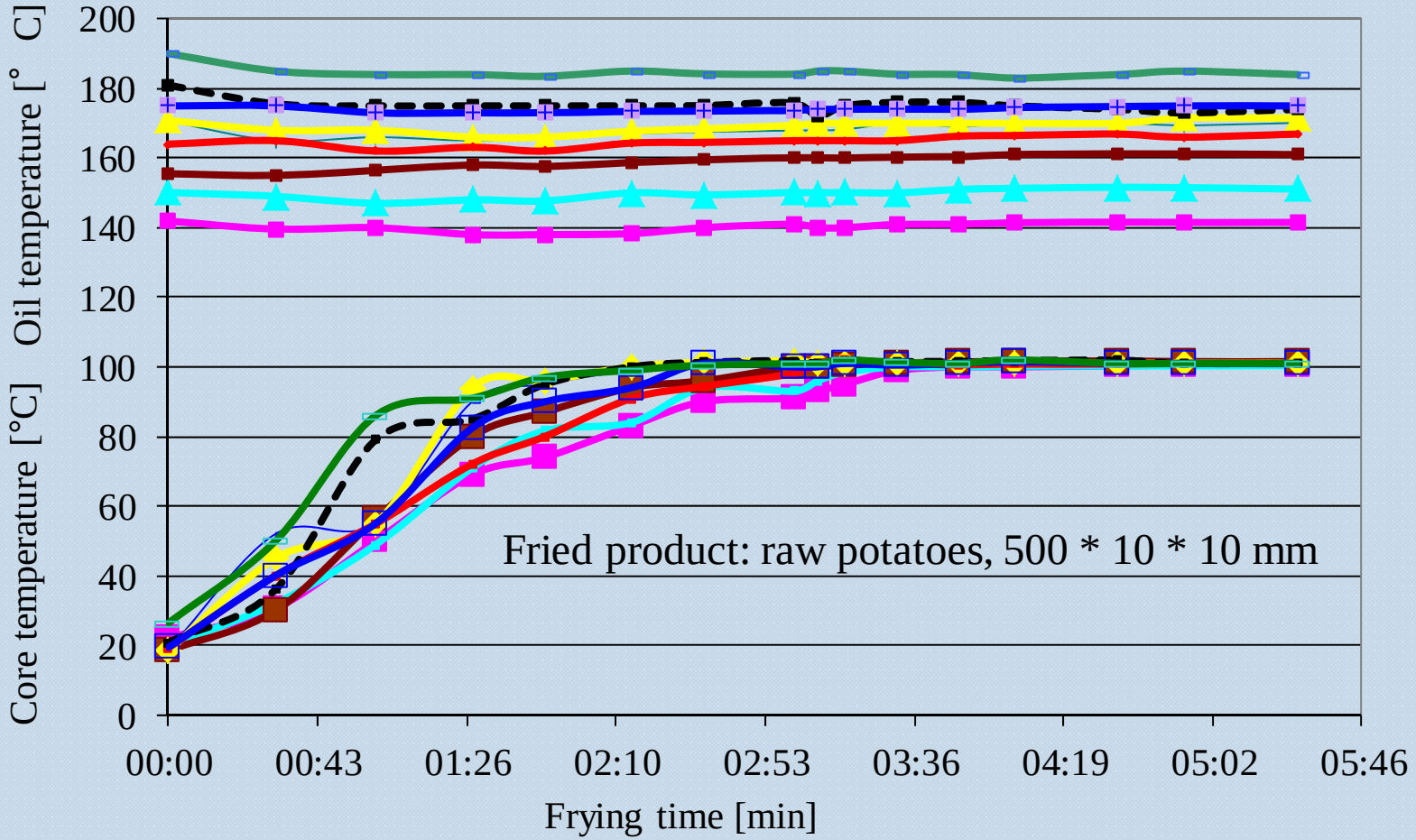
Outline

- Background information
- Formation of 3-MCPD and glycidyl ester during barbecuing, frying and deep-fat frying
- Influence of free fatty acids on the product quality during storage of potato crisps
- Summary

Temperatures necessary for different cooking methods

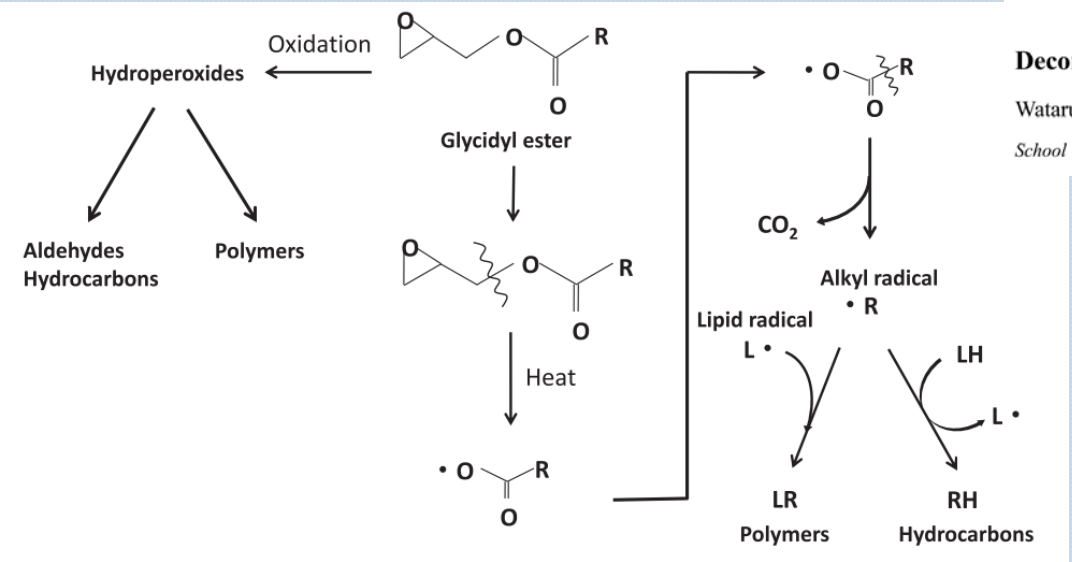


Change of the core temperature during deep-fat frying



Source: Chr. Gertz, Maxfry

Decomposition of glycidyl esters during heating



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Vol. 81, No. 3, 581–586

Decomposition products of glycidyl esters of fatty acids by heating

Wataru Kimura and Yasushi Endo*

School of Bioscience and Biotechnology, Tokyo University of Technology, Hachioji, Japan

Glycidyl palmitate might be quickly decomposed to hydrocarbons, aldehydes and CO_2 besides polar compounds by heating, in comparison with tripalmitate.

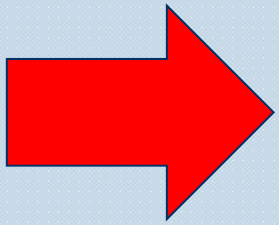
Glycidyl ester present in vegetable oils and French fries could be thermally unstable and easily decomposed to aldehydes, hydrocarbons, and polar compounds including polymers.

Oils higher in glycidyl esters are more susceptible to degradation by high temperature

Is the source of 3-MCPD- and glycidyl esters in fried food endogenous or exogenous?

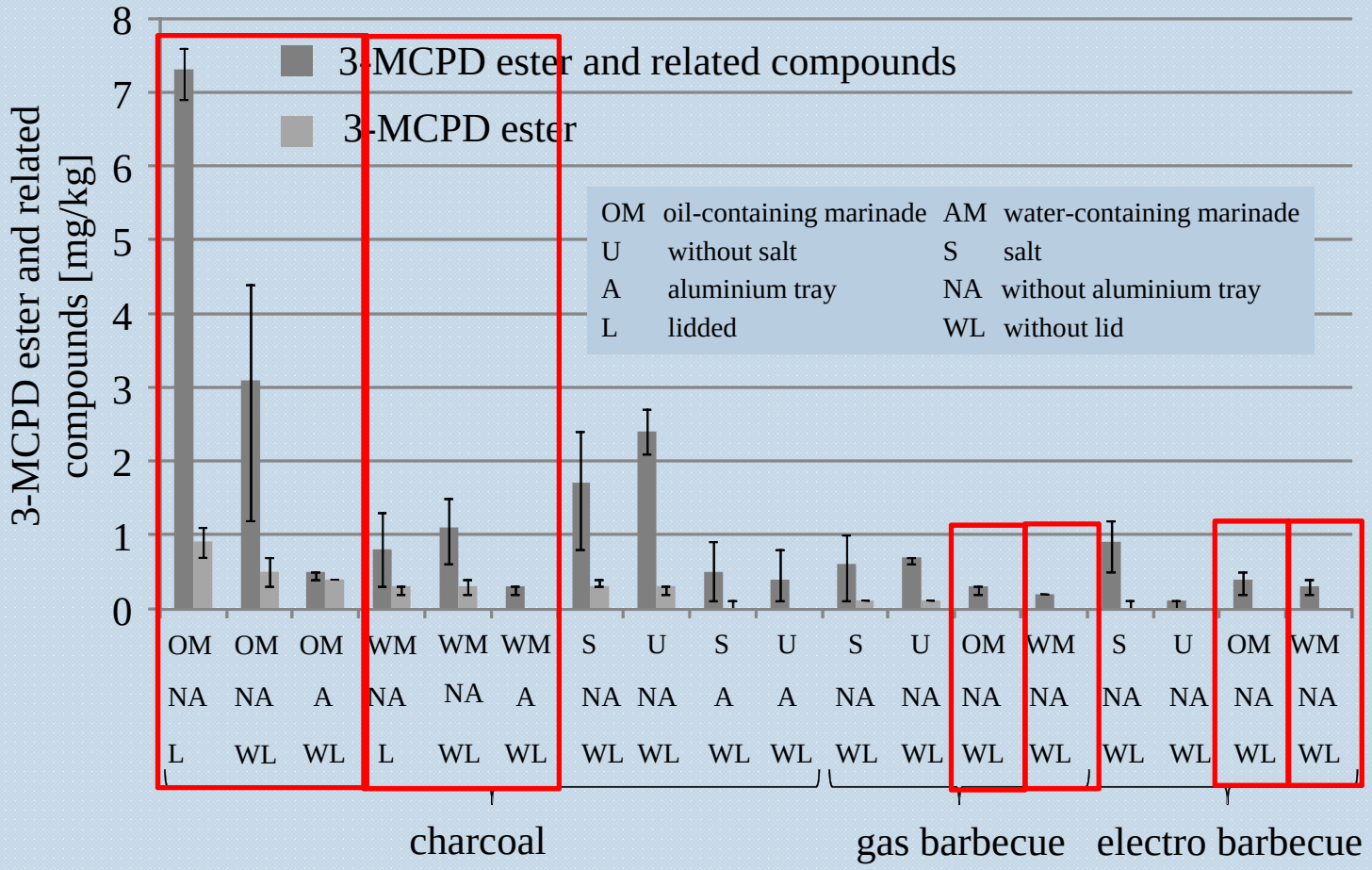
Endogenous: 3-MCPD and glycidyl esters are formed during processing

Exogenous: 3-MCPD and glycidyl esters are derived from the raw material, no new formation during processing



- In the case of an endogenous source of 3-MCPD and glycidyl esters the producer has to optimize the processing.
- In the case of an exogenous source of 3-MCPD and glycidyl esters the producer is depending on the quality of the raw material.

Influence of processing on the content of 3-MCPD and glycidyl ester during barbecuing



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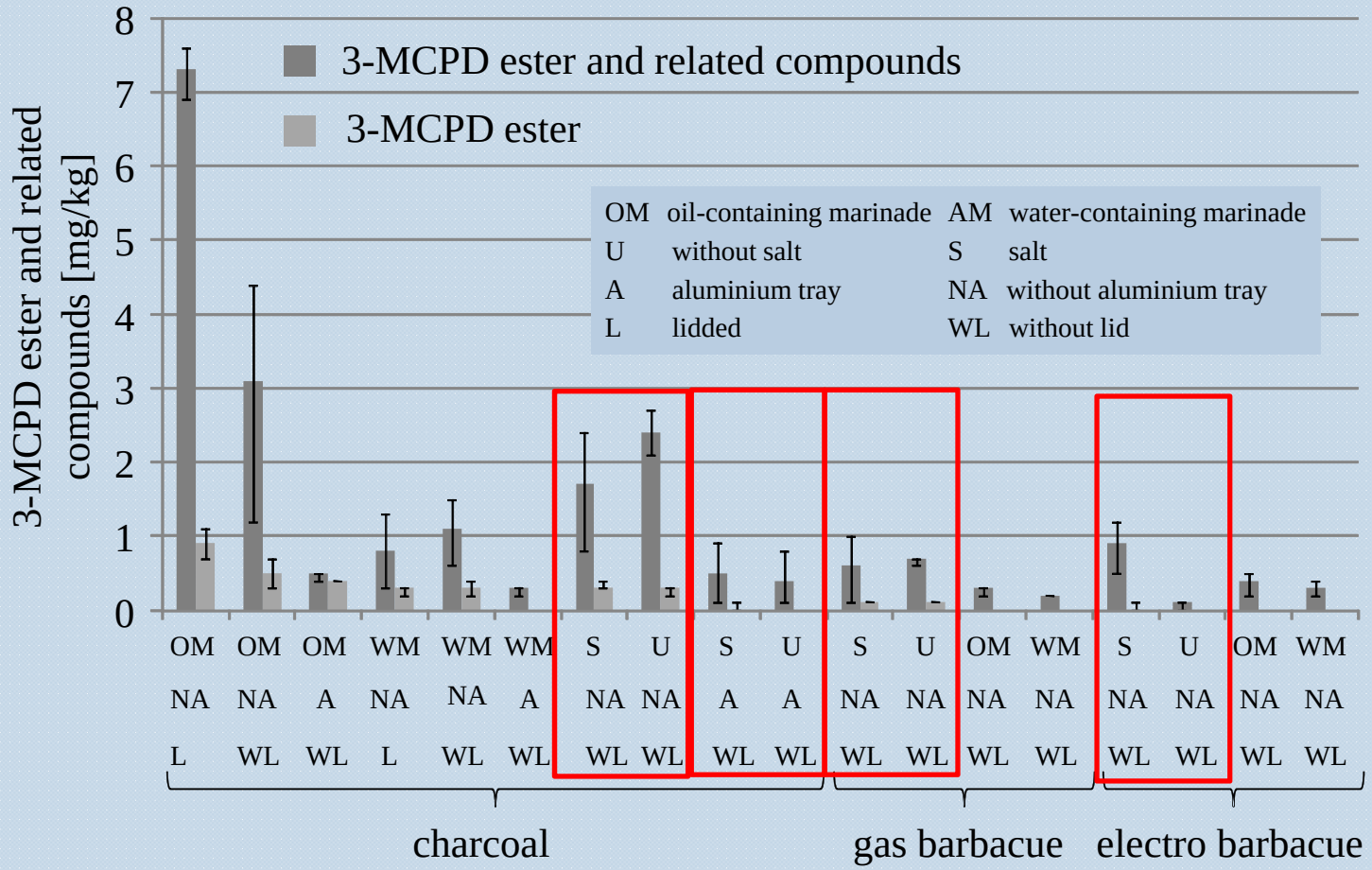
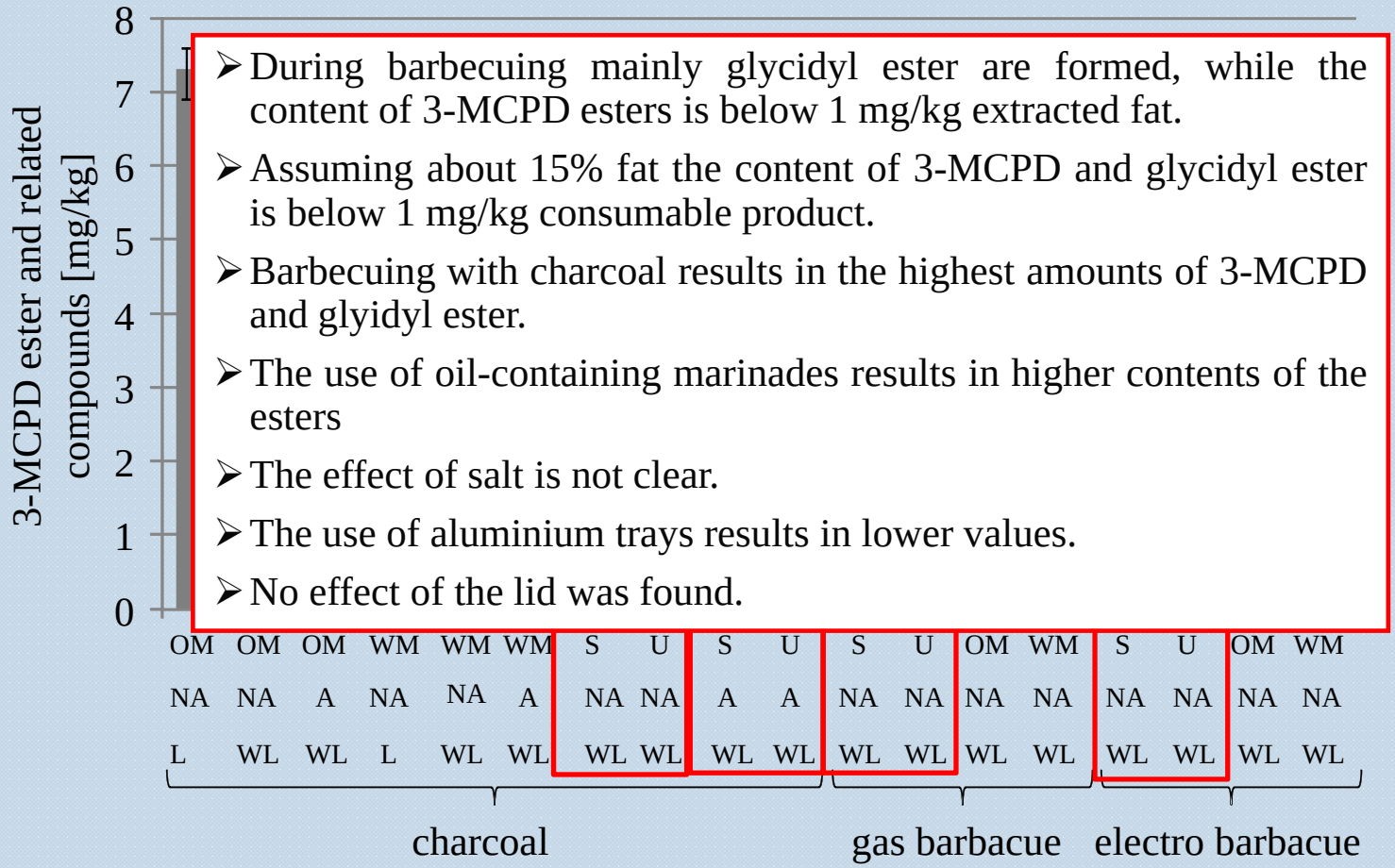


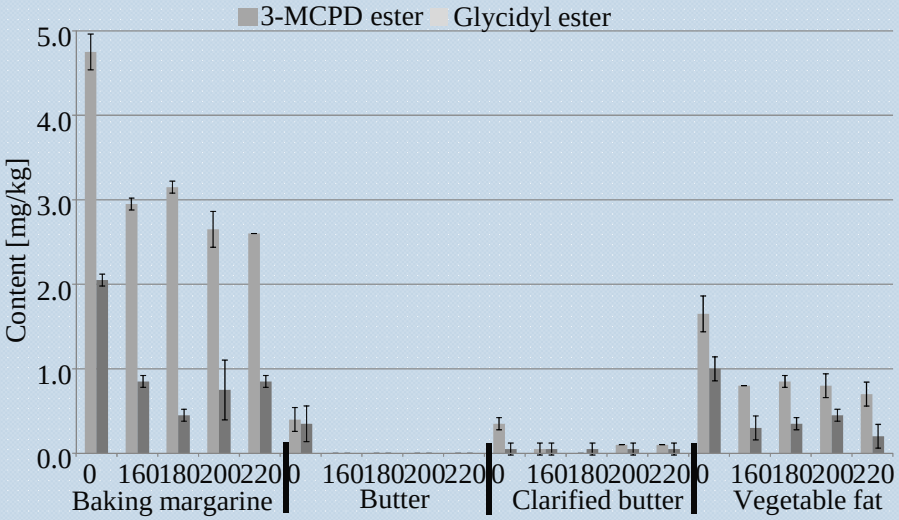
Influence of processing on the content of 3-MCPD and glycidyl ester during barbecuing

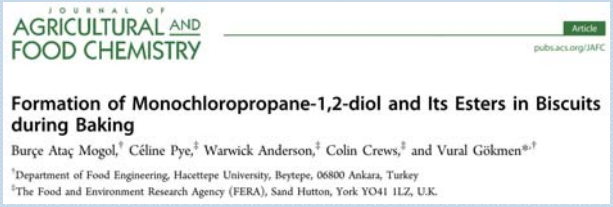


- During barbecuing mainly glycidyl ester are formed, while the content of 3-MCPD esters is below 1 mg/kg extracted fat.
- Assuming about 15% fat the content of 3-MCPD and glycidyl ester is below 1 mg/kg consumable product.
- Barbecuing with charcoal results in the highest amounts of 3-MCPD and glyidyl ester.
- The use of oil-containing marinades results in higher contents of the esters
- The effect of salt is not clear.
- The use of aluminium trays results in lower values.
- No effect of the lid was found.

Influence of baking on the formation of 3-MCPD and glycidyl esters

Baking of cookies




JOURNAL OF AGRICULTURAL AND FOOD CHEMISTRY

Article

pubs.acs.org/JAFC

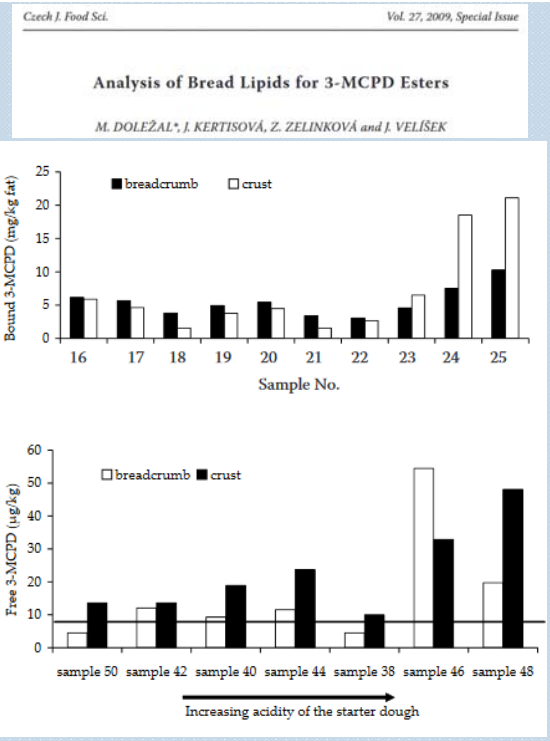
Formation of Monochloropropane-1,2-diol and Its Esters in Biscuits during Baking

Burçe Ataç Mogol,[†] Céline Pye,[‡] Warwick Anderson,[‡] Colin Crews,[‡] and Vural Gökmen*[,†]

[†]Department of Food Engineering, Hacettepe University, Beytepe, 06800 Ankara, Turkey

[‡]The Food and Environment Research Agency (FERA), Sand Hutton, York YO41 1LZ, U.K.

- Removal of chloride from biscuit formulations controls formation of 3-MCPD, 2-MCPD, and bound-MCPD
- Careful selection of the type of vegetable oil or shortening and testing for MCPD ester content prior to their use in baking

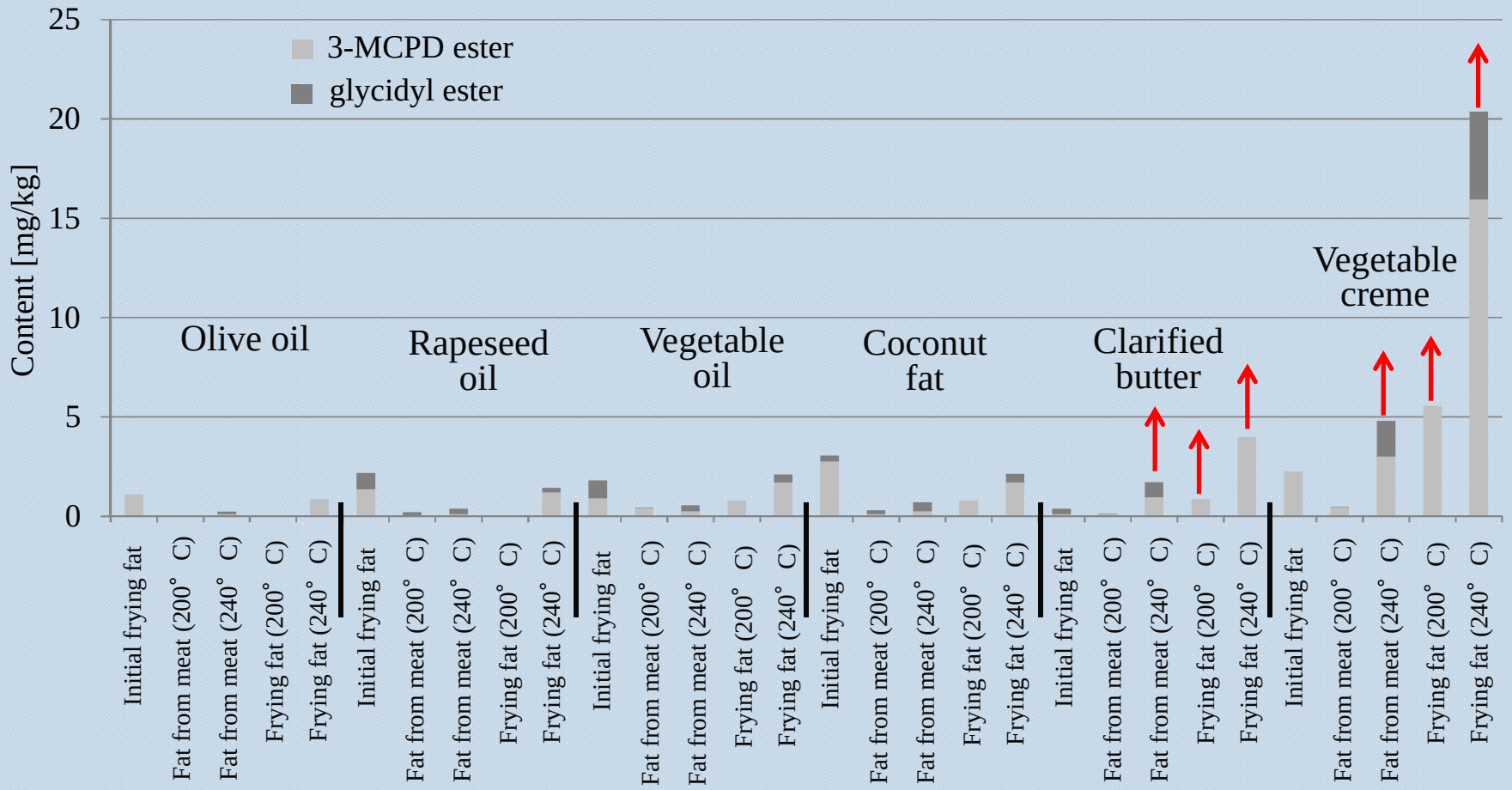

Czech J. Food Sci. Vol. 27, 2009, Special Issue

Analysis of Bread Lipids for 3-MCPD Esters

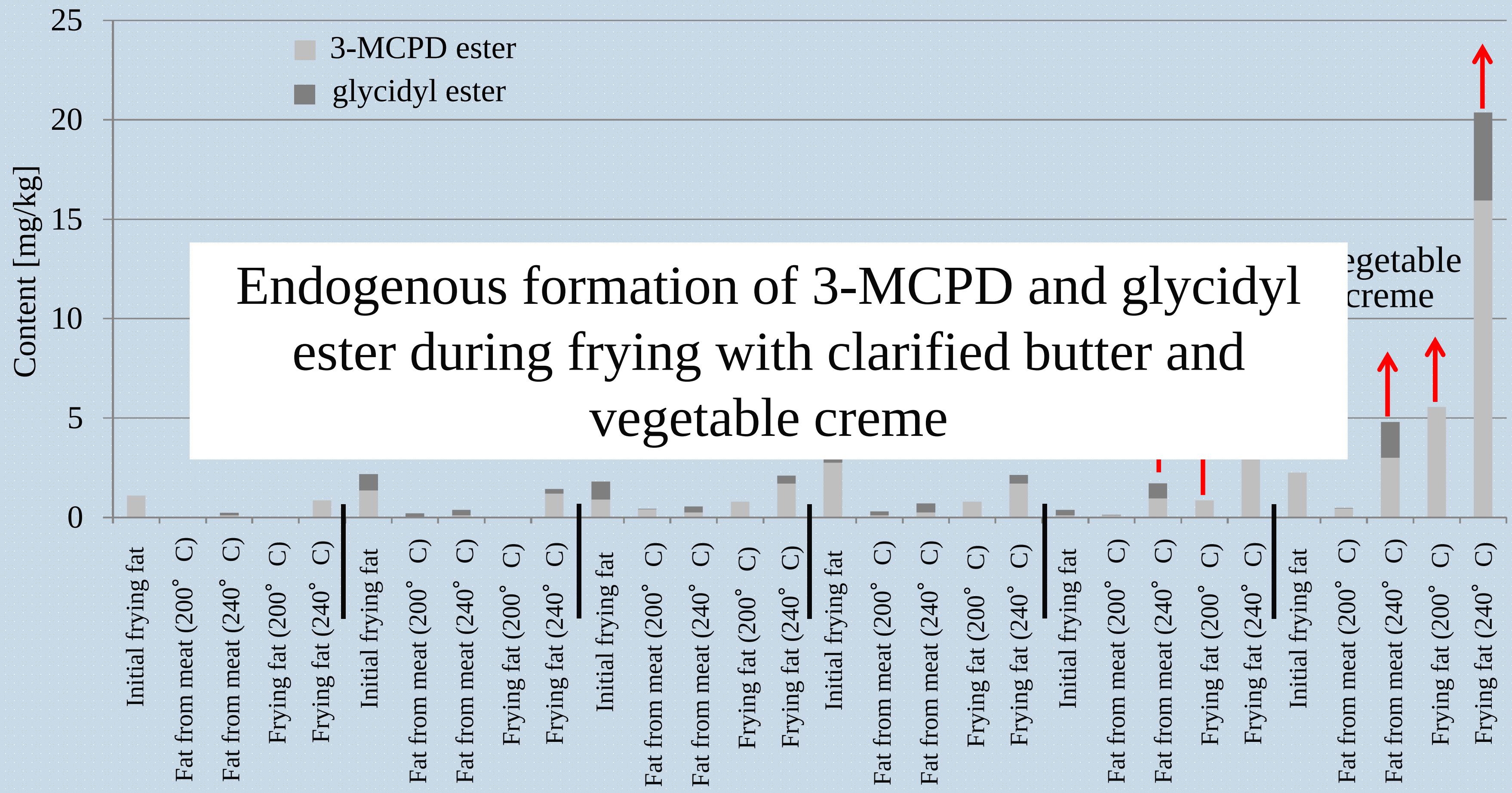
M. DOLEŽAL*, J. KERTISOVÁ, Z. ZELINKOVÁ and J. VELÍŠEK

Increasing level of free 3-MCPD with stabilised yeast according to increasing acidity of the starter dough

Influence of temperature and frying oil on the content of 3-MCPD- und glycidyl ester

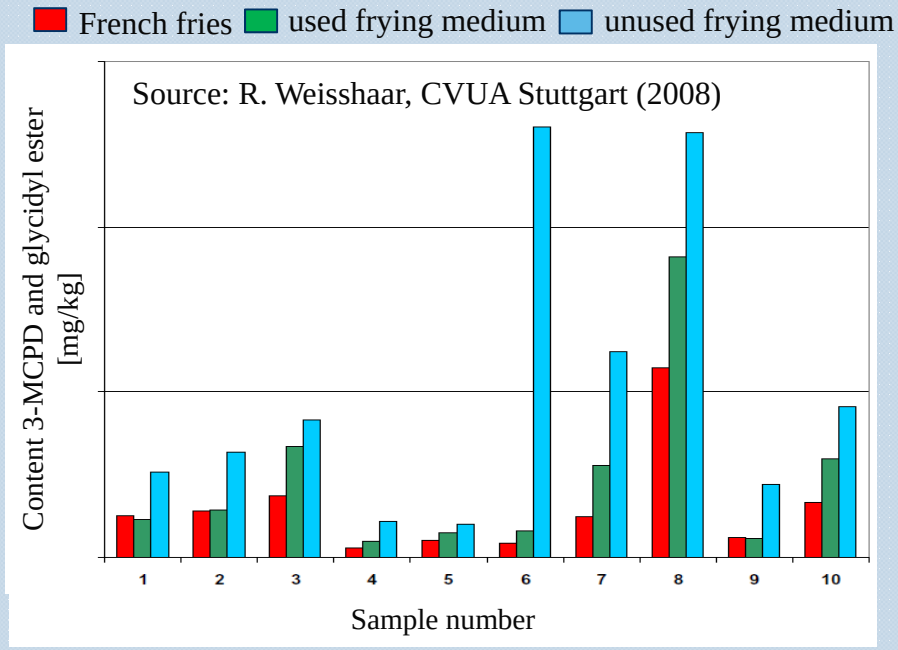


Influence of temperature and frying oil on the content of 3-MCPD- und glycidyl ester



Endogenous formation of 3-MCPD and glycidyl ester during frying with clarified butter and vegetable creme

Effect of deep-fat frying on 3-MCPD and glycidyl ester



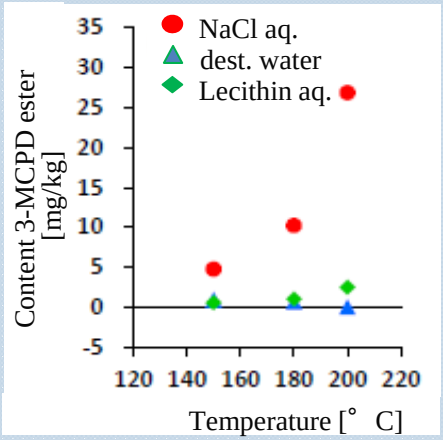
The effect of raw materials on thermo-oxidative stability and glycidyl ester content of palm oil during frying

Magda A Aniołowska* and Agnieszka M Kita

J Sci Food Agric 2016; 96: 2257–2264

Table 4. Changes in composition of glycidyl esters (GEs) in palm oil used for frying different products

Fried product and age of oil (h)	GE content (mg kg^{-1}) C16:0-GE	C18:0-GE	C18:1-GE	C18:2-GE
Fresh oil	14.83a ± 0.03	1.00a ± 0.01	16.84a ± 0.07	3.26a ± 0.10
Chips				
8 h	11.77b ± 0.01	0.80b ± 0.01	12.52b ± 0.01	2.53b ± 0.05
24 h	5.85e ± 0.11	0.41e ± 0.00	6.38e ± 0.01	1.53e ± 0.06
40 h	2.02 h ± 0.01	ND	2.05 h ± 0.01	0.64 h ± 0.01
French fries				
8 h	10.88c ± 0.10	0.68c ± 0.00	10.99c ± 0.01	2.11c ± 0.01
24 h	4.22f ± 0.01	0.29f ± 0.01	4.94f ± 0.07	1.13f ± 0.01
40 h	0.95i ± 0.01	ND	1.08ij ± 0.01	0.49i ± 0.01
Snacks				
8 h	8.65d ± 0.01	0.58d ± 0.01	8.66d ± 0.01	1.75d ± 0.01
24 h	3.03 g ± 0.01	0.18 g ± 0.01	3.04 g ± 0.01	0.96 g ± 0.01
40 h	0.83j ± 0.00	ND	0.94j ± 0.01	0.19j ± 0.00



K. Toho, AOCS Anual Meeting 2014

NaCl in the product leads to increased formation of 3-MCPD ester. No glycidyl esters are formed.

Eur Food Res Technol (2015) 241:719–723
DOI 10.1007/s00217-015-2491-1

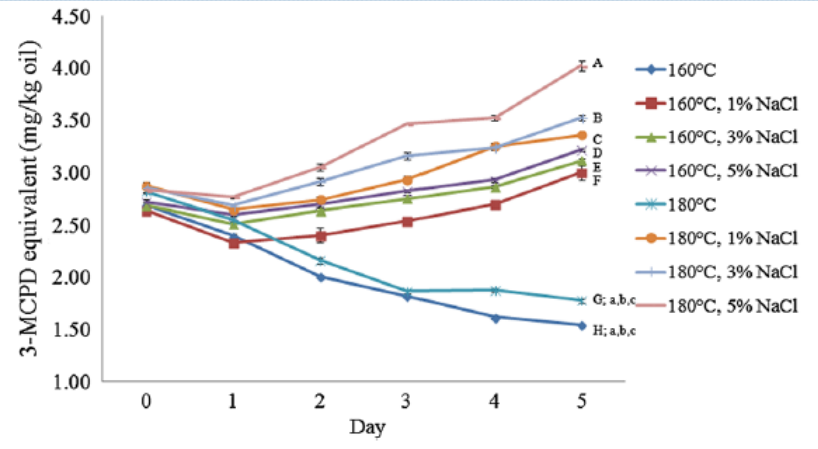
SHORT COMMUNICATION

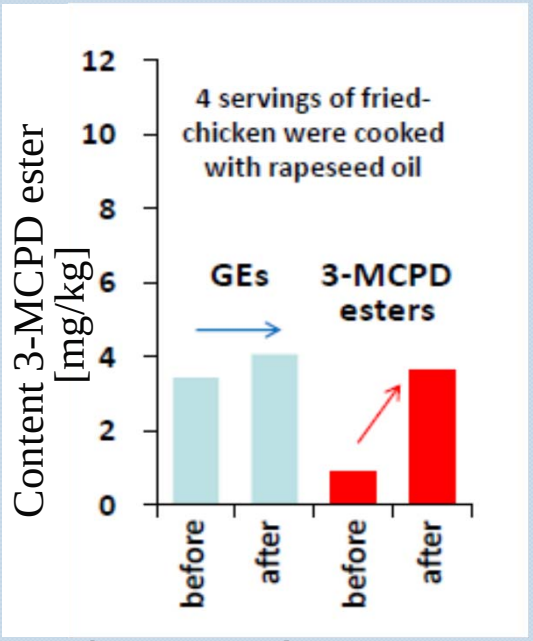
Esters of 3-monochloropropane-1,2-diol and glycidol: no formation by deep frying during large-scale production of potato crisps

Anna Dingel[1] · Reinhard Matissek[1]

No endogenous formation of 3-MPCD- and glycidyl esters during production of potato crisps with HOSO

Effect of temperature and chloride on the formation of 3-MCPD and glycidyl esters during deep-fat frying of chicken breast meat





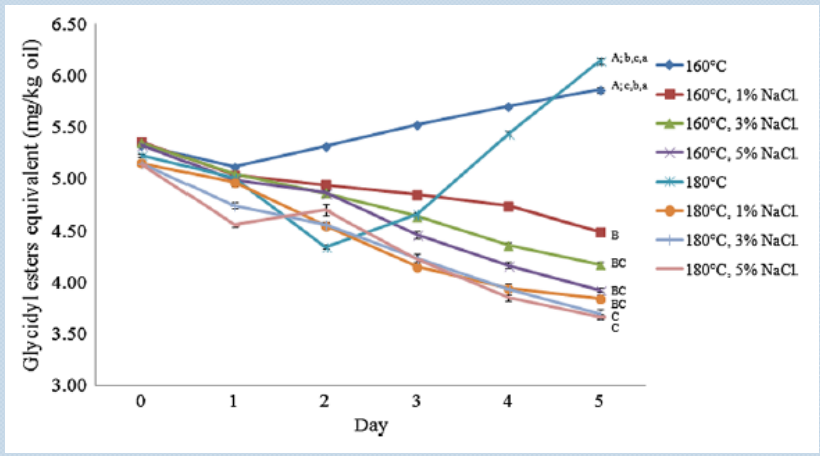
K. Toho, AOCS Anual Meeting 2014

J Am Oil Chem Soc (2017) 94:759–765
DOI 10.1007/s11746-017-2991-1

ORIGINAL PAPER

Factors Impacting the Formation of 3-MCPD Esters and Glycidyl Esters During Deep Fat Frying of Chicken Breast Meat

Yu Hua Wong[1] · Oi Ming Lai[2] · Faridah Abas[3] · Kar Lin Nyam[4] · Imededdine Arbi Nehdi[5] · Halimah Muhamad[6] · Chin Ping Tan[1,7]



- Significant ($p < 0.05$) **decrease** in the 3-MCPD esters and glycidyl esters with the increasing of the frying duration.
- Significant ($p < 0.05$) **increases** in the 3-MCPD esters formed when the concentration of NaCl increased from 0 to 5%.
- Addition of NaCl caused decreases in the level of GE.

No formation of glycidyl esters, remarkable increase of 3-MCPD esters during frying of chicken.

Mitigation of exogenous 3-MCPD and glycidyl ester during food processing

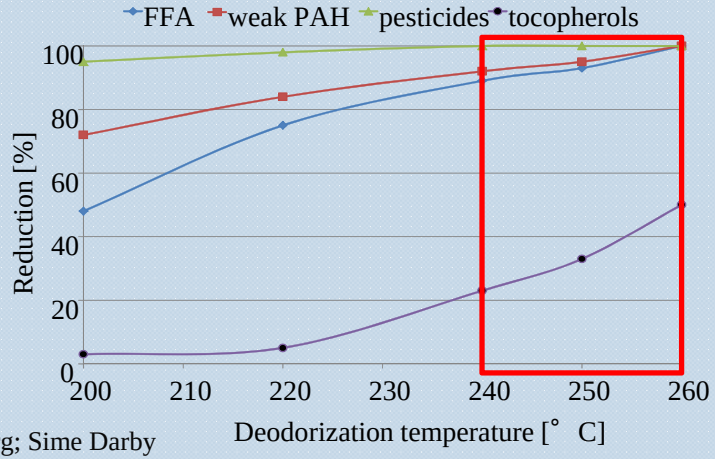
Results show no endogenous formation of 3-MCPD and glycidyl ester in fried vegetable products, but increase in meat and fish products

Contamination of fried vegetable products mainly from exogenous sources

Possiblilities of mitigation

Application of fats and oils with low contents of 3-MCPD and glycidyl ester

Is it possible to use refined vegetable oils with higher amounts of free fatty acids for the preparation of food without changing the food quality?



Source: I. Berg; Sime Darby

Effect of refined palm oils with different amounts of free fatty acids on product quality of processed food

Five palm oils with different contents of free fatty acids:
0.02; 0.12; 0.21; 0.31 and 0.49 g/100 g

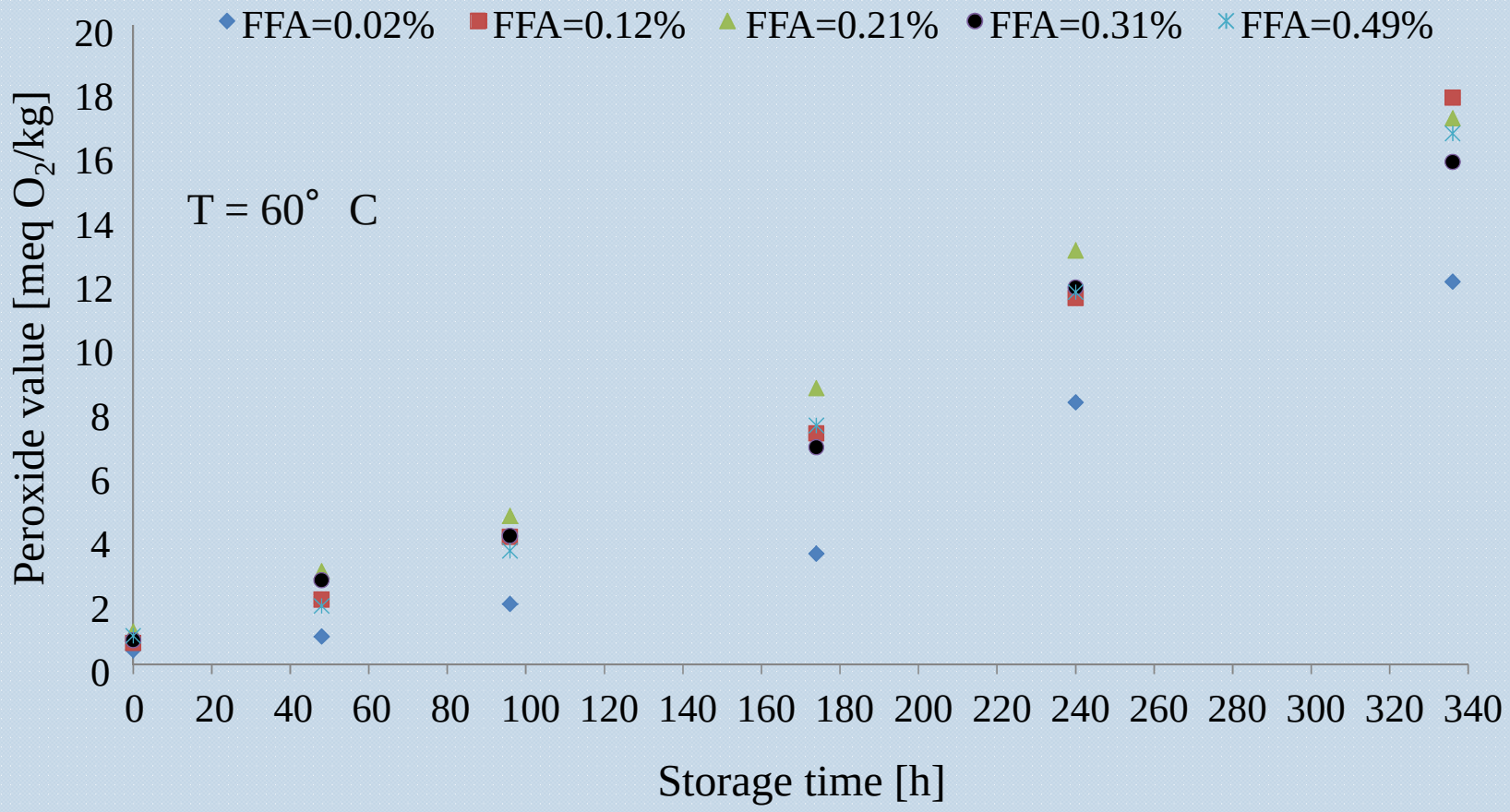
Potato crisps: Storage 6 month at room temperature

Parameters
Sensory evaluation
Peroxide value
Content of free fatty acids

	0.02 %	**0.12 %**	**0.21 %**	**0.31 %**	**0.49 %**	
Glycidyl ester [mg/kg]	4.1	3.3	2.7	2.2	0.8	↓
2-MCPD ester [mg/kg]	3.4	3.1	3.2	3.3	2.9	→
3-MCPD ester [mg/kg]	6.1	5.6	5.9	6.1	5.6	→

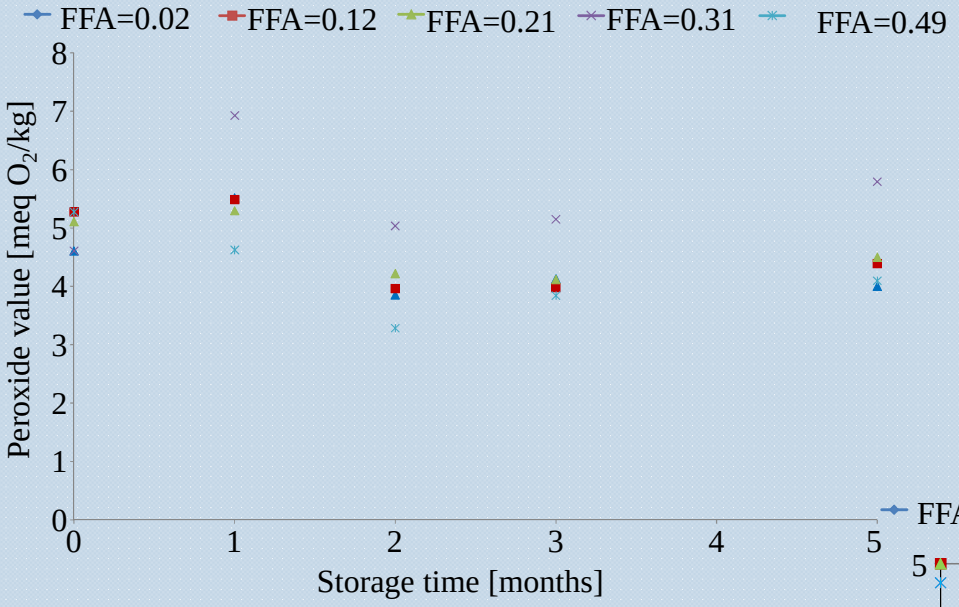
- No contaminants like pesticides, PAH, or aflatoxins
- Low levels of heavy metals

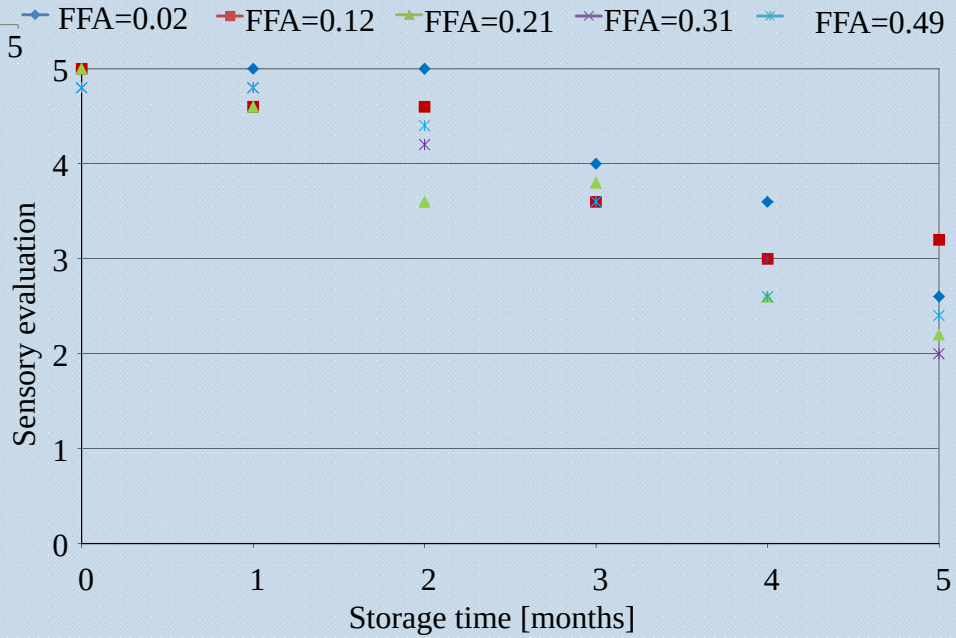
Influence of palm oil quality on storage stability of palm oil



Significant influence of free fatty acids on storage stability of palm oil during storage at 60° C

Influence of different contents of free fatty acids on the quality of potato crisps during storage





Summary

- Endogenous formation of glycidyl esters during barbecuing, depending of the conditions.
- Endogenous formation of 3-MCPD and glycidyl ester during frying with clarified butter and vegetable cremes.
- No endogenous formation of esters during frying of potato crisps, but increase of 3-MCPD esters in presence of chloride.
- Higher amounts of 3-MCPD and glycidyl ester in fried vegetable products resulted from exogenous sources.
- Formation of 3-MCPD esters during frying of meat or fish.
- Content of free fatty acids negatively influences the sensory evaluation of the final product during storage.

Thank you for your attention

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