Processing Contaminants in Edible Oils: MCPD and Glycidyl Esters

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Industry, academia and legislators have awaited the publication of a book such as this for quite some time. Heightened awareness around the presence of fatty acid esters of monochloropropanediol in refined edible oils began in 2006 with a publication by Zelinkova. This book was published following a key seminar to address this issue at an AOCS conference in 2011. The issue attracted intense scrutiny because of its occurrence in infant formulae with the source being the deodorised vegetable oils utilised in the blends. Compiler and editor, Dr. Shaun MacMahon, is a research chemist with the USFDA.

3-Monochloropropanediol (3-MCPD) esters, 2-monochloropropanediol (2-MCPD) esters and glycidyl esters (GEs) are contaminants that are not present in virgin unrefined oils but can be produced during processing, specifically during high temperature deodorisation.

Where did the chlorine atoms come from?

The book consists of 7 chapters, 10 authors and comprises 230 pages of extremely useful information. When the topic of these contaminants emerged a key question arose as to the source of chlorine atoms. Hypotheses and proposals which seem logical are proposed in the first chapter.

Chlorine atoms are sourced either from chlorides in the soil, from marine origins, or from added fertilisers or pesticides. While the mechanisms of the formation of these contaminants have not been conclusively elucidated, there is evidence suggesting that 3-MCPD esters are formed from iron chloride in the soil and/or natural organochlorine compounds.

Before an accurate risk assessment of these contaminants in food can be made, detailed, accurate, and repeatable analyses must be established.

Analytical methods for contaminants

About 50% of the book is dedicated to a systematic and very detailed description of these different analytical methods. They fall into two categories: indirect and direct methods. In the early years of these contaminant analyses, trial indirect methods of transesterification were used and results were ambiguous and distrusted by industry.

The chapters on direct methods, by both MacMahon and German researchers Alice Thüer and Michael Granvogl, summarise the current techniques utilising liquid chromatography and time-of-flight mass spectrometry. Following accurate direct methods, a great deal of work has subsequently occurred to validate indirect techniques. The establishment of standard AOCS methods (AOCS, 2014) greatly assists in this development. Ranges of levels found in vegetable oils, from 0.5 µg/g (ppm) to 40 µg/g, are presented. Deodorised palm and grape seed oils appear to have the highest levels recorded.

Management of contaminants

Mitigation strategies that have been used successfully to decrease the concentrations of these contaminants in edible oils are discussed in the second chapter. These include removing precursor molecules before processing, using alkaline additives before deodorising, adding ethanol to the oil, and using selective adsorbents. The fact that MCPD esters begin forming at temperatures exceeding 200°C makes mitigation difficult because deodorisations with physical refining are generally run at temperatures greater than 200°C.

It is a small oversight, probably due to timing of the compilation, that the book does not have any extra reported work from edible oil practitioners who have experience in changing process conditions to observe changes in contaminant levels. Such work was presented at AOCS seminars in 2012 and 2013 (De Greyt, 2012). Practical economic techniques, suggested by process suppliers such as Desmet, are assisting the edible oil industry in reducing levels to acceptable amounts. This practical work will no doubt be presented at future AOCS conferences and seminars.

Toxicology

The toxicology of glycidyl esters and of the MCPD fatty acid esters is dealt with in two chapters reporting work on the two classes of compound separately. Any toxic effects are due to the products after metabolism in the gut. Free 3-MCPD and glycidol have been shown to be carcinogenic in rats, with demonstrated effects on kidneys and reproductive systems. Glycidol is well characterised due to its use in the chemical industry. 3-MCPD and glycidol were classified by the European Scientific Committee on Food in 2001 as a non-genotoxic threshold carcinogen. Toxicology is dealt with in a detailed way in the last two chapters of the book by researchers at Nestlé and at BfR, the Federal Institute for Risk Assessment.

Areas of interest for the future

There is no separate chapter on legislation, either by the US FDA or the European Food Safety Authority (EFSA), and one may assume that legislators are still working through key issues such as the breakdown rate of the esters by gut lipases into free MCPD and glycidol plus arriving at sensible maximum allowable levels in oils and foods containing them. The final chapter in the book, on toxicology, summarises the
In 1995 Ken Kirkpatrick was awarded the J C Andrews Award, the New Zealand Institute of Food Science and Technology’s most prestigious award, for a substantial contribution to science and technology and leadership in the food industry. In his acceptance address he reflected on the future directions for food technology in New Zealand. He expressed pride at having “the great good fortune at the start of my career to be in on the ground floor of the application of a new technology, namely ultrafiltration, and have been given the opportunity to follow it through the various stages of its commercialisation over the succeeding 20 years.”

Eleven years later, one of this book’s chapter authors, Kevin Marshall, received the same award. He devoted his address to innovation in the New Zealand dairy industry, using the story of whey protein concentrate and the development of ultrafiltration technology in the 1960’s and 70’s as his case study.

Whey protein concentrate, or WPC as it is generally known, is a soluble form of whey protein used in a variety of foods and beverages including cakes, protein shakes, sports drinks, infant formulae and processed meats.

In the early 1970’s, Britain was about to join the EEC and New Zealand’s dairy industry was desperate for new markets and new products. They were found through the efforts of a group of talented young technologists, scientists and marketers, a multi-national beverage company and a transformational new technology called ultrafiltration.

At the time, casein products were seen as an important part of the diversification push. But there was a problem: how to deal with the potentially polluting whey by-product from large new casein plants? One answer came through ultrafiltration, a technique that enabled the production of whey protein concentrates. They could be tailored as specialised food ingredients and were so valuable that processing highly dilute liquid whey could be profitable. These concentrates, along with other whey products, are now an established industry and almost no whey is wasted. It is New Zealand’s biggest waste to riches story.

Whey to Go is the story of the early decades of development, written by several of the pioneers.

Fonterra chief technology officer, Jeremy Hill had this to say about this book: “A fascinating story about how industrial innovation really works in practice. It takes time, it’s often not linear, it takes collaboration across disciplines and across organisations, but most of all, it works because of the confidence, imagination, passion and perseverance of individuals. The New Zealand dairy industry has grown to global leadership through a number of technologically based phases of innovation. Whey to Go describes one of the most important of them.”

**Useful references**


De Greyt, W., How to minimize 3-MCPD- and Glycidyl Esters during Edible Oil Processing, Paper presented to AOCS seminar, Korea, May 11-12th (2012)

AOCS Standard Methods Cd 22a-13 (2- and 3-MCPD fatty acid esters and glycidol fatty acid esters in edible oils and fats by acid transesterification), Cd 29b-13 Determination of bound monochloropropanediol- (MCPD) and bound 2,3-epoxy-1-propanol (glycidol-) by gas chromatography/mass spectrometry), Cd 29c-13 (Fatty-acid-bound 3-chloropropane-1,2-diol (3-MCPD) and 2,3-epoxy-propanol-1-ol (glycidol), Determination in oils and fats by GC/MS (differential measurement)), 2014.

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