3-Monochloropropane-1,2-diol Esters in Refined Edible Oils and Fats

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INTRODUCTION

The 3-Monochloropropane-1, 2-diol (3-MCPD) esters belong to the family of chloropropanols and are categorised as process-induced contaminants. In refined oils and fats the chloropropanols are in the ester form. Esters of chloropropanols contain fatty acids in position 1 or 2 or both as monoester or diester. Research on 3-MCPD ester has been going on since 1978 (Velisek et al., 1978) and the focus has been on acid hydrolysed vegetable proteins (acid –HVP). In 1980, Velisek et al. were the first to report on the presence of chloroesters in hydrolysed vegetable protein. Davidek et al. (1980) observed the presence of significant amounts of mono- and diesters with fatty acids in foods. Since then extensive studies have been carried out to identify food ingredients and food products that contain 3-MCPD and its esters. Further studies have been conducted on the occurrence, formation pathways, toxicological aspect and probable mitigation steps to reduce the formation of 3-MCPD and the esters.

Studies on the formation of the fatty acid mono- and diesters of 3-MCPD after thermal treatment of triacylglycerols with hydrochloric acid was observed by Davidek et al. (1980) and Gardner et al. (1983). Figure 1 shows the structure of the mono- and diesters of 3-MCPD. The factors, which influence the formation of 3-MCPD esters are: the level of chloride, level of acylglycerols (tri-, di- and monoacyl glycerols), pH, temperature and time. Figure 2 shows the possible pathways for the formation of 3-MCPD esters from triacylglycerol.

There are several methods for determining these compounds, indirect methods by converting the esters to free form, and the direct methods which measures individual esters without conversion or destruction. It is important to have a reliable and easy to use method for the analysis of 3-MCPD esters and related compounds for routine monitoring of oils and fats.

The 3-MCPD esters were first determined using the indirect Deutsche Gesellschaft fur Fettwissenschaft: DGF standard Method C III 18b (2009). However, the German Federal Institute for Risk Assessment (BfR) proposed three indirect methods – BfR Methods 008, 009 and 010. A collaborative trial for the determination of 3-MCPD (free and bound) based on these three methods was conducted in September 2009. Of the three methods, MPOB uses the BfR method 008. Numerous palm oil samples and other vegetable oils were analysed using this method. Indirect methods were found to be more acceptable in general. Samples from the industry were collected and reported in a paper by Raznim et al. 2012. Values reported in Europe tend to be higher, and may not be representative of oils sourced locally. Continuous monitoring of our industry will be carried out once steps for mitigations are adopted.

Zelinkova et al. (2006) were the first group of researchers to report on the presence of 3-MCPD esters in oils and fats. Since then, various studies have been conducted and reports published to show the presence of the esters in refined oils and fats. The formation of 3-MCPD esters is attributed to the reaction of the triglycerides of...
the oils and fats with chlorine containing compounds at high temperature during the refining process of crude oils and fats.

An examination of the whole refining process to determine the source of chlorine is the first step in mitigating the formation of 3-MCPD esters. Possible sources of chlorine are the raw oil/fat itself, acid for degumming, chloride in sodium hydroxide in the alkaline neutralisation step, bleaching earth and in the water used to produce steam during deodorisation.

The Malaysian Palm Oil Board conducted 33 pilot plants trials to examine all the possible factors that contribute to the formation of 3-MCPD esters. The results obtained have been published in the article by Ramli et al. (2011) and a summarised version of the studies has been discussed in this issue.

In 2001, the Joint FAO/WHO Expert Committee on Food Additives (JECFA) established a provisional maximum total daily intake (PMTDI) of 2 µg/kg body weight for 3-MCPD. Commission Regulation No 1881/2006 stated the maximum level for 3-MCPD is 20 µg kg⁻¹ for hydrolysed vegetable protein and soya sauce. In December 2007, the German Federal Institute Risk Assessment (BfR) brought about the issue on 3-MCPD esters. Though there are no toxicological data on 3-MCPD esters, the toxicological concern is the possible conversion of the esters into free 3-MCPD by gut lipase. On 28 March 2008, the Europe Food Safety Authority (EFSA) stated that the Scientific Panel on Contaminants in the Food Chain (CONTAM) concurred with the German Institute for Risk Assessment assumption that 100% of 3-MCPD esters are converted to the free 3-MCPD since there is no scientific evidence at present to dispute the assumption.

A workshop on 3-MCPD esters was organised by International Life Science Institute on 5-6 February 2009 in Brussels. Among the recommendations of the workshop were the need for a database on 3-MCPD esters occurrence, the need to understand the mechanism of 3-MCPD and glycidol esters formation for developing effective mitigation measures, and the need for validated analytical methods. A subsequent workshop held 9-10 November 2011, also in Brussels noted advances in analytical methods, but recognised the need for harmonisation. It also noted that several mitigation measures at the processing stage could reduce the formation of 3-MCPD esters in products such as palm oil. The workshop noted that MCPD fatty acid esters and glycidol esters are hydrolysed to free MCPD in vivo after oral administration. It was noted that while data on 3-MCPD esters existed for several oils there was a dearth of data on levels in foods.

CONCLUSION

In summary, the current concern for 3-MCPD esters is their presence in refined edible oil, and since palm oil is one of the major edible oils traded in the global market, this is of primary concern to the oil palm industry, generally and to MPOB specifically. The articles in this issue of Palm Oil Developments are based on the research conducted by MPOB to address this matter.

The current efforts by both MPOB and the Malaysian industry to address the issue on level of 3-MCPD esters in palm oil have
been fruitful. Certain companies, which have been identified, are able to produce refined oils with lower or only traces of 3-MCPD esters, while others are in process of trying out various possible mitigation procedures.

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