Feature Article

Mitigation for 3-MCPD Esters at Palm Oil Mills

Nuzul Amri Ibrahim* and N Ravi Menon*

INTRODUCTION

This article was specially prepared by MPOB scientists to communicate the concern on food safety associated with the 3-Monochloropropane-1, 2-diol (3-MCPD) esters contamination of refined palm oil to palm oil millers. Although the contamination is hardly seen in crude palm oil (CPO), its significant presence in refined palm oil is a cause for concern not only for the refinery but also for palm oil mills. This is because the chloride that is reported to be responsible for the formation of the contaminant 3-MPCD esters in the refined palm oil appears to be a strong contender and one of its sources can be traced to the process water used in the mills. Acidity has also been proven as a precursor for the formation of the esters where higher level of the esters was formed in acidic condition.

The 3-MCPD esters are processing-induced contaminants which belong to the family of chloropropanols. The esters have been detected in various food namely salami, toasted bread, doughnut, French fries, coffee (Watkins, 2009) and refined vegetable oils (Zelinkova *et al.*, 2006). The formation of the esters in refined vegetable oils occurs mainly during deodorisation due to a chemical reaction between chloride and an intermediate compound known as cyclic acyl oxonium ion (Hamlet *et al.*, 2002). The latter is formed due to hydrolysis of acylglycerols.

The 3-MCPD and its esters are classified as nephrotoxic (damage to one or both kidneys) by the European Food Safety Authority (EFSA) (2016) which had created a stir in Europe. The report also stated that refined palm oil contained the highest level of 3-MCPD esters as compared to other refined vegetable oils. This had prompted several NGOs in Italy to launch campaigns to remove food products containing palm oil from supermarket shelves. Recently, Nutella has been linked to cancer by journalists in the USA since palm oil is one of the ingredients. This issue spread to USA and perhaps, this would influence other countries too.

The purpose of this article is for disseminate some basic scientific knowledge about the 3-MCPD esters to the millers to

* *Malaysian Palm Oil Board,*
6, Persiaran Institusi, Bandar Baru Bangi,
43000 Kajang, Selangor, Malaysia.
E-mail: nuzul@mpob.gov.my

enable them to prepare a strategy to mitigate any contamination at the CPO source which could either be the mill or the plantation. In the plantation, the chemicals used as herbicides or fertilisers also could be the source of chloride in the CPO.

THE ISSUES AT HAND

The health implication by EFSA report would jeopardise palm oil industry since the oil is widely used in food formulations, where safety cannot be compromised. There would be a drastic decline in the export of the commodity if mitigation measures are not taken to address this issue and consequently would affect all parties involved in the whole supply chain of palm oil industry, especially the livelihood of oil palm smallholders which form the largest segment of the supply chain. Therefore, all parties involved should play a role in combatting the formation of 3-MCPD esters in palm oil. Even though the formation of the esters occur during refining process, palm oil mills should also take necessary measure to reduce or remove the presence of chloride during the extraction process.

OIL EXTRACTION PROCESS

It is important to understand the process flow of a palm oil mill in order to eliminate precursors for formation of 3-MCPD esters from the system. The oil extraction process is illustrated in *Figure 1* and the sources for precursors to enter the process are numbered with 1 to 6, namely steam,

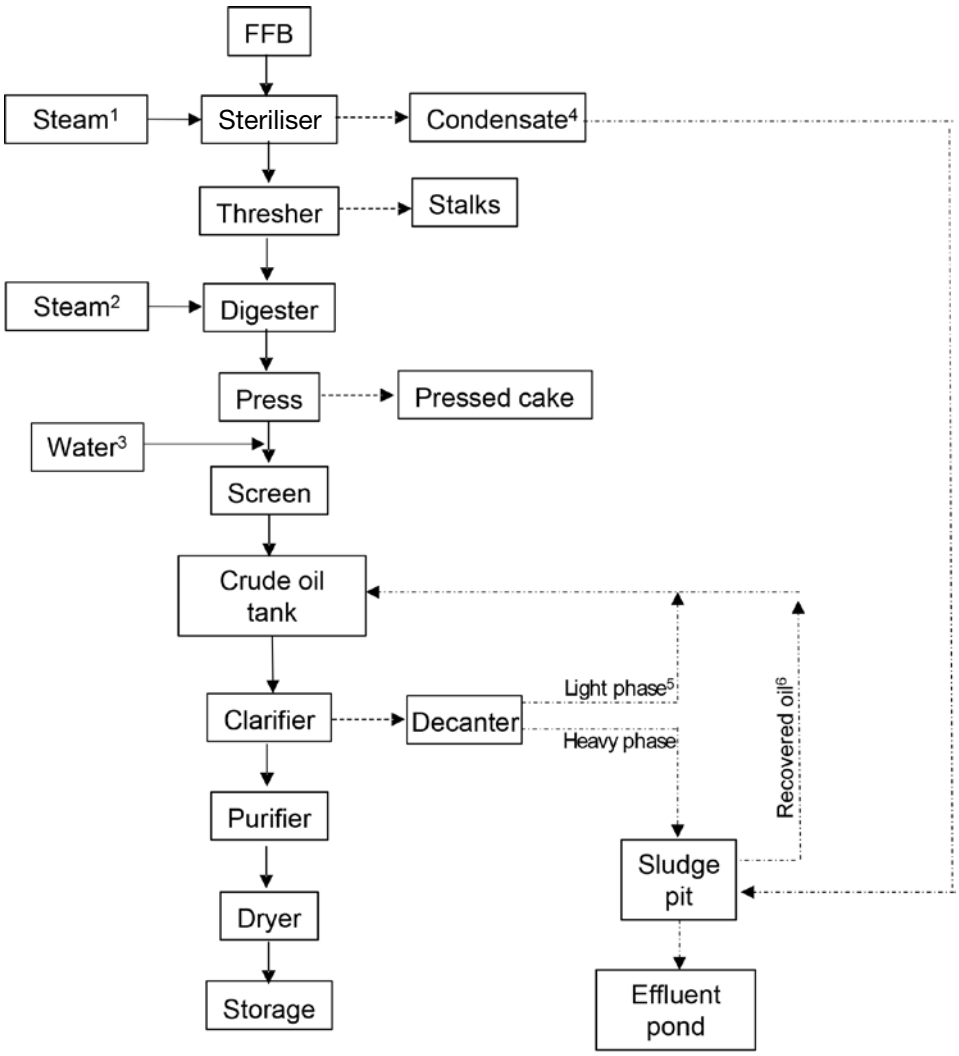

Figure 1. Flow chart for crude palm oil (CPO) extraction.

water, recycling of condensate and oil from sludge pit. Water is added to the pressed oil to reduce the viscosity which promotes its flow to the vibrating screen. This would also improve the separation of the oil from the sludge containing fibre and other impurities during clarification stage, which subsequently generates a large volume of effluent.

Most impurities are removed by the clarifier. However fine particles that are still present in the oil and could be removed by high speed centrifuge or also known as purifier. Since the purifier has to be cleaned at least once a week, currently, it is quite common for mills to by-pass the purifier in order to reduce maintenance cost. This practice would subsequently lead to accumulation of impurities in storage tank as sediment which still contains the precursor for the formation of 3-MCPD esters.

SOURCE OF PRECURSORS

Water

Water is applied at several stages namely sterilisation (as steam), digestion (as steam) and dilution. Most mills obtain their raw water supply from nearby river for the processing, generation of steam in the boiler and for domestic water supply to the workers and staff quarters. The raw water is treated with alum, soda ash and flocculant prior to usage. However, chlorine is excluded from the treatment process. Further treatment is necessary for feed water to reduce the water hardness and to remove impurities such as sulphite.

During visits to several palm oil mills it was found that the range of chloride content in blowdown water were 300 to 700 mg kg^{-1}. This indicated that the water used by the palm oil mills contained chloride, which could be originated from the raw water or from the chemicals used for the treatment. It could quite difficult for millers to avoid the presence of chloride in the water, therefore, it is highly recommended to install chloride scavenger for feed water and water for dilution.

Reclaimed Oil from Sludge Pit

Waste water from palm oil mills originate from the sterilisers, oil station and a minor amount from the hydrocyclones or claybath which are pooled in a reclaim pond called deoiling tank. The oil droplets will rise to the surface, skimmed and re-cycled back to the clarification tank. The remaining sludge water is pumped into the effluent buffer ponds and subsequently distributed to the anaerobic digestion ponds.

A thin layer of oil having the characteristic of golden colour can be seen surfacing in the buffer ponds. This oil is likely to be from the unbroken cells of mesocarp that finally ruptured under the solar radiation or agglomerated sub-micron oil particles or both. This oil generally has very high free fatty acid (FFA) content often exceeding 10% and should be strictly kept away from the fresh crude palm oil (CPO) and stored in separate tanks.

The recovered oil from the deoiling tank and buffer pond should not be recycled into the oil extraction process since it contains a lot of impurities such as wax and gum and high FFA due to migration of foreign matters from the effluent into the oil. The oil might be reclaimed and sold as industrial grade oil.

Pressed Fibre Oil

The remaining oil in pressed fibres is about 5% to 8% (Abd. Majid *et al.*, 2012), which could further be extracted using a solvent followed by evaporation process to obtain the oil. Despite contribution to higher-oil extraction rate (OER) to mills, blending this oil with crude palm oil aggravated the formation of 3-MCPD esters in heated samples since the former is quite

acidic (pH 4.6) (Ramli *et al.*, 2015). Due to the detrimental effect, pressed fibre oil should not be blended with the crude palm oil. It could be sold as industrial grade oil or to feed mill industry. Alternatively, the oil could be a source for carotenoids, sterols and vitamin E (tocopherol and tocotrienol) since it contains high amount of these compounds, *i.e.* 4000 ppm to 6000 ppm, 4500 ppm to 8500 ppm and 2400 ppm to 3500 ppm respectively (Choo *et al.*, 1996).

Empty Fruit Bunch Liquor

A number of mills have started extracting the residual oil from empty fruit bunch and mix it with extracted CPO in a dilution tank in an attempt to boost the mill OER. This practice should not be encouraged as it contains significant amount of contaminants such as gum and wax that will hinder the smooth and economic operation of the refinery. This oil should be isolated and labelled as industrial grade oil and should never be recycled into the extraction process.

CONCLUSION

Majority of mills in Malaysia practice dilution of CPO with water to reduce the viscosity which consequently ease the oil recovery stage. Most mills get their water supply from a nearby river or a pond and treat the water prior to use. Even though addition of chlorine is not part of the treatment process, the presence of chlorine has been detected in blowdown water. Since chlorine is the major cause for the formation of 3-MCPD esters, it is highly recommended to remove the chlorine from water prior to usage for mill operation either by reversed osmosis method or other chlorine scavenger equipment.

Mills should produce a better quality CPO by adopting good milling practices. This could be achieved by processing fresh fruit bunch (FFB) within 24 hr upon receipt, avoid the recycling of empty fruit bunch liquor and skimmed oil from sludge pit into the extraction process. Eventually, this would lead to production of good quality CPO which is low in FFA, diacylglycerol (DAG), chloride, impurities and has pH that is close to neutral. Those recovered oil could be sold as industrial grade oil. Due to the high content of phytonutrients, pressed fibre oil could be a source for carotenoids, sterols and vitamin E.

CPO washing has been proven as an effective mitigation measure to eliminate chloride and other impurities from the oil. Perhaps, millers could offer a better quality CPO to refiners at a premium price since the oil requires less bleaching earth and phosphoric acid for refining.

RECOMMENDATION

1. Chloride or chlorine scavenger should be installed at palm oil mills to remove the precursor from water.
2. FFBs should be processed within 24 hr upon receipt.
3. It is strongly discouraged to recover oil from steriliser condensate, empty fruit bunch liquor, deoiling tank and buffer pond.
4. CPO should not be mixed with pressed fibre oil.
5. It is highly recommended to rinse CPO with water prior to delivery to refineries.

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