XX Conferencia Internacional sobre PALMA DE ACEITE
20th International Oil Palm Conference

EL PODER TRANSFORMADOR DE LA PALMA DE ACEITE

fedepalma 60 cenipalma

Total chlorine mitigation in *Elaeis guineensis* fresh fruit bunches processing and its impact on the formation of MCPD and glycidol esters

Kennyher Caballero Blanco[1], Darlis Adriana Varón Cárdenas[1], Sergio David Mosquera González[1], Nidia Elizabeth Ramírez-Contreras[1], Jesús Alberto García-Núñez[1]

[1]Programa de Procesamiento, Corporación Centro de Investigación en Palma de Aceite (Cenipalma). **Correo:** kcaballero@cenipalma.org

Introduction

The food safety of crude palm oil (CPO) is key for both industry and consumers as more than 80% of CPO is used in food and related applications (Lakshmanan & Yung, 2021). Currently, an issue of concern in refined palm oil products is the content of 3-monochloropropane-1,2-diol esters (MCPDE's) and glycidol (EG) (Lakshmanan & Yung, 2021; Tiong *et al*., 2021). The International Agency for Research on Cancer belonging to the World Health Organization has classified MCPDE as a possibly carcinogenic contaminant (Group 2B) and EG as a probable carcinogenic contaminant (Group 2A) for humans (IARC, 2021). In this respect, chlorine is potentially associated with the formation of these compounds in refined palm oil, then a chlorine concentration of less than 2 ppm is suggested. However, it is also influenced by other factors such as free fatty acids and acylglycerols (Baena *et al*., 2021).

In the processing of fresh fruit bunches (FFB), it has been shown that the recirculation of the flows within the process in the palm oil mill (POM) increases the content of total chlorine, observing a directly proportional increase in the content of MCPDE's and EG in the oil by subjecting it to high temperatures in the refining process (Tiong *et al*., 2018). Regarding the flows, a higher proportion of total chlorine has been reported in sterilization condensates and liquid from pressing empty fruit bunches (EFB) (Tiong *et al.*, 2021) compared to the CPO.

Three potential sources of contaminants have been defined before, during, and after the processing of crude palm oil (Figure 1), where total chlorine has been identified as a contaminant present. Therefore, it is necessary to adopt mitigation strategies for Chlorine, as a polluting precursor, throughout the production chain (cultivation and CPO extraction and refining).

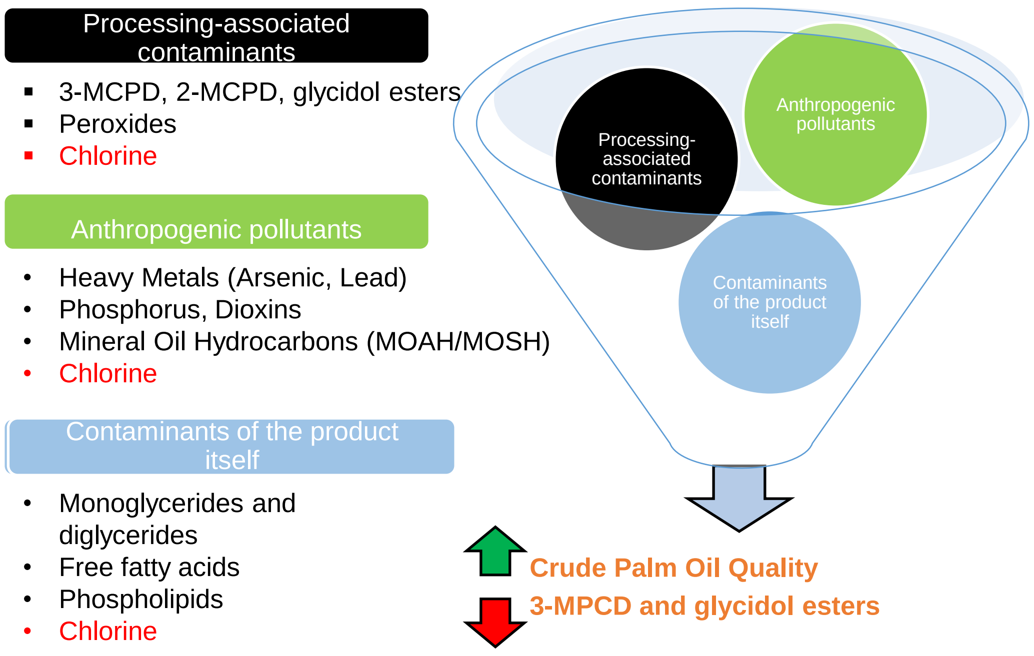

Figure 1. Potential sources of contaminants before, during and after the processing of crude palm oil.

This study aims to evaluate one mitigation strategy that includes the process in the POM and the refining process. First, the separation of the sterilization condensates and liquids from pressing EFB in the conventional process in the POM is evaluated to quantify the impact of the separation fluids on the quality of crude palm oil. Second, the formation of MCPD and glycidol esters in the CPO refining process on an industrial scale is evaluated.

Methodology

In a POM, sampling was carried out for 3 days, evaluating the total chlorine content for the conventional process (A) as well as the mitigation process (B) (Figure 2). Every 2 hours, a 1-liter sample was taken at the 13 selected sampling points. The samples were centrifuged to obtain the oily fraction of each sample and subsequently obtain a composite sample of 500 mL. The oily fraction from each process (A and B) was stored and refined to evaluate the impact of chlorine content on the formation of MCPD and EG. Total chlorine was quantified by combustion and quantification by CIC chromatography under ASTM 7359-18, and of MCPD's and glycidol esters by means of CG-MS under the AOCS – Cd 29a-13 method.

The oily samples evaluated were taken from the POM flows, namely, oil extracted from crude fruit (OCF); sterilized fruit oil (SFO); flow from the fruit pressing section: undiluted crude oil (UCO) and diluted crude oil (DCO); pre-separation section oil (OPRE) and sludge (SPRE), primary separator oil (SOP) and sludge (SSP); dynamic separator flow: inlet (DSI) and outlet (DSO); crude palm oil (CPO) and RBD palm oil.

Figure 2 shows both the process flows of the mitigation strategy and the conventional process. Note that these streams were replaced with dechlorinated water to aid in oil separation after extraction.

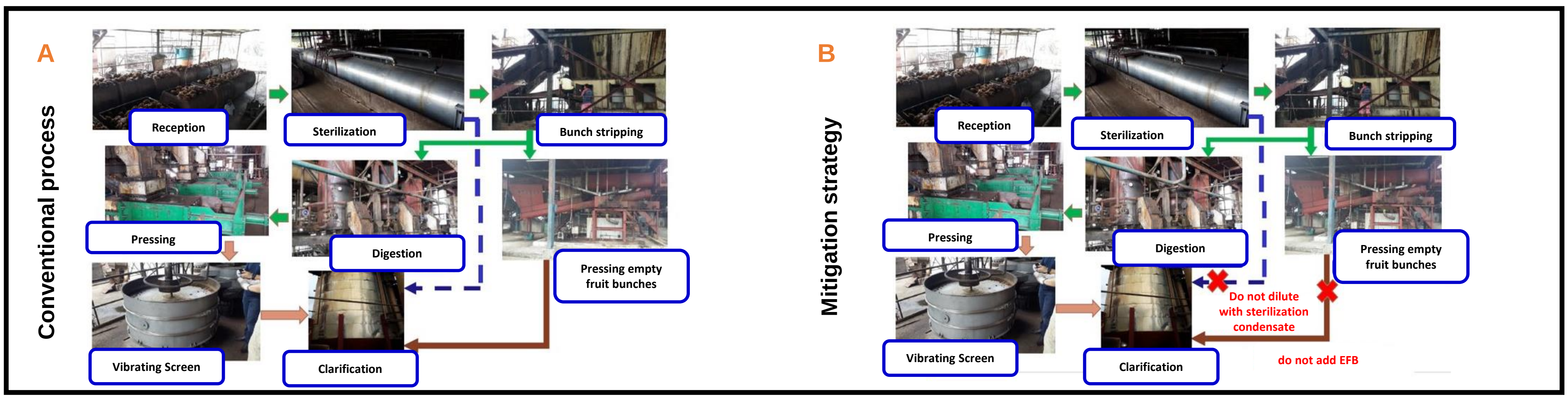

Figure 2. A) Conventional process. B) Flow separation mitigation strategy in the POM process.

Results

POM process

When applying the mitigation strategy, a "washing" effect is produced on the oil due to the use of chlorine-free water. This allowed a 19% reduction in the chlorine content of the flow obtained at the outlet of the fruit presses (dilute liquor, DCO), stabilizing it in a range of 2 to 2.8 ppm for the rest of the process stages in the POM (Figure 3). Also, it is observed that between the sterilization and pressing stages there is a 38% reduction in chlorine content, which may be caused by the direct contact of the steam with the fruit during maceration in the digester equipment. These behaviours are in line with research that reports the removal of pollutants such as chlorine through hot water washing of the CPO (Baldini & Manager, 2019; Willits, 2013).

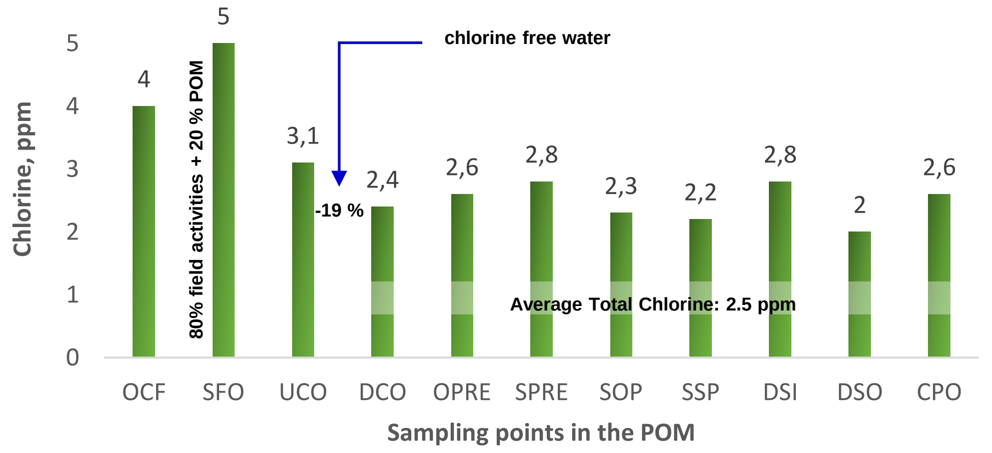

Figure 3. Behavior of total chlorine in the oily phases when applying the mitigation strategy in the clarification stage of crude palm oil from *E. guineensis*

The initial stages of the extraction process (fruit reception and sterilization) report the highest concentration of chlorine in the oil. This makes it possible to identify that 80% of the chlorine contained in the oil comes from field activities, and the rest is contributed by the processing of the fruit in the POM.

Palm oil refining

Figure 4 shows that the mitigation strategy reduces the concentration of total chlorine in the ACP by 34%, which allows obtaining concentration of 3-MCPD in values allowed for refined vegetable oils (maximum 1.25 ppm). However, glycidol esters are outside the required parameters (1.0 ppm), which may be caused by the refining conditions used (temperature, pressure, and residence times). Moreover, it can be caused by the presence of monoglycerides, and diglycerides contained in the CPO.

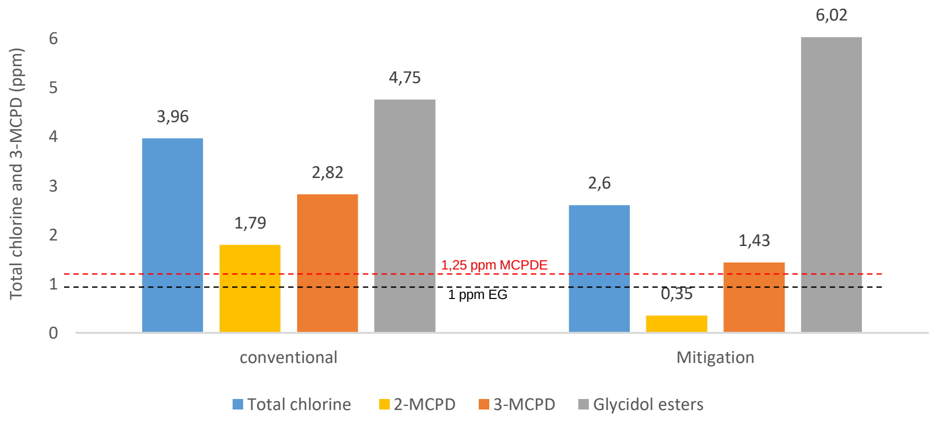

Figure 4. Concentration values of contaminants MCPD and glycidyl esters in refined palm oil

Conclusions

The mitigation strategy evaluated consisted of three steps: i) separation of the liquor flows from the pressed empty fruit bunches, ii) sterilization condensate, and iii) the use of chloride-free treated water as a dilution agent. This strategy allowed the reduction of 34% of total chlorine in the CPO for E. *guineensis*. Similarly, this strategy contributed to obtaining concentrations of 3-MCPD esters close to those required by international markets in CPO refining. According to the results of each process in the POM, it could be decided how to market the oil based on the degree of quality required by the destination market.

References

Baena S., M. A., García Núñez, J. A., González D., A., Mondragón, A., & Caballero B., K. (2021). La calidad del aceite de palma como un nuevo reto para la palmicultura mundial. *Revista Palmas*, *42*(1), 65–80. https://publicaciones.fedepalma.org/index.php/palmas/article/view/13450

Baldini, R., & Manager, T. (2019). *Mitigación de 3-MCPDE y GE mediante diversas tecnologías de proceso*. *40*, 69–75.

IARC. (2021). Agents Classified by the IARC Monographs. In *World Health Organization* (Issues 1–129, pp. 1–39). https://monographs.iarc.who.int/agents-classified-by-the-iarc/

Lakshmanan, S., & Yung, Y. L. (2021). Chloride reduction by water washing of crude palm oil to assist in 3-monochloropropane-1, 2 diol ester (3-MCPDE) mitigation. *Food Additives and Contaminants-Part A Chemistry, Analysis, Control, Exposure and Risk Assessment*, *38*(3), 371–387. https://doi.org/10.1080/19440049.2020.1842516

Tiong, S. H., Nair, A., Siti, S. A., Saparin, N., Nur, N. A., Ahmad Sabri, M. P., Mohd, M. Z., Teh, H. F., Adni, A. S., Ping Tan, C., Lai, O. M., Cheah, S. S., & Appleton, D. R. (2021). Palm oil supply chain factors impacting chlorinated precursors of 3-MCPD esters. *Food Additives and Contaminants-Part A Chemistry, Analysis, Control, Exposure and Risk Assessment*, *00*(00), 1–14. https://doi.org/10.1080/19440049.2021.1960430

Willits, J. (2013). 3-MCPD and its Significance to Palm Oil Industry. *Palmas*, *34*(II), 165–173.