High Oleic Palm Oil (HOPO) Potential: A Physicochemical Evaluation and Comparative Analysis with various Edible Oils

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19th Euro Fed Lipid Congress and Expo
17–20 September 2023
Poznań · Poland

Abstract:

High Oleic Palm is an interspecific hybrid derived from the backcrossing of different oil palm varieties. It was developed to provide resistance to the Bud Rot (BR) disease, which destroyed entire populations of Elaeis Guineensis (E.G) species in Latin America. High Oleic Palm is the combination of the advantages of the American palm Elaeis Oleifera: tolerance to BR and other diseases, oil fluidity, slow vertical growth, and oil rich in unsaturated fatty acids, with the African oil palm: high oil yield; thus, obtaining improved varieties. There are some differences in the characteristics of the High Oleic Palm Oil (HOPO) compared to E.G: HOPO has higher levels of iodine value, between 60 to 72 compared to 51 to 55 for E.G; the melting point ranges between 20 and 30°C, which makes its operation suitable for cold weather, whereas that of E.G ranges from 35 to 38°C; the palmitic acid content of HOPO is up to 33% lower than that of E.G, resulting to an oil with approximately 27% less saturated fatty acids (SFA); and the oleic acid content of HOPO is up to 31% higher than that of E.G, contributing to the amount of monounsaturated fatty acids (MUFA), which is 33% higher than that of E.G. However, the main characteristics of HOPO are the phytonutritional properties, containing significant values of tocotrienols, tocopherols and β-carotenes; indeed, the latter is attributed to the characteristic red color of the oil.

Characterization of HOPO was performed and compared with E.G and other edible oils: canola oil, soybean oil and sunflower oil. The triglyceride profile applying gas chromatography (GC), solid fat content curve (SFC) by nuclear magnetic resonance (NMR), iodine value (IV), melting point (MP), smoke point (SP) and oxidative stability (OSI) by rancimat, were evaluated in the different oils. Furthermore, phytonutrients values for HOPO and E.G were determined, tocopherols by high performance liquid chromatography (HPLC) and β-carotenes by near-infrared spectroscopy (NIR).

Table 1. Main differences of E. Guineensis and High Oleic Palm Oil.

	E.G	HOPO
Iodine Value	51 – 55	60 – 72
Melting Poing (°C)	35 – 38	20 – 30
Fatty Acids Profile (%)		
Palmitic (C016:0)	40 – 45	30 – 38
Oleic (C018:1)	38 – 44	49 – 55
MUFA (%)	38 – 44	49 – 55
PUFA (%)	9 – 11	10 – 12
SFA (%)	45 – 53	33 – 41

Material and Methods:

Fatty acid profiles were determined by gas chromatography (GC) according to the AOCS Ce 1-62 by using an Agilent Technologies 7820A with a flame ionization detector (FID). The **solid fat content (SFC)** was directly measured by means of a Nuclear Magnetic Resonance (NMR) device operating at a frequency of 20 MHz or higher from Oxford Instruments model MQC following the method described in AOCS Cd 16b-93. The AOCS Cc 3-25, AOCS Cd 1d-92 and AOCS Cc 9a-48 methods were followed for the measurement of the **melting point,** the **iodine value** and the **smoke point,** respectively. **Oil oxidative stability** was determined according to the AOCS Cd 12b-92 method by Rancimat, Metrohm 743 instrument, at a temperature of 110 °C. **Tocopherols** concentrations were obtained by high-performance liquid chromatographic (HPLC) coupled with a UV detector set at 292 nm as described in the AOCS Ce8-89 method, using a Novapack C18 guard column 20 x 3.9 mm packed 4 µm, two analytical columns 150 x 3.9 mm packed with C18 having a mean particle size of 4µm. **β-carotene** values were obtained by a Fourier transform near-infrared spectroscopy (FT-NIR), Quant model with a Universal Vial analyzer of the brand Q-interline. **Differential scanning calorimetry (DSC)** analysis was performed by the ICIPC institute following the AOCS Cj 1-94 methodology using the Universal V4.5A TA Instruments. Finally, the study of **oil crystallization** was conducted at DAABON fractionation plant, in a MoBulizer™ 2018 crystallizer, technology from Desmet. The oil was cooled down from 60°C to 16°C at different ramps. Samples were taken every hour and observed on an Olympus CX21 microscope enhanced with a RisingCam ALPHA 1080B HD camera.

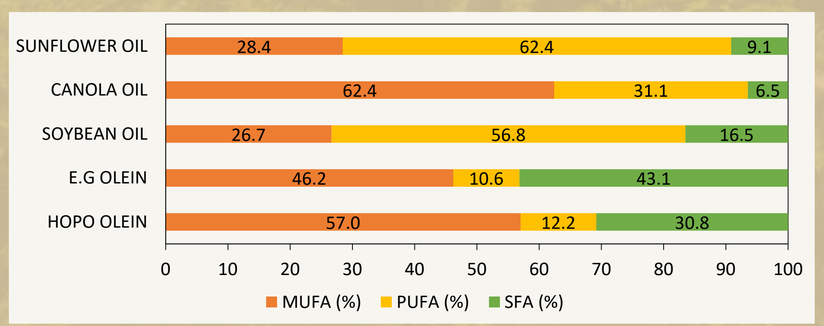

Figure 5. Fatty acids profile of HOPO and E. Guineensis Olein, sunflower, canola, and soybean oil.

The monounsaturated fatty acid (MUFA) content of HOPO Olein reaches values of up to 57% compared to 46.2% of E.G Olein. The MUFA content of HOPO Olein is also comparable to that of canola oil which is 62.4%, and higher than that of sunflower oil, at 28.4% and soybean oil, at 26.7%. On the other hand, the saturated fatty acid (SFA) content of HOPO Olein is almost 30% lower than SFA of E.G Olein. Furthermore, the combined MUFA and PUFA content is almost 20% lower in HOPO Olein and E.G Olein than in sunflower, canola, and soybean oil.

Figure 6. Iodine value and melting point of HOPO and E. Guineensis Olein, sunflower, canola, and soybean oil.

Figure 6 presents the melting point and iodine values (IV) of E.G olein, HOPO olein and other edible oils. The one-step fractionation of HOPO reached iodine values of 72 for the olein fraction, while the one-step E.G fractionation gives IVs of 58 for olein. The higher values of IVs of HOPO olein allow its use in formulations with other edible oils such as canola, soybean, or sunflower oil, which have IVs higher than 110.

Results and Discussion:

Thermal behavior of E.G and HOPO (Figure 1) was studied during the melting and crystallization process. During the melting of the oil, HOPO absorbs an energy of 31.40 J/g, while E.G of 49.83 J/g, values comparable with the study presented by de Almeida et al [1]. On the other hand, in HOPO cooling, the heat released is 42.90 J/g and that of E.G 51.78 J/g. In both cases, E.G presents higher enthalpies for the morphological changes in its structure, which are attributed to the number of saturations in its composition compared to HOPO with a higher amount of unsaturated fatty acids.

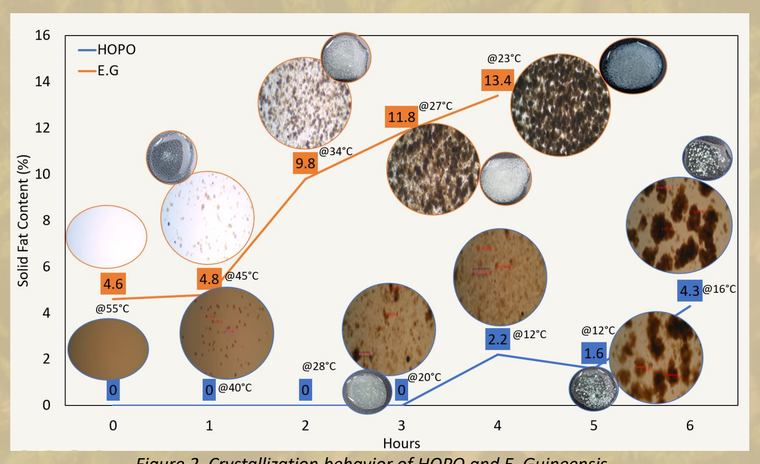

Figure 2. Crystallization behavior of HOPO and E. Guineensis.

The analysis of the solids content is significant in the formulation of fat blends, as it needs to be controlled to define the functional properties of the fatty acid ingredients, thus making it possible to understand the mouthfeel when ingestion occurs. Figure 3 shows the melting profile of HOPO and E.G, understanding the oil behavior at different temperatures. It can be observed that HOPO has lower solids content compared to E.G, which makes its application suitable for cold temperatures.

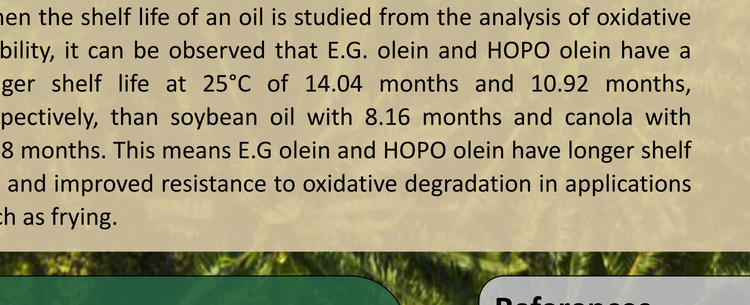

Figure 4. Beta-carotene and tocopherols (Vitamin E) content of HOPO and E. Guineensis.

Figure 7. Shelf-life plots based on induction periods at 110°C and 120°C and extrapolated to long time storage at 25°C of HOPO and E. Guineensis Olein, canola and soybean oil.

When the shelf life of an oil is studied from the analysis of oxidative stability, it can be observed that E.G. olein and HOPO olein have a longer shelf life at 25°C of 14.04 months and 10.92 months, respectively, than soybean oil with 8.16 months and canola with 4.68 months. This means E.G olein and HOPO olein have longer shelf life and improved resistance to oxidative degradation in applications such as frying.

Figure 1. DSC curves in a heating and cooling program of HOPO and E. Guineensis.

Crystallization phases of HOPO and E.G can be seen in figure 2, where nucleation and crystal growth took place.

The cooling process presents some differences in crystallization for both types of oils. Although the nucleation process starts from the first hour, crystal formation for E.G is visualized from the second hour, while for HOPO it consolidates from the 5th hour. Furthermore, crystal growth occurs differently, in HOPO agglomerations of crystals are observed leaving free liquid oil content compared to E.G, where crystal formation is homogeneous throughout the space, this is because HOPO has a higher content of oleic acid compared to E.G.

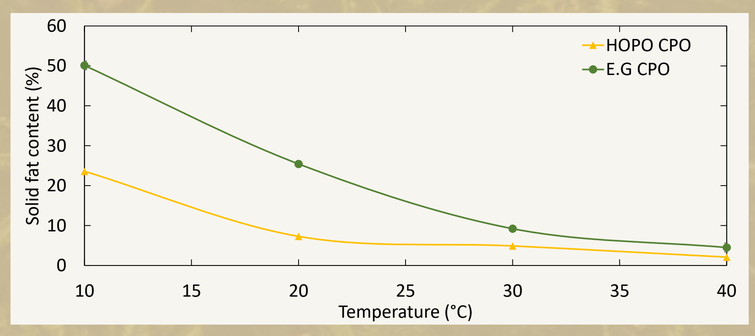

Figure 3. Solid fat content (SFC) of HOPO and E. Guineensis.

Both HOPO and E.G oils are highly beneficial for human consumption in terms of their phytonutrient content, characterized by their beta-carotene and tocopherol (vitamin E) content. The beta-carotene content for Daabon HOPO crude palm oil (CPO) is 1127 ppm, while for Daabon E.G CPO it is 873 ppm. Furthermore, the vitamin E values of Daabon E.G CPO and Daabon HOPO CPO are 1478 ppm and 1311 ppm, respectively. Compared to other types of edible oils, both E.G CPO and HOPO CPO have higher values than, for example, olive oil with 20 ppm, sunflower oil with 550 ppm or soybean oil with 900 ppm [2].

Figure 8. Smoke point of HOPO and E. Guineensis Olein, sunflower, canola, and soybean oil.

The smoke point is an indicator that the oil is breaking down which can give food an undesirable burnt or bitter flavor. A smoke point around 230°C represents a particularly good value for frying applications. Thus, HOPO olein with smoke point 227°C is suitable for deep frying processes, as well as canola and sunflower oil with smoke points 235 °C and 237 °C, respectively.

Conclusions

- The High Oleic Palm is an alternative for the food industry with considerable expectations due to its characteristics and properties that are different from the E. Guineensis palm.
- The higher content of oleic fatty acid (C18: 1) and the decrease in palmitic fatty acid (C16: 0) allows an increase in MUFA and a decrease in SFA in HOPO.
- The difference in the melting point, smoke point and iodine value of E. Guineensis Palm Olein and High Oleic Olein allows us to explore new market opportunities for the use of these oils due to their versatility in applications and expectations regarding their behavior and performance.
- Phytonutrients in terms of beta-carotene and tocopherols (vitamin E) content of HOPO and E. Guineensis compared to other types of vegetable oils are significantly higher, which provides benefits to human health.

References

[1] E. S. de Almeida et al., "Thermal and physical properties of crude palm oil with higher oleic content," Applied Sciences, vol. 11, no. 7094, Aug. 2021, doi: 10.3390/app11157094.
[2] David. Firestone, Physical and chemical characteristics of oils, fats, and waxes.

Acknowledgments

The authors would like to thank Ph.D. Maria del Pilar Noriega E., R&D and innovation director of Daabon Group, for her support and guidance, M.Sc. Luis Caicedo and Eng. Leidy Cely, from the quality assurance direction of Daabon Group, for the analysis tests of the different oil samples.