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NIR prediction models for CPO & CPKO quality parameters and process losses: Entrepalmas S. A. S. POM and Cenipalma calibration process

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Introduction

The oil palm agro-industry produced around 75 million metric tons during the last year 2021. The crude palm oil (CPO) represents 34 % of oil production within the world oil crop market [1]. This productive sector generates multiple products during the processing of fresh fruit bunches (FFB), such as: fiber, empty fruit bunches (EFB), nuts, palm kernel and palm kernel oil (CPKO). However, there are other by-products obtained during processing that are generally used as the basis for monitoring oil loss and quality (Figure 1).

Figure 1. Main products and by-products obtained during FFB processing at palm oil mills (POMs). (1) FFB before processing, (2) EFB pressed, (3) fruit pressed with nuts and fiber, (4) cracked nuts, (5) fiber, (6) nuts, (7) palm kernel, (8) palm kernel pressed cake, (9) CPO, (10) CPKO, (11) sludge, (12) effluent treatment systems (POME).

Big Loses at POMs by process efficiency and palm oil quality

Cenipalma together with Palm Oil Mills (POMs) have identified losses in different contexts of productivity and quality during the processing of FFB. On the one hand, process efficiency losses have been analyzed from specific studies using Key Performance Indicators (KPI) such as Overall Equipment Efficiency (OEE) [2]. On the other hand, oil losses have historically been covered from publications and monitoring of POMs with specific Cenipalma projects, however, these measurement methods and tools have opportunities to be improved in relation to high response waiting time, mixed samples with average information, high human subjectivity, unrepresentative sample sizes, exposure to dangerous chemicals, high long-term cost of operation, among other disadvantages (Figure 2).

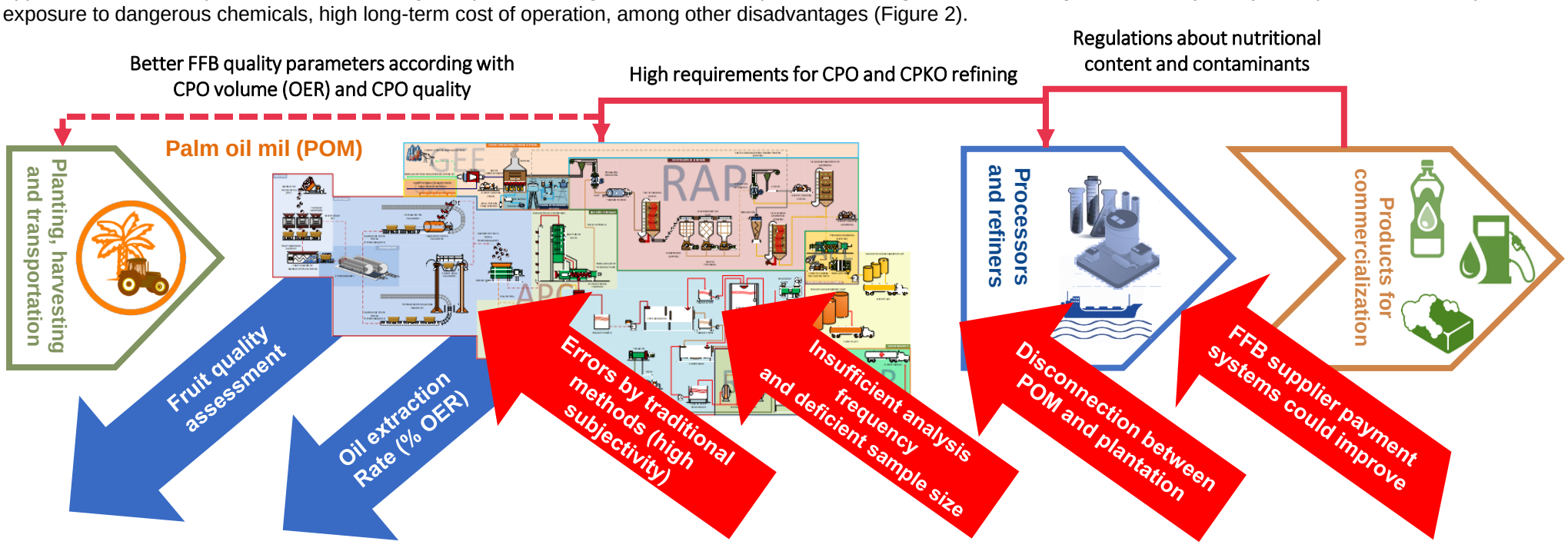

Figure 2. Opportunities at palm oil processing chain according with inputs and outputs at upstream and downstream processes.

Near infrared spectroscopy (NIR): technologies with timely response and multiple parameters by sample

About 80% of oil losses in a POM are made up of losses in pressing fiber and sludge from clarification and centrifugal equipments. Cenipalma together with the Swiss developer of laboratory analytical technologies, Büchi Labortechnik AG, has been developing prediction models using NIR equipment.

Calibration and validation process through POM: Entrepalmas S. A. S.

Previously, the NIR Proximate equipment was used for the development of prediction models with emphasis on the quality and chemical aspects of CPO. Later, this equipment is taken to the POM Entrepalmas in order to validate and create new prediction models. It has been possible to consolidate more than 30 prediction models for applications based on solid matrices and oily matrices (Table 1).

Figure 3. (1) NIR Proximate, (2) Samples preparation by petri dishes, (3) spectral response and prediction model.

Statistical indicators and prediction efficiency

In general, each prediction model has more than 80 samples, including information about *E. guineensis* and OxG hybrids cultivars, also considering the fresh base and dry base state for each sample. Indicators like R^2 are above 0.79. Simultaneously, the *SEC* and *SECV* indicators are like each other (+/- 2% deviation). The residual analyzes show that the prediction models are coherent and functional according to the parameters to be predicted. Finally, these prediction models allow to POMs to take decisions with reliable data and processes can be controlled with better precision.

Table 1. Prediction models developed and improved at Cenipalma laboratories and POMs.

G	H	F	D	Analyzed matrix and predicted parameters
■	■	■		**Fruit mesocarp**
				- Oil content (CPO)
				- Moisture
■	■	■		**Oil and water condensed by sterilization**
				- Oil content
				- Moisture
■	■	■		**EFB pressed**
				- Oil content
				- Moisture
■	■	■		**Pressed fiber (cake without nuts and palm kernels)**
				- Oil content
				- Moisture
■	■	■		**Sludge from clarification and centrifugal equipments**
				- Oil content
				- Moisture
■		■		**Palm kernel**
				- Oil content (CPKO)
				- Moisture
■		■		**Palm kernel cake**
				- Oil content (CPKO)
				- Moisture
■	■	■		**Cracked nuts**
				- Oil content (CPO)
				- Moisture
■	■			**CPO**
				- Moisture
				- Impurities by organic materials
				- Free Fatty Acids (FFA)
				- DOBI (CPO deteriorability)
				- Lodine index
				- Peroxides
				- Vitamin E
				- Carotens (alpha and betha)
				- Fatty Acids (myristic, palmitic, stearic, oleic, linoleic)
■				**CPKO**
				- Moisture

Directions: G: Elaeis *guineensis*, H: Hybrid OxG, F: fresh base, D: Dry base.

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