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Research Article

# Traceability Parameters of Palm Oil Extractions *(Elaeis guineensis)* from Two Oil Mills in Côte d'Ivoire

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**Abstract:** A diagnosis of the traceability parameters on the palm oil extraction rates was carried out from the huilerie centrale mill and from the Antenne 2 to determine the origin of the fluctuation of the oil extraction rates with a view to an optimization. Average rates of oil extraction, green diets and oil loss on treatment methods were determined and compared between the plants through statistical variance analysis of the statistica software at the critical threshold of 5%. The average rates of green and oil extraction are different at the huilerie centrale mill (5.2 ± 1.2 and 20.58 ± 1.32) and at Antenne 2 (2.6 ± 1.1 and 24.33 ± 1.28). With regard to the average oil loss rates obtained, a difference was observed in defibration (0.54 ± 0.05 against 0.52 ± 0.03), destemming (1.32 ± 0.18 against 1.08 ± 0,28 and) respectively at the huilerie centrale mill and the Antenne 2. However, at the clarification the rate of oil loss recorded at the central mill (0.86 ± 0.50) is lower by compared to that of Antenne 2 (1.23 ± 0.35). In addition, the coefficients of variability show a high variability of the rates of green schemes and oil losses at the clarification with proportions that do not respect the standard respectively of 100% and 60% unlike the Antenne 2. All these differences show that the quality of the diets and the treatment methods can be the basis for the variability of oil extraction rates in the production plants.

**Keywords:** *Elaeis guineensis*, Palm oil, extraction rate.

## INTRODUCTION

Palm oil is produced from the fruit pulp of the oil palm diet Elaeis guineensis which is an oleaginous plant, originating from the humid intertropical zone of Africa (Anonymous, 2002). Three (3) varieties of palm regimes exist for the manufacture of crude oil: Tenera, Dura and Pisifera (CNRA,2018). Traditionally, palm oil is known for its use as cooking oil. Its use is due to the fact that it has many therapeutic as well as technological virtues (Cheyns *et al.*, 2000). In addition, the main outlet is the agri-food industry which consumes nearly 80% of the palm oil produced in the world, followed by the pharmaco-chemical and cosmetic industries (about 10%), and just behind (a little less than 10%) agro-fuels (Oil World, 2013**)**. The main palm oil producing countries are Malaysia, Indonesia, Nigeria, Colombia, Brazil and Côte d'Ivoire (Yeo, 2013). Stimulated by an agro-industrial development of the sector for 30 years, Côte d'Ivoire is today the main African exporter (60% of the total exports of palm oil of the ECOWAS) and feeds the regional market in crude oils and refined products as well as by-products such as soaps, cosmetics and margarines (Anonyme, 2016**)**. In addition to the market for artisanal and industrial soaps and cosmetics, red palm oil is still valued for its specific characteristics that differentiate it from industrial refined palm oil (Cheyns *et al.*, 2000). The success of the use of this oil is due to its richness in saturated fat and carotenoids. In addition, palm oil has many derivatives and is found in thousands of products (Mirova, 2014). All these reasons make the palm oil sector an economically profitable sector, providing employment, fighting against poverty and thus ensuring food security by its availability. However, oil mills are often subject to fluctuations in oil production rates over the last five years. The objective of this study is to make a diagnosis of the traceability parameters of palm oil extractions *(Elaeis guineensis*) from two oil mills in Côte d'Ivoire to determine immature diets, oil loss rates and of oil extraction at each stage of technological processing

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(destemming, defibration and clarification) of the palm regimes for comparison.

## MATERIALS AND METHODS

Crude palm oil (HPB) has been obtained in PALMCI's Central and Antenne 2 mills from the oil palm (*Elaeis Guineensis*) varieties Tenera, Dura and Pisifera come from a number of industrial plantation sites (V2, V3, V4, V5 A, V5 B, V6) and village plans (411, 412, 413, 414) according to a complex but well-honed treatment process (Figures 1 and 2). The extraction of the fruit oil thus prepared is ensured by means of continuous screw presses. The juice obtained by pressing, called raw juice, will go through a process of heating and settling successively. This last step called clarification, makes it possible to obtain finished crude oil palm oil in accordance with the commercial standards which will be stored in tanks.

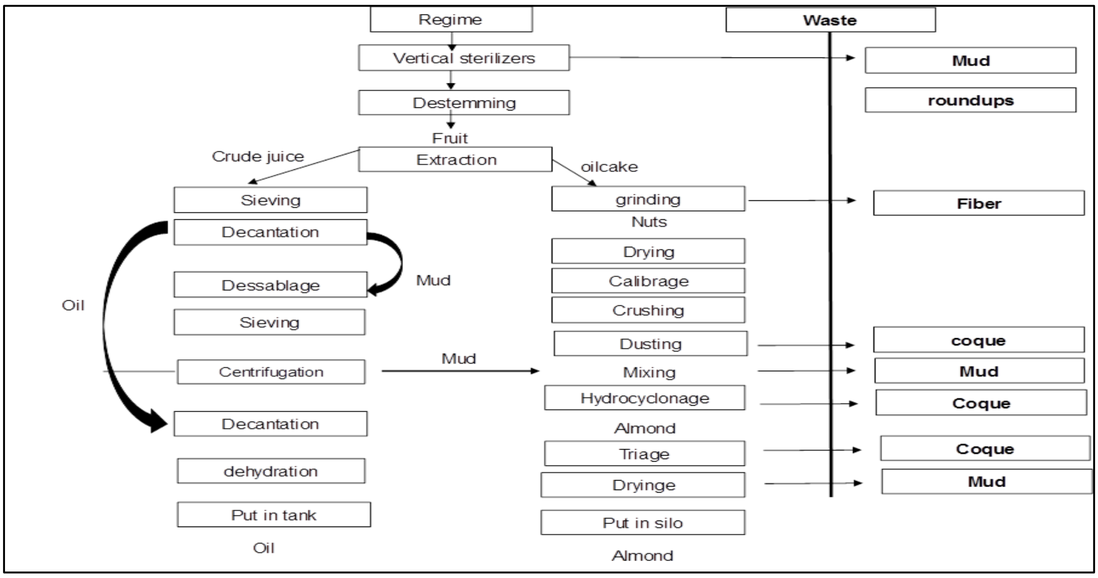


**Figure 1: Diagram of the manufacture of palm oil at the huilerie centrale.**

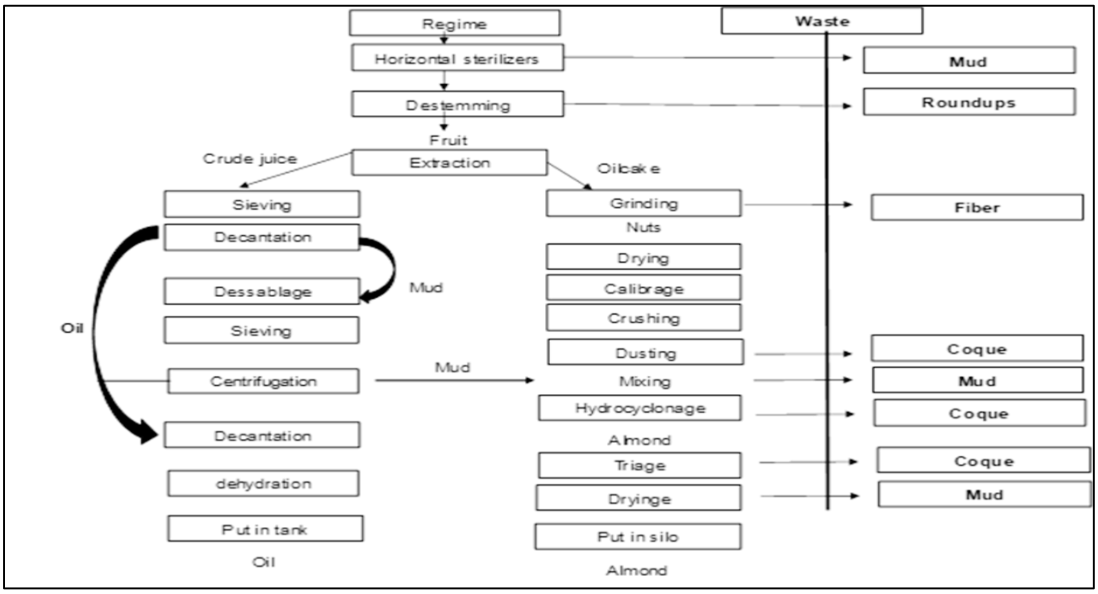


**Figure 2: Diagram of the manufacture of palm oil at the antenne 2.**

Green diets are counted during the process to determine the proportion of immature diets processed for each extraction (Noel *et al.*, 1997).

$$RV = \frac{NRV}{NRT} \times 100 \quad \text{with} \quad NRT = \frac{RT}{PM} \qquad (1)$$

**RV:** proportion of green regimes processed by extraction; NRV (number of green regimes counted) ; NRT (total number of plans processed) ; RT (number of total regimes processed in tonnes), PM (average weight of regimes, 15 kg during the period of our study).

The extraction rate is calculated by reducing the mass of extracted oil to that of the diets. It is determined by the ratio of the amount of oil obtained after extraction to the amount of diets processed (Ahouansou, RH.,*et al.*,2008). The oil extraction rate is determined by the formula no. 2.

$$T(\%) = \frac{MH}{MR} \times 100 \qquad (2)$$

**$M_R$: MASS OF REGIMES PROCESSED; AVEC $M_H$ : OIL MASS OF OBTAINED**

The determination of oil loss rates on the extraction rate was carried out at each treatment stage (de-stemming, defibration, clarification). Samplings of the stalking stalks, fibers and nuts at defibration and heavy phases and clarification effluents were performed according to the method AOAC (2009). The determination of the fat was done according to the AOAC method (2009). The oil loss rate is the ratio of the amount of oil lost on each parameter (H / Rnp and H / Rp) to the amount of diet being processed. The standard Q-ratio of waste at these three treatment stages is respectively 24%, 12% and 2.8% for pressed or unpressed cakes, fibers and nuts and solid sludge waste. For the effluents, we take the flow of the Florentin at the exit of the waste. The determination is hard oil losses each parameter is needed to find the amount of oil lost (Ahouansou *et al.*, 2008). The rate of oil loss on the extraction rate is determined according to formula n° 3 and n° 4.

$$Qp = \frac{loss\ index \times Q\ of\ waste}{100} \qquad (4)$$

**T= OIL LOSS RATE; QP : AMOUNT OF OIL LOST ON EACH PARAMETER; RT : REGIME TREATED.**

The data were analyzed to determine averages. The comparison of averages was performed by the analysis of variance (ANOVA) at the $p < 5\%$ significance level. The variability of production quantities was evaluated at each stage of treatment of the plans. The influence of the rate of processed regimes on the quantity of oil produced was carried out by multiple linear regression The coefficient of variation (CV) of the traceability parameters was determined from the formula of Zar (1999).

$$CV(\%) = \frac{\sigma}{\mu} \times 100$$

σ = standard deviation of the considered parameter; μ = average of the parameter considered. According to the value of CV, three categories of variation are highlighted. There is a very small variation of the parameter, if CV is inferior to 2 %. The parameter variation is low if CV is between 2 and 25%. The parameter varies greatly if CV is greater than 25%.

**RESULTS**

At the central oil mill, oil extraction rates vary between 18.30 and 22.31% with an average rate of 20.58%. As for antenne 2, the oil extraction rates are between 22.19% and 26.72% with an average rate of 24.33%, the variation in the extraction rate in these two oil mills is low. with a coefficient of variation of between 2 and 25%. In addition, the frequency of obtaining rates complying with the standards are respectively 0% at the central oil mill against 80% at Antenne 2. Loss rates are determined for grinding (pressing), destemming and clarification. Overall, the results indicate that the average oil loss rates are 0.54%, 1.32% and 0.86% respectively at these three stages at the central oil mill. As for Antenne 2, these rates are respectively 0.52%, 1.08% and 1.23%. At the press level, the average oil loss rate at the central oil mill (0.54 ± 0.05) is substantially equal to that of Antenne 2 (0.52 ± 0.03) (Table 1). In addition, the frequency of obtaining standards compliant rates are respectively 95% at the central oil mill versus 100% at Antenne 2. At stalking level, the average oil loss rate at the central oil mill (1.32 ± 0.18) is greater than that at Antenne 2 (1.08 ± 0.28%) (Table 1). In addition, the frequency of obtaining rates complying with standards are respectively 50% at the central oil mill versus 75% at Antenne 2.

At the level of clarification, the average oil loss rate at the central oil mill (0.86 ± 0.50) is lower than that at antenne 2 (1.23 ± 0.35) (Table 1). In addition, the frequency of obtaining the rates complying with the standards are respectively 63% at the central mill and the antenne 2.

**Table 1**: **Comparison of green regimes rates, oil extraction and oil losses from two oil mills**.

| Factories | Variable | Rate of green regimes | Extracted oil rate | Oil loss rate |
|---|---|---|---|---|

| | | | | Destemming | Pressing | Clarification |
|---|---|---|---|---|---|---|
| Huilerie Centrale | Averages | 5,12 ±1,2[b] | 20,58 ±1,32[a] | 1,32 ± 0,18[b] | 0,55 ± 0,05[a] | 0,86 ± 0,5[a] |
| | CV | 23,43 | 6,41 | 13,63 | 9,25 | 58,13 |
| | Frequency* (%) | 0 | 0 | 50 | 95 | 63 |
| Antenne 2 | Averages | 2,6 ± 1,1[a] | 24,33 ±1,28[b] | 1,08 ± 0,28[a] | 0,52 ± 0,03[b] | 0,52 ± 0,35[b] |
| | CV | 41,33 | 5,26 | 25,92 | 5,76 | 28,45 |
| | Frequency* (%) | 40 | 80 | 75 | 100 | 63 |

* The frequency of obtaining standards compliant rates; CV : coefficient of variation, ANOVA (Newmann-Keuls, p<0,05).

The quantity of oil produced is strongly influenced at the 5% significance level by the quantity of diets treated at 97% of the Huilerie centrale (Figure 3) compared to 98% at the Antenne 2 (Figure 4).

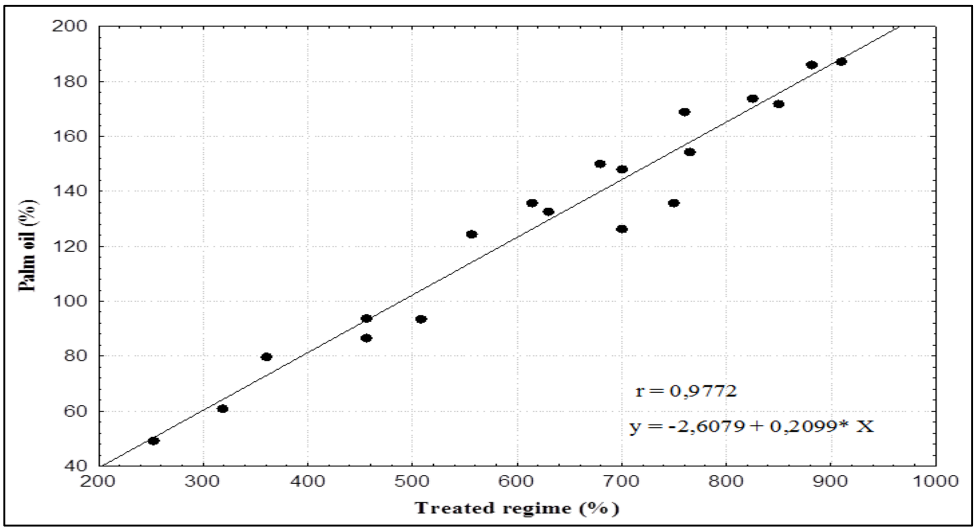


**Figure 3: Correlation of the amount of oil produced and the quantity of regime processed at the huilerie centrale.**

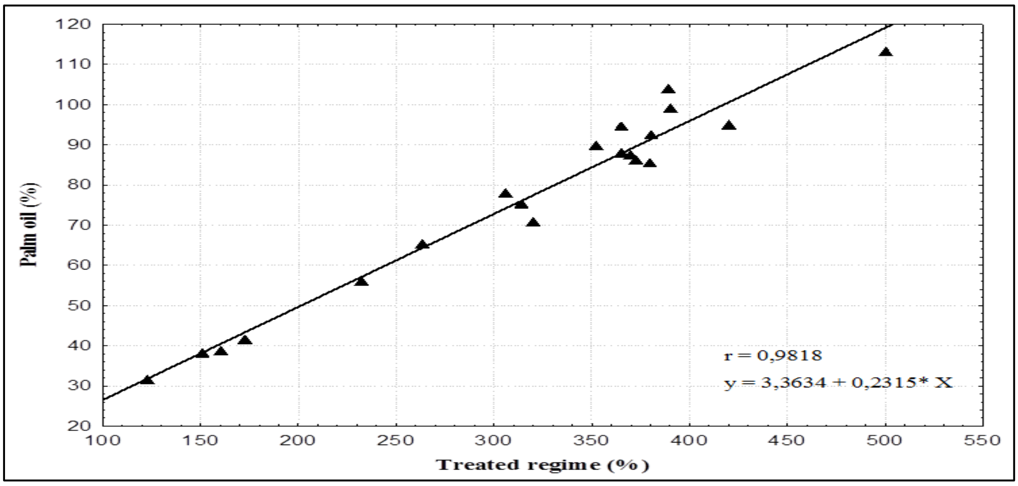


**Figure 4: Correlation of the amount of oil produced and the quantity of regime processed at the Antenne 2.**

## DISCUSSION

The poor quality of the diet received by the central oil mill is largely private (from village plantations). Given the competition in the agro-food industries in the area, most village planters do not let the palm-based schemes mature. On the other hand, the plans received by Antenne 2 are largely industrial (from industrial plantations). In addition, these plantations are very well maintained and the criteria and cutting intervals of these regimes are respected compared to those from village plantations. Our results are consistent with those of Paho (2005) who argue that the quality of the diets received by the plant is the primary determinant of the value of oil and palm kernel produced. This quality depends to a large extent on the conditions of cultivation, harvesting and transportation to the plant, which are the domain of the farmer. These results are not consistent with those of Irho (1967) who states that the percentage of green diet must be less than 2% of the number of plans harvested. The immature diet (green) is a diet that does not leave fruits on the ground while still on the palm. These diets may not contain enough oil during their extraction. Studies have shown that these (green) diets may influence the rate of palm oil extraction. This thesis is supported by Libert (2007) who states that a lack of maturity of the diets leads to a very strong decrease of the fruit oil richness, difficulties of destemming, clarification, crushing of the nuts. Overly mature diets arrive at the incomplete plant and the fruits lost out of the plant are those that contain the most oil (Paho, 2005). In other words, these regimes have an influence on the rate of extraction of the oil in these two oil mills. This fluctuation of oil losses would be due either to a mishandling of the operators or to the failure of the press at the central oil mill.

The strong correlation that exists between the treated mill and the oil produced at the central oil mill and at Antenne 2 could be due to the processing methods applied during the extraction of palm oil from these two oil mills at each processing stage including sterilizer, defibration, destemming and clarification. Indeed at the level of the sterilizer there is a loss of condensate (oil-water mixture). This loss can be caused by the pipes that would be plugged, connecting the sterilizer to the recovery tank. The condensate contains a quantity of recoverable oil so its loss could cause a drop in the daily yield. In the stalking at the central oil mill, this loss of oil at this stage is caused by a malfunction of the stalk press. But, in Antenne 2 it could be due to a bad sterilization (adaptation of a bad recipe) which will lead to the increase of oil losses on a raid. In addition, the results of the work done by Hadjadj (2008), reported the influence of heat treatment-water content on the oil extraction rate of oilseeds. In fact, the increase in temperature makes it possible to increase the solubility, the diffusivity of the solute and the decrease in viscosity. As a result, it facilitates the flow and extraction of the substrate under the effect of pressure (Kartika,2005). According to Hadjadj (2008) it must be limited to avoid the risks of thermal degradation of the solute. At the grinding stage there is a loss of oil in the fibers and nuts at the press. At this stage, the flowmeter does not work where the operator can not master the water that enters to facilitate the extraction of oil, which will cause a large loss of oil during oil separation water-mud at the level of the tricanteurs. These oil losses at these two previous stages are not recovered, which could lead to a decrease in the extraction rate. But, in Antenne 2, we have essentially two (2) levels of losses (stalking and florentin). Staling losses are due to poor sterilization. On the other hand, in Florentin, these levels of losses would be due to a lack of follow-up during oil recovery. This difference in the extraction rate demonstrated in these two oil mills can be caused by the aging of the equipment or the improper handling of the operators at each stage of treatment of palm seeds. This is what was revealed by Lebailly and Tentchou (2012) who reports that the care provided in manufacturing, equipment adaptation and maintenance can minimize manufacturing losses. At the clarification stage, the differences in oil loss rates could be explained by a lack of monitoring of the operators or the strainers placed at the level of the florentin of Antenne 2, by a failure of the three phases (tricants) at oil mills, or to a bad dilution of water in the press. Indeed, the operator puts a quantity of water at his discretion to make the dilution, which could negatively impact the separation of the oil-water-mud at the three phases.

## CONCLUSION

The treated regimes strongly influence the amount of oil produced at Antenne 2 than at the central oil mill. Rates of green diets are not the only factors that can influence the rate of oil extraction. However, the processing methods applied to diets during palm oil extraction could influence the rate of oil extraction, thus explaining the differences with oil losses at the clarification level in the two plants. Thus, it would be necessary to regularly maintain equipment to limit residual oil losses and avoid the high frequency of cutting green diets.

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