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# Genetic determinism of oil acidity among some DELI oil palm (*Elaeis guineensis* Jacq.) progenies

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**The oil palm (*Elaeis guineensis* Jacq.) is cultivated mainly for crude palm oil (CPO) which is extracted from the mesocarp of fruits. The quality of CPO is generally impaired due to high acidity, as a result of the activity of a lipase present in the mesocarp of the fruits at maturity. The objective of this study was to establish the genetic determinism of "palm oil acidity" (POA) from *E. guineensis*. Acidity was analyzed on CPO from the mesocarp of ripe fruits of some DELI parent palms used for the production of commercial seeds at CEREPAH Dibamba. Acidity analysis of 457 individuals from 11 progenies, issued from nine parents showed that, the segregation of forms with respect to this trait is compatible with a monohybridism with dominance. The dominant allele denoted that "Pa" determines high acidity while the recessive allele "pa" favours production of oil with low acidity.**

**Key words:** *Elaeis guineensis* Jacq., free fatty acid content, crude palm oil, inheritance.

## INTRODUCTION

The oil palm (*Elaeis guineensis* Jacq.) is a perennial crop that belongs to the family Arecaceae. It produces two types of oil: crude palm oil (CPO) extracted from the mesocarp and palm kernel oil (PKO) extracted from the seed (Sambantharmurthi et al., 2000). Since 2006, palm oil became the most consumed oil of plant origin (SoyStats, 2007), thanks to massive plantings in Indonesia and Malaysia and selection and improvement of the crop with the major objective of increasing oil yields (Yew et al*.,* 2010). With an average world annual yield of 4 tons/ha/year (Jacquemard, 2011), the production of palm oil in 2015 was estimated at 62.1 million tons (SoyStats, 2016). This production represents about 35% of world's production of vegetable oils. The highest palm oil producing countries are Indonesia and Malaysia, who, respectively produced 28.4 and 19.2 million tons of oil in 2013; Cameroon contributed 0.23 million tons (Faostat, 2014).

CPO production in Cameroon is carried out by two main sectors: industrial and informal (smallholders). In industrial oil production which supplies about 70% of total national production, bunches are harvested and treated immediately. CPO produced in this way does not degrade easily and is thus of better dietary quality in terms of acidity. In the smallholder sector which supplies 30% of CPO, bunches are treated several days after harvest. In

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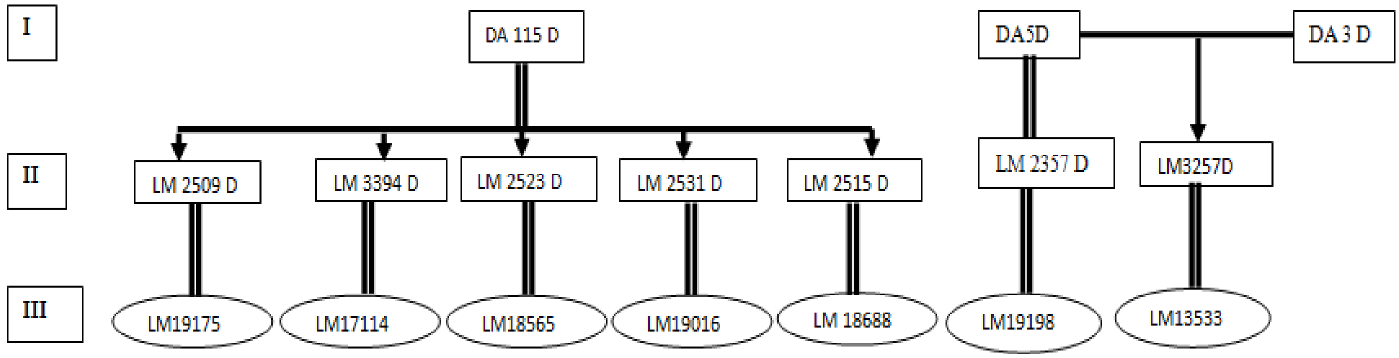


**Figure 1.** Progenies issued from self- pollination.

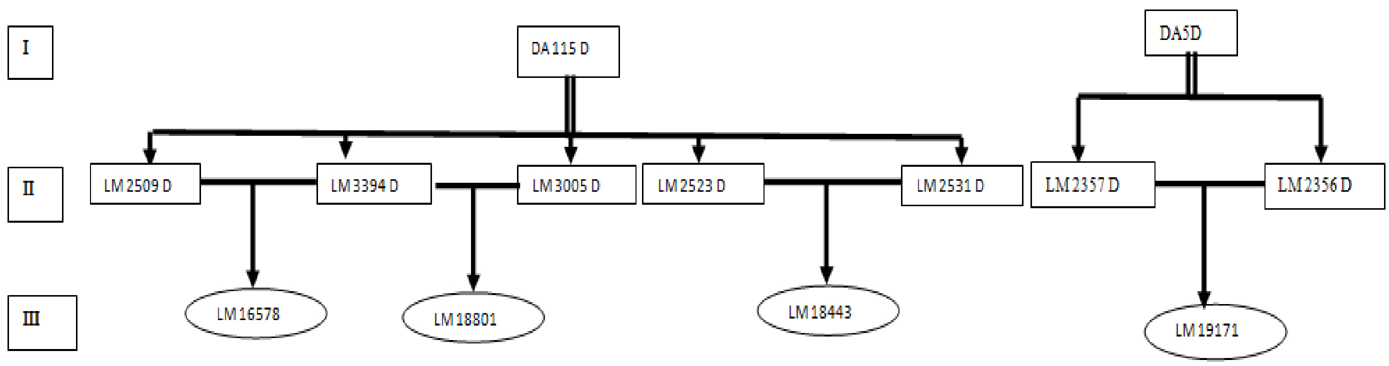


**Figure 2.** Progenies issued from crosses.

the course of this delay required to let fruits become easily detachable from the bunch, lipase activity in the fruit mesocarp accentuates with the hydrolysis of triglycerides, thus releasing free fatty acids. Oil produced as such has a high free fatty acid content and cannot be stored for long and is inappropriate for consumption (Anonymous, 2009). In the case in which the acidity ratio is high (above 5%), oil is classified as “acidic oil” (AFNOR, 1988). Below this threshold, oil is “non acidic”. Without prior refining, acidic palm oil is improper for human consumption (Anonymous, 2005). The fact that potentially acid oil cannot be stored for long enhances scarcity in the market during low production seasons, thus rendering the price of CPO very high.

Preliminary studies on palm oil acidity (POA) have shown that there is a wide variability for this trait (Ngando et al., 2008). In fact, oil acidity can vary from 0.75 to 41%. However, the genetic determinism of this trait is not yet clearly elucidated. The objective of this study was to precisely establish the genetic determinism of POA of oil from *E. guineensis* as a contribution to the genetic analysis of this trait, towards production and supply of commercial planting material susceptible to produce oil with low acidity.

## MATERIALS AND METHODS

### Plant

A total of 11 progenies of oil palm planted in CEREPAH of La Dibamba between 1993 and 1997 served for this study. They included LM 17114, LM 19175, LM 18565, LM 19016, LM 19198, LM 18688, and LM 13533, issued from self-pollination (Figure 1) and progenies LM 16578, LM 18443, LM 18801, and LM 19171 from crosses (Figure 2). All of these materials were derived from nine parent palms: LM 3394 D, LM 2509 D, LM 2523 D, LM 2531 D, LM 3005 D, LM 2515 D, LM 2357 D, LM 2356 D, and LM 3257 D.

The analysis of POA of all the progenies of the study served as a probe to elucidate the genetic determinism of this trait and to specify the genotype of the 09 parents for the concerned locus.

### Determination of palm oil acidity (POA)

The evaluation of POA was done on oil extracted from mesocarp of matured fruits. Bunch maturity was determined by the presence of 2 to 6 loose fruits (Sambantharmurthi et al., 2000). A bunch per tree and sixteen trees at least were haphazardly chosen per progeny. Oil extraction was done using hexane with the Soxhlet method (Ngando et al., 2008). Determination of acidity was done by titration using a burette with a solution of KOH 0.1N in three replicates per sample according to AFNOR (1988). For this study, the threshold between high acidity and low acidity was fixed at 5%.

### Statistical analysis

Results of POA per progeny were compared to the theoretical proportions derived from monohybridism with relationship to dominance using Chi square test ($\chi^2$) at 5% significance threshold as in Yuste-Lisbona et al. (2010).

## RESULTS

### Progenies issued from self-pollination

The analysis of data from selfed progenies revealed two types of results: homogeneity or heterogeneity for the trait under study. Progeny LM 19175 showed homogeneity for POA. For a sample of 50 individuals analyzed, all of them showed low oil acidity. It can thus be deduced that the parent LM 2509 D self-pollinated (SP) is homozygous for this trait. The same result was obtained with progeny LM 19016, as all of the 80 individuals analyzed showed low oil acidity and it can be deduced that the parent LM 2531 D SP is also homozygous for this trait. The progenies LM 19198 and LM 13533 showed more consistency for high oil acidity on a total of 29 and 17 trees respectively analyzed for both progenies. It can therefore be concluded that, parents LM 2357 D and LM 3257 D self-pollinated palms are homozygous for this trait. On the other hand, progeny LM 17114 showed heterogeneity for POA. From a sample of 45 individuals analyzed, 34 produced highly acidic oil and 11 produced oil with low acidity. It can be deduced from this, that the parent LM 3394D SP is heterozygous for oil acidity. Progeny LM 18565 also showed heterogeneity for POA. In fact, from a sample of 50 trees, 39 produced highly acidic oil while 11 produced oil with low acidity. This leads to the deduction that the parent LM 2523 D SP is heterozygous for this trait. Progeny LM 18688 showed heterogeneity for POA. From a sample of 26 trees, 20 produced highly acidic oil while 6 produced oil with low acidity thus making the parent LM 2515 D SP to be considered heterozygous for this trait.

### Progenies issued from crosses

Progeny LM 16578 showed heterogeneity for POA. From a sample of 25 individuals analyzed, 16 produced highly acidic oil while 9 produced low acidity oil. Progeny LM 18443 on its part showed heterogeneity for POA, with a sample of 75 trees, revealing 36 with high acidity oil and 39 with low acidity oil. Of a total of 100 individuals sampled from these two progenies issued from crosses, 52 produced high acidity oil while 48 produced low acidity oil. These results reveal a distribution of 1:1 (Table 1). This suggests that the two progenies are issued from crosses between a heterozygous and a recessive homozygous individual.

Progeny LM 18801 showed homogeneous high acidity oil for the 32 trees analyzed. The parent LM 3394 D being heterozygous, it can be concluded that the LM 3005 D parent is homozygous for the high oil acidity trait. This once more confirms the dominance of the high acidity phenotype. The LM 19171 progeny on its part also showed consistency for high oil acidity for the 28 analyzed trees. The parent LM 2357 D is homozygous for high acidity oil. From the earlier mentioned result, it can easily be concluded that the genotype of the parent LM 2356 D (unknown) does not influence the result of this progeny, and this again confirms the dominance of high oil acidity phenotype.

## DISCUSSION

Genetic determinism of palm oil acidity highlighted in this study by Mendelian inheritance, indicates that it is a monogenic trait with dominance of the “higher oil acidity” form on the “lower oil acidity” form. This analysis is consistent with the results of a recent study based on a molecular approach on mesocarp lipase of oil palm fruits (Morcillo et al., 2013). The lipase enzyme is generally recognized as responsible for the acidification of palm oil (Desassis, 1957; Ngando et al., 2006). The molecular approach indeed shows that within mesocarp proteins of ripe oil palm fruits, there is a unique protein (55-kDa) with lipase properties. This protein is present in the mesocarp of individuals producing oil with high acidity and absent among those which produce the oil with low acidity (Morcillo et al., 2013). The uniqueness of the protein clearly refers to the monogenic trait in Mendelian inheritance. Moreover, the production of the protein with lipase activity in hybrid justifies the dominance demonstrated during this study.

Similar results were obtained on the transmissibility of acidity in apple fruits (Hiroshi et al., 2012), the transmissibility of linoleic acid in carthamus (Hamdan et al., 2008) and for the transmissibility of erucic acid in Ethiopian mustard (Velasco et al., 2003). However, the great diversity of acidity rates renders it difficult to separate dominant homozygote from heterozygote in the present study. This same difficulty was encountered in the study of Ethiopian mustard (Velasco et al., 2003). In apple, there is good separation between low acidity individuals though with great proximity between heterozygotes and dominant homozygotes (Hiroshi et al., 2012). For the transmissibility of linoleic acid in mustard N2-4961, it was possible to separate three phenotype classes with the ratio 1:2:1 in the $F_2$ (Velasco et al., 2002). The diversity of acidity rates could also be explained by a possible polygeny. A digenic determinism could be considered with a distribution ratio at $F_2$ of 1:4:6:4:1 (Pandey et al., 2013) or 1:14:1 (Alemayehu and Becker, 2001). A trigenic determinism has equally been postulated with one locus partially dominant on others (Perez et al., 2002).

**Table 1.** Segregation for POA of some progenies at CEREPAH/La Dibamba.

| Progenies | Number of HAI | Number of LAI | Total | Theoretical Ratio (HAI:LAI) | Calculated χ2 | Critical χ2 |
|---|---|---|---|---|---|---|
| **Homogeneity for low acidity** | | | | | | |
| LM 19175 | 0 | 50 | 50 | 0:01 | 0 | |
| LM 19016 | 0 | 80 | 80 | 0:01 | 0 | 3,84 |
| Total Low acidity | 0 | 130 | 130 | 0:01 | 0 | |
| **Heterogeneity 3:1** | | | | | | |
| LM 17114 | 34 | 11 | 45 | 3:01 | 0,008 | |
| LM 18 565 | 39 | 11 | 50 | 3:01 | 0,024 | 3,84 |
| LM 18 688 | 20 | 6 | 26 | 3:01 | 1,61 | |
| Total Heterogeneity3:1 | 93 | 28 | 121 | 3:01 | 0,23 | |
| **Heterogeneity 1:1** | | | | | | |
| LM 16 578 | 16 | 9 | 25 | 1:01 | 1,96 | |
| LM 18 443 | 36 | 39 | 75 | 1:01 | 0,12 | 3,84 |
| Total Heterogeneity1:1 | 52 | 48 | 100 | 1:01 | 0,16 | |
| **Homogeneity for high acidity** | | | | | | |
| LM 19 198 | 29 | 0 | 29 | 1:00 | 0 | |
| LM 18 801 | 32 | 0 | 32 | 1:00 | 0 | |
| LM 19 171 | 28 | 0 | 28 | 1:00 | 0 | 3,84 |
| LM 13 533 | 17 | 0 | 17 | 1:00 | 0 | |
| Total high acidity | 106 | 0 | 106 | 1:00 | 0 | |

HAI: High acidity individuals; LAI: low acidity individuals, LM: LA ME, station at which material was developed.

**Table 2.** Genotypes of parents used.

| Type of cross | Progeny | Status of Progeny | Status of parent(s) | Genotype(s) of parent(s) |
|---|---|---|---|---|
| Self-pollinisation | LM 19016 | Homogenous | Homozygous | [pa//pa] |
| | LM 19175 | Homogenous | Homozygous | [pa//pa] |
| | LM 17114 | Heterogenous | Heterozygous | [Pa//pa] |
| | LM 18565 | Heterogenous | Heterozygous | [Pa//pa] |
| | LM 18688 | Heterogenous | Heterozygous | [Pa//pa] |
| | LM19198 | Homogenous | Homozygous | [Pa//Pa] |
| | LM13533 | Homogenous | Homozygous | [Pa//Pa] |
| Cross | LM 16578 | Heterogenous | One of the parents is Heterozygous | [pa//pa] x [Pa//pa] |
| | LM 18443 | Heterogenous | One of the parents is Heterozygous | [Pa//pa] x [pa//pa] |
| | LM 18801 | Homogenous | One of the parents is Heterozygous | [Pa//pa] x [Pa//Pa] |
| | LM 19171 | Homogenous | two of the parents are Homozygous | [Pa//Pa] x [Pa//Pa] |

Pa: Dominant allele for oil acidity; pa: recessive allele for oil acidity; LM: LA ME, station at which material was developed.

Results obtained from this study have led to the suggestion of a simple and clear model for genetic determinism of palm oil acidity. This trait is considered as monogenic and “high oil acidity” is dominant over “low acidity”. Since palm oil acidity is expressed as a percentage of palmitic acid, it is proposed that the allele responsible for high oil acidity be named «Pa» and that favoring production of oil with low acidity «pa», in order to facilitate interpretation of results obtained (Table 2).

Plant material used in this study was from DELI «*Dura*» families. Given that cultivated oil palm varieties are obtained from crosses between DELI «*Dura*» female individuals and LA ME «*Pisifera*» males, it is necessary to further search for and identify recessive homozygous individuals for low acidity in the LA ME population. Thence, it will be possible and easy to produce hybrids with low acidity from homozygous parents.

## Conclusion

Definitely, in all of the results obtained, offspring are homogeneous with high acidity phenotype if at least one parent bears this trait. It is homogeneous with low acidity if both parents have a genotype producing low acidic oil. Heterogeneous offspring are obtained if and only if both parents are heterozygous. In addition, results obtained from self-pollination progenies were consistent with those from intercrossing.

These results could lead to the conclusion that: the rate of oil acidity in palm oil is controlled by a major locus which within the analyzed population presents two alleles. This study opens up the possibility for breeders to select “low acidity” genitors from which improved oil palm seeds can be produced and supplied especially to smallholders for the production of better quality palm oil in terms of acidity.

## Conflict of Interests

The authors have not declared any conflict of interests.

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