

Full Length Research Paper

# Variations in morphological characteristics, lipid content and chemical composition of safou (*Dacryodes edulis* (G. Don) H.J.LAM.) according to fruit distribution. A case study

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A ten year old safou tree studied here bears 2820 fruits gathered on 557 bunches with 1 to 31 fruits on bunch. The fruit distribution was examined according to the geographical orientation (North, South, East, West) and the distance to the ground (Levels I, II, III), from the bottom towards the top of the tree). A sample of ten fruits per orientation and per level (120 fruits) was submitted to a detailed study (morphology, moisture, oil contents, fatty acid and triacylglycerol composition) according to the preceding factors. It was observed that East-West axis charged out 60% of total fruit number and these fruits were more homogeneous than North-South axis, and level III, (top of the tree) carried more than half of the total fruit number. Oil content of pulp increased from level I to level III (18–50%) whereas it varied weakly according to orientation. The fatty acid and triacylglycerol compositions were influenced neither by the orientation, nor by the distance to the ground.

**Key words:** Safou, *Dacryodes edulis*, oil, chemical composition, biodiversity.

## INTRODUCTION

The safou tree, *Dacryodes edulis* (G. Don) H.J. LAM, belongs to the Burseraceae family. It is a beautiful tree which can reach 8-12 m height, sometimes 20-25 m, when it grows up in dense forest. The safou tree was classified according to Kengue (2002) in the Rauh architectural model. It is characterized by orthotropic type branches. The flowers lead to fruits gathered in bunches.

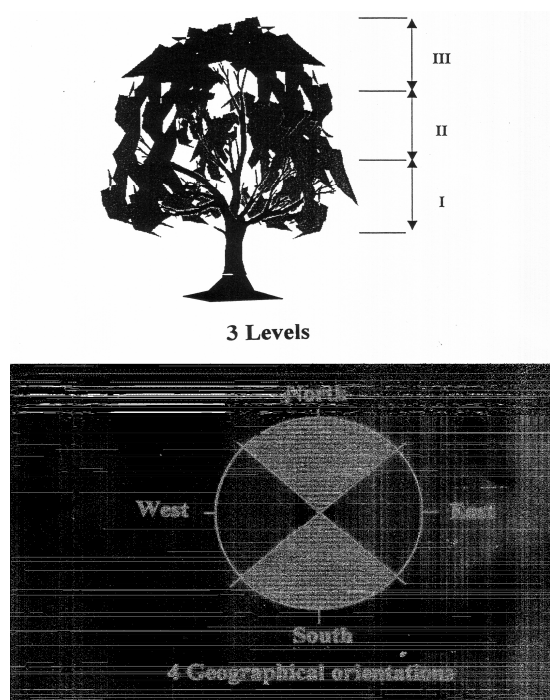
The safou, local name of *D. edulis* fruit, is a 4-8 cm long by 3-6 cm wide drupe; only its pulp (0.3-1.2 cm thickness) is edible and it is consumed after softening

with heat. This pulp presents very good nutritional qualities: 50-70% of lipid content, 15-30% of protein content and 2-5% of ash content on dry weight basis. Pulp oil contains linoleic acid (C18:2, n-6) from 18-27% and oleic acid (C18:1, n-9) from 15-30% (Silou, 1996).

To our knowledge, no correlation is established between the morphology, the nutritional composition of the fruits and their localization on tree. It is known that, according to some works on citrus (Fellahy et al., 1989), the fruit quality varies significantly with the geographical orientation and the position on the canopy. This work aims to provide more knowledge in fruit localization of the safou tree and morphological and chemical consequences of this localization.

Do fruits on the same tree have similar morphology and

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**Figure 1.** Delimitation of levels and geographical orientations for a tree.

chemical composition or not? Does a natural calibration of these fruits exist? That is the main question of this study. To answer this, we consider the quantitative and qualitative aspects:

- The fruit production at different canopy levels above the ground (levels I, II, III) and geographical orientations: North (N), South (S), East (E), West (W)
- The fruit size and oil composition of these fruits in the different canopy levels and geographical orientations.

The output of this work could provide important information on the management of safou crop for industrial or domestic uses (Silou, 1996; Kanmegne et al., 1996).

## MATERIALS AND METHODS

### Vegetable material

The studied tree is localized in Loufoulakari (District of Louingui, Pool Region, the Congo-Brazzaville). This approximately 10 years old tree with a fruit production of 100 kg/year on average was divided into three levels from the ground to the top and four geographical orientations (Figure 1).

- Fruits of each level and each orientation were gathered and counted.
- 10 fruits per orientation and per level amounting to a 120 fruit sample for the 3 levels and the 4 geographical orientations

were randomly chosen. They were used to determine the morphological characteristics, the moisture and oil contents.

- 10 fruits per orientation (3 fruits for level I, 3 fruits for level II, 4 fruits for level III), giving a total of 40 fruit sample for the 4 orientations, were used for fatty acid (FA) and the triacylglycerol (TAG) analysis.

### Morphological and physical characteristics

**Number of bunches:** The flowers of the safou tree can be male, female or bisexual. They gather in panicle whose complexity varies with the sex and the age of the safou tree. These panicles lead to fruit bunches.

**Morphological characteristics:** The studied morphological characteristics are the length and the width of the fruit, the thickness of pulp, as previously defined (Silou, 1996).

**Mass of the entire fruit and the mass of pulp:** Using a balance, the entire fruit was weighed to obtain the total mass ( $M_t$ ). After withdrawal of the seed, the pulp was weighed to obtain pulp mass ( $M_p$ ). Here pulp means exo-, meso- and endocarp.

**Specific gravity of the fruit:** Specific gravity was measured as previously described (Silou, 1996).

### Chemical composition of the fruit

**Moisture content:** The fruit was opened lengthwise using a knife and the seed was removed. The moisture content is given as:  $[(M_1 - M_2) / M_1] \times 100$ .  $M_1$  is the mass of fresh pulp and  $M_2$  the mass of the dried pulp (drying in oven at 105°C until constant mass),

**Oil content:** The pulp was dried, crushed and weighed (mass  $M_1$ ) and then introduced into a Soxhlet extractor. After a 5 h extraction with petroleum ether, the extract was dried with sodium sulphate. The solvent was evaporated in a rotary vacuum evaporator and the solvent traces were eliminated by drying oil in an oven at 103°C for 6 h.  $M_2$  is the mass of extracted oil. The oil content is given as:  $(M_2 / M_1) \times 100$ .

**Fatty acid (FA) analysis by gas chromatography (CG):** After the trans esterification of fatty acids by sodium methylate 0.5 N in methanol at ambient temperature during 2 min and under agitation, fatty acid methyl esters (FAME) were analyzed by gas chromatography (Becker-Packard, Rungis, France, model 417), provided with wide bore column (30 m length and 0.4 mm in inner diameter) coated with carbowax 20 M (Applied Science labs, State College, Pa, the USA). The analyses were made at a constant temperature 195°C with a nitrogen flow of 3 ml/min under a pressure of 0.5 bar. The injector and detector (FID) temperatures were respectively: 230 and 220°C (Kinkéla and Bézard, 1993).

**Triacylglycerol (TAG) analysis:** Triacylglycerols were isolated from the total lipids by column chromatography (45 g silicic acid, 100 mesh and pentane : diethyl ether, 80:20, v:v as solvent) and their purity tested by thin layer chromatography (Kieselgel 60G, thickness 250 µm) with hexane : diethyl ether : methanol : acetic acid (90:20:3:2, v/v/v/v) as solvent system.

The purified TAG were analyzed by reverse-phase high performance liquid chromatography (RP-HPLC) with a Waters 510 chromatograph (Waters, Milford, MA, USA) provided by a stainless steel column (250 mm x 4.6 mm; 4 µm; Hibar Lichrospher 100 CH-

**Table 1.** Distribution of the fruits by bunch, according to geographical orientation safou tree.

Number of fruits	Number of bunches				
	N	S	E	W	Total
1	31	24	22	30	107
2	20	20	30	26	96
3	12	10	22	17	61
4	9	16	19	16	60
5	5	7	11	12	35
6	7	7	4	10	28
7	6	4	11	12	33
8	5	3	7	5	20
9	7	3	5	5	20
10	5	2	4	4	15
11	11	6	2	3	16
12	2	1	2	4	9
13	4	1	3	4	12
14	2	-	2	3	7
15	-	-	4	2	6
16	-	-	1	5	6
17	-	1	3	-	4
18	-	-	1	3	4
19	1	-	1	-	2
20	-	1	-	3	4
21	2	-	-	1	3
22	1	-	-	1	2
23	-	-	-	2	2
24	-	-	1	-	1
25	-	-	-	-	-
26	-	-	-	-	-
27	1	-	-	1	2
28	-	1	-	-	1
29	-	-	-	-	-
30	-	-	-	-	-
31	1	-	-	-	1
<b>Total</b>	<b>126</b>	<b>103</b>	<b>158</b>	<b>170</b>	<b>557</b>

18, Merck), an automatic injector system (Waters 717) and a refractometric detector (Waters 996 Photodiode Array Detector). Analyses were carried out at ambient temperature (19-21 °C), using acetone-acetonitrile (70:30, v:v) as solvent system with 1 ml/min of rate flow. Data processing was carried out using Azur v2.0 software, Datalys, Saint Martin d' Hères, France (Kinkéla and Bézard, 1993).

## RESULTS AND DISCUSSION

### Number of bunches on the tree and fruit morphology

Table 1 shows the distribution of bunches on the tree, according to the increasing ratio of fruit per bunch. It appears that:

- The number of fruits in a bunch varies from 1-31 with 5 fruits per bunch in average for the tree.
- This ratio for North and level II was 1 unit higher than of this average value.
- And ratios for South, East, West orientations and levels I, III have the average value.

Table 2 shows the bunch and fruit distributions according to the level (levels I, II, III) and the geographical orientations (N, S, E, W). Generally, the average ratio "number of fruits per bunch" is independent of the level to the ground and geographic orientation. It is also interesting to note that:

- 70% of bunches have from 1-6 fruits/bunch on a range between 1 and 31 fruits.
- The East-West axis has 60% of fruits, while the top of the tree (level III) carries more than half of the total fruits of the tree.
- The ratio of the immature fruits was on average 7%, except the south orientation, where it was nearly 1.5 times larger (10%).

Table 3 presents the morphological characteristics, moisture and oil content according to the level to the ground and the fruit localization on the tree. In reference to previously classification (Silou et al., 2002), studied safous belong to size II. The low values of the standard deviations of the morphological characteristics show a good fruit homogeneity on studied tree.

### Chemical composition of the fruits

The oil content (Table 3) varies from 18 (level I) to 50% (level III); the fruits of the top of the tree were more oily than those which are closest to the ground. It follows that, for oil extraction with a good output, it would be necessary to gather much more safous fruits localized in levels III and II; the safous in level I could be used as current food for domestic consumption. The 4 orientations have similar oil content. Table 4 and Figure 2 show the fatty acids composition of safou pulp oil according to geographic orientation. The FA profile remains always the same; C16:0>C18:1 n-9>C18:2 n-6>C18:3 n-3.

The saturated, mono-unsaturated, poly-unsaturated fatty acid contents range between 50 and 54%, 24 and 30%, and 20 and 25%, respectively. Safou pulp oil contains a limited number of FA but whose percentage has interesting nutritional value. Palmitic acid is the main FA as in palm oil. Linoleic acid, present in noticeable accounts is nutritionally worth while. Consequently (% polysaturated FA) / (% saturated FA) with C18:2/C18:3 ratios respectively ranging between 0.4 and 0.5, 11 and 15, also deserve attention. These results agree with

**Table 2.** Distribution of the fruits of a tree by level to the ground and geographical orientation.

	Number of bunches (%)	Number of ripe fruits (%)	Number of immature fruits (%)	Mean fruits/bunch
<b>Levels</b>				
I	139 (24.9%)	689 (24.3%)	67 (8.8%)	5
II	151 (27.1%)	902 (3.0%)	81 (8.2%)	6
III	267 (47.3%)	1232 (43.7%)	71 (5.4%)	5
<b>Total (Levels)</b>	<b>557 (100%)</b>	<b>2820 (100%)</b>	<b>219 (100%)</b>	<b>5</b>
<b>Orientations</b>				
North	126 (22.6%)	697 (24.7%)	50 (6, 7%)	6
South	103 (18.5%)	438 (15.5%)	50 (10.2%)	5
East	158 (28.4%)	772 (27.4%)	57 (6.9%)	5
West	170 (30.5%)	913 (32.4%)	62 (6.4%)	5
<b>Total (Orientations)</b>	<b>557 (100%)</b>	<b>2820 (100%)</b>	<b>219 (100%)</b>	<b>5</b>

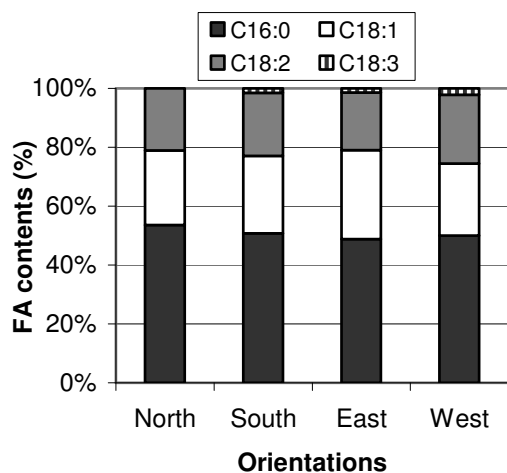
**Table 3.** Distribution of the fruit characteristics on the same tree.

	Level	Length *	Width *	Thickness*	Mt *	Mp *	Specific gravity	Moisture* Content	%Oil **
North	I	5,9 (0,3)	3,5 (0,1)	0,6 (0,06)	44 (4,4)	31 (3,9)	0,9 (0,07)	79,8 (1,3)	19,1
	II	5,9 (0,3)	3,6 (0,1)	0,6 (0,03)	45 (5,7)	30 (0,1)	1,0 (0,09)	78,2 (3,2)	36,3
	III	6 (0,1)	3,5 (0,05)	0,6 (0,05)	44,5 (2,6)	30 (0)	0,9 (0,06)	73,5 (3,1)	51,2
South	I	5,7 (0,1)	3,4 (0,1)	0,6 (0,04)	35,5 (4,9)	23 (4,4)	0,9 (0,08)	70,4 (6,8)	19,7
	II	5,7 (0,1)	3,5 (0,1)	0,6 (0)	38,5 (3,3)	28,5 (3,3)	0,9 (0,05)	79,8 (2,4)	33,4
	III	5,7 (0,2)	3,4 (0,1)	0,6 (0,05)	37 (5,3)	24 (3,9)	1,0 (0,06)	66,3 (5,5)	50,9
East	I	6,1 (0,1)	3,6 (0,1)	0,6 (0,04)	42,5 (4,8)	29 (2,6)	0,9 (0,05)	73,7 (6,7)	18,2
	II	5,9 (0,3)	3,9 (0,2)	0,6 (0,05)	44,5 (6,4)	32,5 (4,2)	1,0 (0,03)	75,9 (3,4)	46,3
	III	5,7 (0,2)	3,4 (0,1)	0,6 (0,07)	39,25 (4,09)	29 (2,6)	1,0 (0,07)	77,4 (3,6)	45,7
West	I	5,7 (0,2)	3,4 (0,1)	0,6 (0,04)	40 (3,5)	29 (2,6)	0,9 (0,04)	77,5 (1,8)	18,7
	II	5,9 (0,1)	3,4 (0,08)	0,6 (0,04)	45,5 (4,9)	32,2 (2,4)	1,02 (0,04)	75,1 (4,01)	38,8
	III	5,7 (0,3)	3,4 (0,1)	0,6 (0,04)	41 (5,1)	29 (3,1)	1,01 (0,05)	72,5 (3,1)	48,5

\* mean of 10 measurements (standard deviation); \*\* Mean of 3 measurements.  
Mt = Mass of fruit; Mp = Mass of pulp.

**Table 4.** FA composition (% m/m) of safou pulp oils according to the geographical orientations on a same tree.

	North	South	East	West	Mean (standard deviation)
C14:0	0.1	0.2	0.1	0.1	0.1 (0.05)
C16:0	50.7	49.1	47.2	48.2	48.8 (1.48)
C16:1 n-7	0.2	0.3	0.2	0.3	0.3 (0.02)
C17 : 0	0.1	0.1	0.1	0.1	0.1 (0.01)
C18 : 0	2.8	2.3	2.6	2.5	2.6 (0.2)
C18:1 n-9	23.9	25.5	29.3	23.7	25.5 (2.7)
C18:2 n-6	20.0	20.7	19.1	22.6	20.6 (15)
C18:3 n-3	1.8	1.5	1.3	2.1	1.7 (0.4)
C20:0	0.1	0.1	0.2	0.2	0.2 (0.02)
C20:1 n-9	0.1	0.1	0.1	0.1	0.1
Saturated FA	54.0	51.9	50.1	51.2	51.8
Mono-insaturated FA	24.2	25.8	29.6	24.1	25.9
Poly-insaturated FA	21.8	22.3	20.4	24.7	22.3
(% polyinsat.)/(%saturated)	0.4	0.4	0.4	0.5	0.4
(% C18:2) / (% C18:3)	11.1	13.8	14.7	10.8	12.6

**Figure 2.** Histograms of FA contents (%) of safou pulp oils according to the orientation.

Silou, 1996; Silou et al., 2002; Mbofung et al., 2002). These 3 main FAs lead to 5 major TAGs (Table 5) and following TAG profiles according to orientation are observed:

- North: PPO > PPL > POO > POL > PLL;
- West: PPO > PPL > POO > POL > PLL;
- South: PPO > POO > PPL > POL > PLL.
- East: PPO > POO > PPL > POL > PLL

where P, O, L are palmitic, oleic, linoleic acids. POO content increases when one passes from West and North

orientations to South and East ones. POO became the second more important TAG for East and South orientations. Generally the 4 profiles were very similar. The “radar plot” graphic allows best visualization of this similarity. Figure 3 shows similar representative forms of studied oils. Each component content on the corresponding axis defines the representative point of the component. All representative points connected by straight segments define a geometrical figure which is characteristic of the considered oil. Safou pulp oil composition was the same for all fruits of this tree. Geographical orientations had no significant influence on fruit composition in the same tree.

## CONCLUSION

On a range from 1-31 fruits, the majority of bunches carry 1-6 fruits (70%). East-West axis bears 60% of total fruits on the tree. The top of the tree (level III), carrying 60% of fruits, gathers the most oily fruits (50% of oil content) irrespective of the geographical orientations. Morphological characteristics and chemical composition of studied fruits were homogeneous. One can conclude that there was a natural calibration of the fruits of the same tree. This conclusion is very important for the development of industrial safou crop.

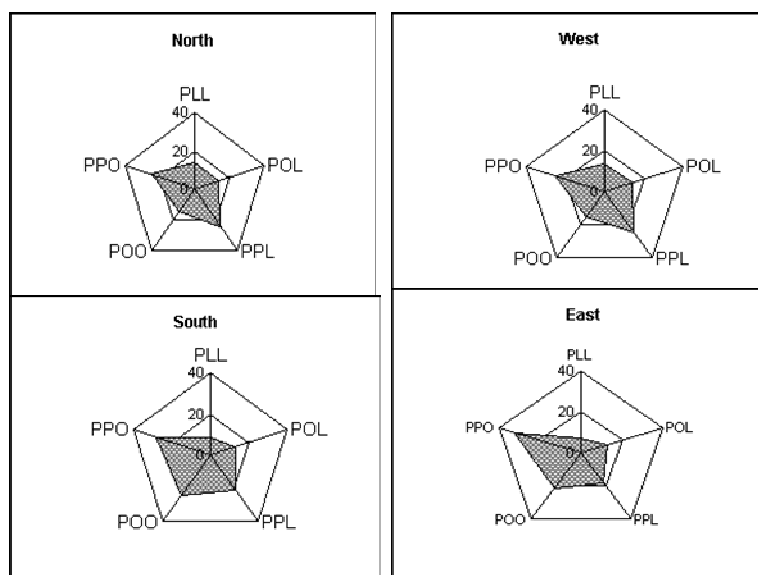
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**Table 5.** TAG composition (% m/m) of safou pulp oils according the geographical orientations on a same tree.

	North	South	East	West	Mean (standard deviation)
OOO	1.9	1.0	0.6	2.9	1.6 (1.0)
PLL	11.0	8.5	7.4	13.8	10.2 (2.8)
POL	12.6	12.8	13.1	13.9	13.1 (0.6)
PPL	23.3	20.9	18.2	24.2	21.6 (2.7)
POO	15.7	24.3	21.0	14.7	18.9 (4.5)
PPO	28.4	28.1	32.2	25.0	28.4 (2.9)
PPP	3.7	1.7	4.1	3.1	3.2 (1.0)
PSO	3.4	2.7	3.3	2.4	3.0 (0.5)

P = palmitic acid (C16:0) ; O = oleic acid (C18:1) ;  
L = linoleic acid (C18:2) ; S = stearic acid (C18:0)

**Figure 3.** “Radar-plot” representations of TAG profiles of safou pulp oils according to the geographic orientations.

Co-operation, (Aire Development, Convention B-3-COG-004-1).

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