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A review of *Ongokea gore* Hua (Pierre) as potential source of oils

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ABSTRACT

Ongokea gore is a multipurpose plant with many attributes and considerable potential. Before using it for industrial uses, it is imperative to have complete information about its biology, its chemistry and some of its applications for maximum profitability. _Ongokea gore_ taxonomy, botanical description and distribution are presented. The possibilities of exploiting the potential of its oil for various applications have been explored. The relative abundance of _Ongokea gore_ seed oil coupled with the low knowledge of its potential has prompted the need for this review.

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INTRODUCTION

Vegetable oils have been used by human since antiquity as sources of heat, light, essential food, cosmetics and medicines [GANEM-QUINTANAR et al., 2000; RABASCO et al., 2000; PARDEIKE et al., 2009; MASSON et al., 2000; METZGER *et* BORNSCHEUER, 2006; PAPANIKOLAOU *et* AGGELIS, 2011; DE CASTRO et al., 2009]. However, the consumption of this irreplaceable produce is increasing because of demographic growth and industrialization [KAPSEU, 2009]. This increased demand for vegetable oils for both industrial and food applications underscores the growing need for research on oils, particularly oilseeds which are little or no exploited, to increase their availability and to meet specific needs. The research axes developed in this framework concern in particular the control of the extraction processes, the characterization of the extracted oils and the definition of their qualities and their functionality [KAPSEU, 2009]. This type of under-exploited oilseeds known as unconventional oilseeds contains several families, one of which is the Olacaceae family, which is made up of a rather special and little studied genre, Ongokea.

Ongokea gore (Hua) Pierre is a tropical rainforest tree encountered in Cameroon, Ghana, Ivory Coast and the Democratic Republic of Congo [DE VRIES, 1957]. The seeds of its fruits contain 60% by mass of oil and a total oil production capacity estimated at more than 30 000 tons per year. This Ongokea gore oil commonly called isano oil or Boleko oil disappointed the industrialists who tried to valorize it, as it proved to be unusable in the applications tempted until then [DE VRIES, 1957]. Thus, apart women living in the area where the Ongokea gore trees grow, who use the oil for the toilet, no particular and clearly established applications of isano oil have been known until now [ADRIANS, 1951]. The purpose of this review is to give some applications of isano oil recently found in the chemical, energetic and medicinal field.

PLANT DESCRIPTION

Generalities

The Ongokea gore (**Figure 1**) is a large tree up to 40 meters tall. The bole of its tree is cylindrical, straight, without shoulders, but sometimes lobed at the base and up to 1.25 meters in diameter. Its wood is yellowish, hard and homogeneous, and its bark is greyish and rough [ADRIANS, 1951]. This bark contains 16% of tannins and is thus used as a purgative or to facilitate deliveries. The bark extract also has a great proteolytic action and is thus also used as a milk coagulant [LIBOUGA, 2008]. Its leaves are simple and entire, acuminate, shortly stalked, glabrous, shining green, without stipules. Its flowers are small, whitish, without fragrant, arranged in parasols, which sometimes form large panicles in the axils of the green leaves, towards the extremities of the branches [DE VRIES, 1957].

Its fruits are globulars, drupaceous, bacciform, composed of a yellowish peel, which reveals a thick fleshy pulp. The spherical, oleaginous seed is covered with a rather hard shell [ADRIANS,1951; LIBOUGA, 2008]. Its seeds contain 60% of oil and the total oil production capacity in DRC is estimated at over 30 000 tons per year according to some studies [DE VRIES, 1957].

Ongokea gore systematic

The phylogenetic classification of Ongokea gore is as follows [KIKUFI, 2009]:

Figure 1|Tree, fruits, leaves and seeds of Ongokea gore: [1]tree **(a)**, [2]shell (left) and almonds (right) **(b)**, [2] seeds (almonds with shell) **(c)**, [1]leaves and fruits **(d)**. *Source* : [1]Bakandja Michel ; [2]Ntumba Joséphine

- Clade : Angiosperms ;
- Clade : Eudicots ;
- Clade : Core eudicots ;
- Ordre : Santalales;
- Famille : Olacaceae;
- Genre : Ongokea;
- Espèce : Ongokea gore (Hua) Pierre.

Vernacular names (D.R.C.)

In some D.R.C. lands, Ongokea gore is named as follow [ADRIANS, 1951] :

- Mayumbe : Isano, Sanu, Tsanu, Iati, Ntuti
- Sankuru : Djileku, Kileku, Muleku, Tshifulufulu, Oleko, Tshileko
- Lomami : Kamatofo
- Batende : Boliena, Boyili
- Kundu : Boleko, Oleko, Bolekwa, Olekwa, Bukuma, Katuma, Buru, Usimi
- Kikega : Kayeke, Monzeke, Mutsheke
- Kenge : Motiti
- Mongo :Olekwa

ONGOKEA GORE OIL

Ongokea gore oil commonly called isano oil or Boleko oil, has been the subject of several studies about its structural characterization in the 60s and 70s [BADAMI, 1963; KNEELAND, 1958]. Until recently, these results had not enabled to find well-defined uses of it as a raw material for the chemical and para-chemical industries of fatty substances. These studies had been motivated by disappointing attempts at industrial use of this oil. These attempts were based on the physical and chemical characteristics of the oil, based on the usual analytical methods of lipochemistry [DE VRIES, 1957]. However, these characteristics only determine in a global and imperfect manner the nature of the fatty acids and their relative proportion in oil.

Physico-chemical properties of Ongokea gore oil

Ongokea gore seeds can contain up to 60% of oil [KNEELAND et al., 1958; NTUMBA et al., 2015], making it an interesting commodity for commercial exploitation. Specific gravity and dynamic viscosity are 0.965 at 20 °C and 46.75 poise at 25 °C [NTUMBA et al., 2015], respectively. An indication of the siccativity of an oil is given by its iodine value, which varies with the degree of unsaturation. The higher this index is, more the oil contains unsaturated molecules and therefore is likely to cross-link with air [WOLFF, 1968]. We call drying oils if the index of iodine is greater than 150, semi-drying if it is between 110 and 150 and non-drying if the index is less than 110 [WOLFF, 1968]. Thus, the high iodine value (163-230 g I_2 / 100 g) certifies that the fatty acids of isano oil are highly unsaturated and therefore classifies the oil as drying [KNEELAND et al.,1958; NTUMBA et al.,2015]. This high degree of unsaturation is also attested by its refractive index having a value of 1.5073-1.5090 at 25 °C. The triglycerides of C-18 fatty acids have a saponification number which varies around 200 mg of KOH/g, whereas for C-12, it is about 260 [WOLFF, 1968].

The saponification index value of isano oil (185-200 mg KOH/g) confirms that its triglycerides are composed of C18 fatty acids (14-16). The saponification value(SV) observed also reveals that isano oil could have applications in the shampoo and soap industry (the SV recommended for these applications varies between 188 and 253 mg KOH/g)[OLUBA et al., 2008]. Unsaponifiable matters consist of several compounds such as phytosterols and tocopherols which have a high commercial value [GUNSTONE, 2002]. A content of 0.5-5.21% in unsaponifiable matters was measured for isano oil [KNEELAND et al., 1958; NTUMBA et al., 2015]. The isano oil acid value is 1.12 mg KOH/g [NTUMBA et al., 2015]. This value is within the acceptable standards of the Codex Alimentarius Commission (the maximum recommended is 4 mg KOH/g, [1993]). The Ongokea

gore oil peroxide value is 10.4 meq/kg of oil [NTUMBA et al., 2015]. This low value of peroxide number indicates that the oil has some resistance to peroxidation during storage. **Table 1** below summarizes the physicochemical properties of Ongokea gore oil.

Tableau I| *Ongokea gore* oil physico chemical properties

Properties	Units	Values
Oil content	%	55-60
Colour	Code	4.0
Specific index (20°C)	g/mL	0.965-0.980
Dynamic viscosity(25°C)	Poise	10-46
Refractive index (25°C)	-	1.5073-1.5090
Refractive index (40°C)	-	1.4972
Iodine index	g I_2/100 g oil	163-230
Saponification index	mg KOH/g oil	185-200
Unsaponifiable matters	%	0.5-5.21
Acid index	mg KOH/g oil	1.12
Peroxide index	$m_{éq}$/kg oil	10.40

Several physicochemical properties of this oil are similar to those of some other commercially available oils, such as linseed oil and rubber oil [AIGBODION *and* PILLAI, 2009; EBWELE *and* IYAYI, 2010]. The latter are used in the production of biodiesel, soap, shampoo, paint, varnish and so on. However, DE VRIES [1957] in a previous study on this oil, reported that it has disappointed the fatty industrialists who tried to take advantage of it. By way of example, in spite of its excellent detersive power, the soft soap obtained by potassium saponification proved to be unusable because of its reddish color, the difficulty of its discoloration and its very unpleasant odor. In addition, he reported that although it had a very high iodine value comparable to that of linseed oil, which was effectively used as a drying oil in the paint and varnish industry, it didn't have a siccative power[DE VRIES, 1957]. Thus the studies that followed were focused on the knowledge of its chemical composition.

Chemical composition of Ongokea gore oil

These studies have revealed that this oil has a particular chemical composition. Indeed, the UV and IR analyzes showed that the triglycerides of isano oil are mainly composed of fatty acids possessing triple conjugated bonds. In 1963, GUNSTONE and SEALY [GUNSTONE, 1963] have shown that this oil contains, in addition to the usual saturated and unsaturated fatty acids, 5 diacetylenic acids, 2 of which are hydroxydiacetylenes. Still in the same year, MORRIS [1963] established the presence of cis-9,10-epoxy stearic acid in Boleko oil. In 1977, MILLER et al. [MILLER et al., 1977] isolated and characterized isanic acid, four acids having an alcohol function adjacent to the diyne moiety and two oxo group-containing acids (**Figure 2**). Thus, the structures of more than 10 different acetylenic compounds composing the triglycerides of this oil have been proposed on the basis of UV data and derivative reactions. Of these compounds, four have an alcohol function adjacent to the diyne moiety and two have a carbonyl function. However, only a few of these compounds had been isolated (as methyl ester, **Figure 2**).

Recently, NTUMBA et al. [2015] isolated and characterized, six fatty acids (ethyl esters) of this oil on the basis of spectral data (HPLC, 1D and 2D NMR, MS and (HR)-MS-APCI, IR) (**Figure 3**). They found that the ^{13}C-NMR quantitative analysis of the crude mixture after transesterification made it possible to determine the following ratio for the identified compounds 1/ 2/ 3/ 4/ 5/ 6/ non identified others compounds: 2/38/4/3/3/2/48.

Common isano oil fatty acids profile

MUTINSUMU et al., [2015] found that isano oil contains the following common fatty acids: myristic acid, palmitic acid, pentadecanoic acid, stearic acid, oleic acid, linoleic acid, linolenic acid and arachidic acid, behenic acid.

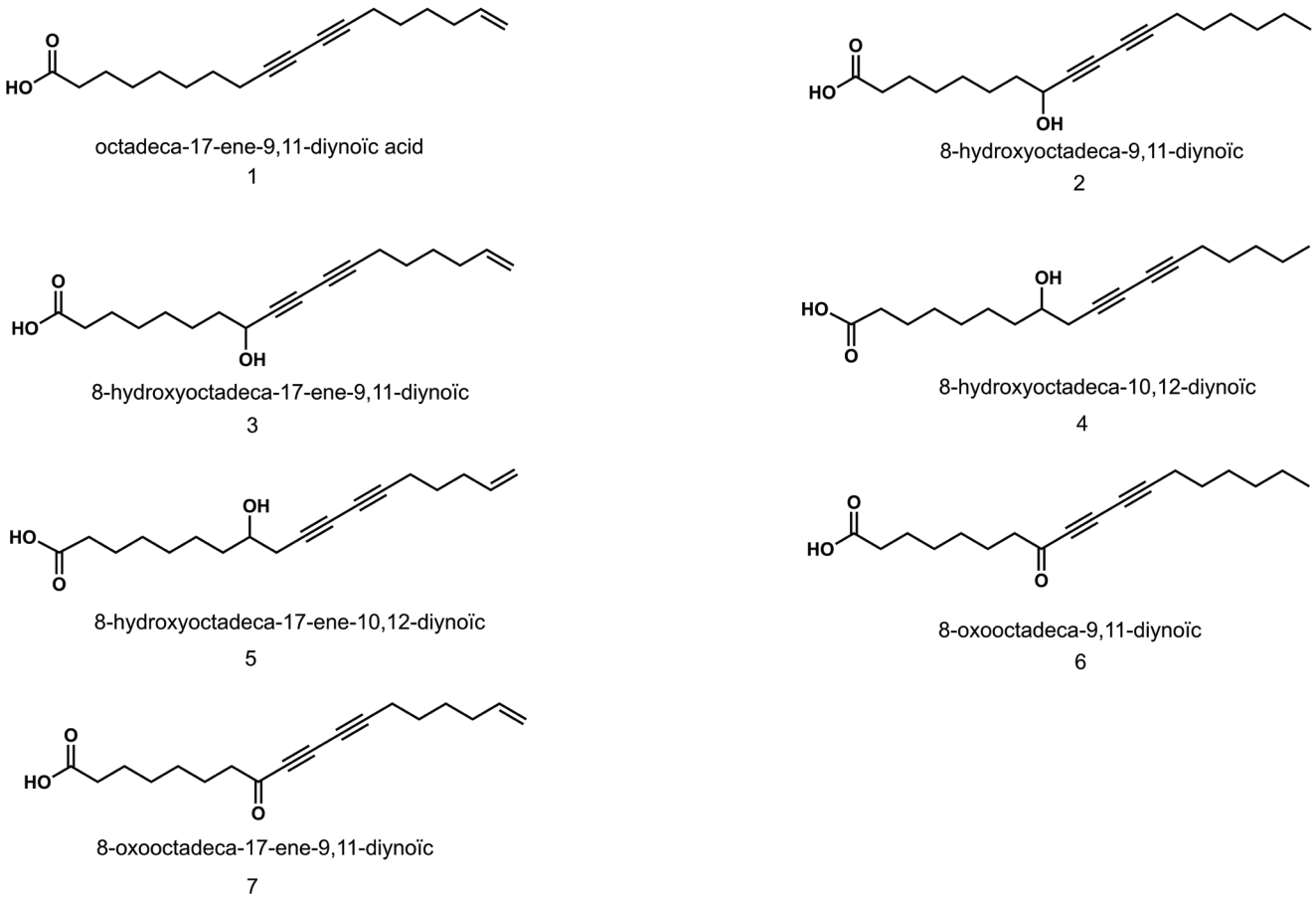

Figure 2| Fatty acids identified by Miller

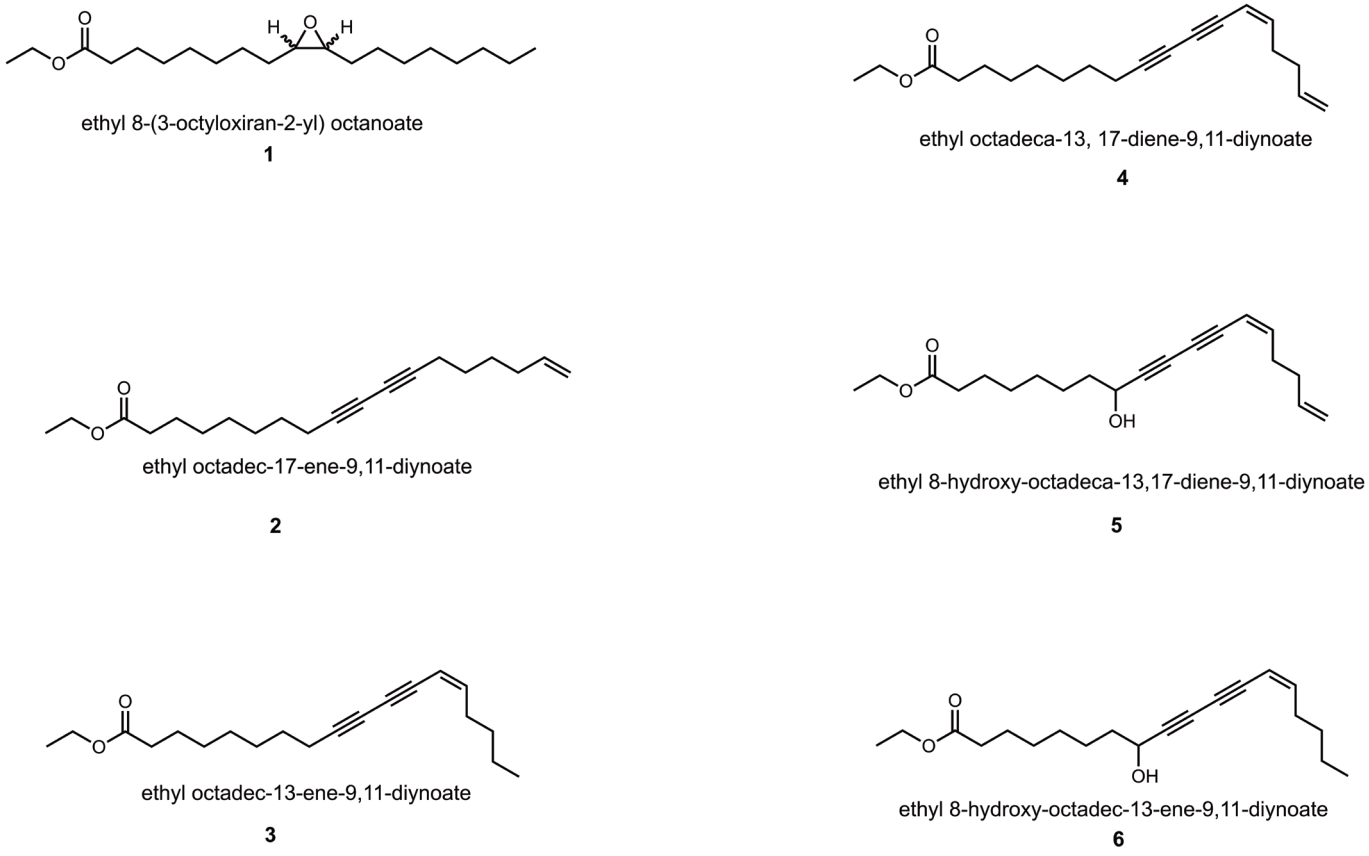

Figure 3|Isolated and identified fatty acids (as ethyl esters) of isano oil [NTUMBA et al., 2015]

Ongokea gore oil uses

As starting material for the new compounds synthesis

The presence of the conjugated triple bonds in the composition of the major isano oil fatty acids has rendered it unusable to date. However, recent studies [NTUMBA et al., 2014] have shown that these unsaturations can be transformed into new compounds. Indeed, the majority diyne isolated after isano oil transesterification were used in the synthesis of several new compounds presented in **Figure 4**.

Some of these novel synthesized compounds (compounds 7-12) were subjected to in vitro antimicrobial activities against four bacterial species and two fungal species [NTUMBA et al., 2014]. From these results (**Table 3** and **Table 4**), it appears that most of the compounds tested possess significant antibacterial and antifungal activities.

As an energy source

Ongokea gore oil is considered as potential source of biofuel production [NTUMBA et al., 2017]. Indeed, after transesterification, the biofuel obtained (B100) has the propertiesof a light fuel oil that can be used in combustion plants. The biofuel derived from the totally hydrogenated Ongokea oil (B100-H) has also the properties of a light biofuel. The properties of B100 and B100-H are shown in **Table 2**. The blend of biofuel and gasoil (20: 80, mixed, B20), on the other hand, has properties comparable to those of conventional gasoil.

Tableau 2| Common isano oil fatty acids profile

Fatty acids	Content in oil (%)
Myristic acid	0.40
Palmitic acid	0.06
Stearic acid	2.60
Oleic acid	19.19
Linoleic acid	5.46
Linolenic acid	0.17
Arachidic acid	0.20
Pentadecanoic acid	19.13
Behenic acid	0.04
Erucic acid	-

Table 3| Antibacterial activities of compounds 7-12 expressed in MIC (µg/mL), in MBC (µg/mL) and in ratio MBC/MIC

Derivatives	*E. coli* ATCC 25922			*K. pneumonie* ATCC 1388			*S. aureus* ATCC 25923			*S. aureus* ATCC 33591		
	MIC	MBC	R	MIC	MBC	R	MIC	MBC	R	MIC	MBC	R
7	100	100	1	6,25	25	4	12,5	12,5	1	100	>100	-
8	25	50	2	100	100	1	25	50	2	50	>100	-
9	12,5	12,5	1	25	100	4	50	50	1	50	50	1
10	25	25	1	≥100	>100	-	25	100	4	12,5	>100	-
11	50	100	2	25	50	2	12,5	50	4	100	>100	-
12	50	100	2	100	100	1	≥100	100	-	100	100	1

Legend: MIC (Minimum Inhibitory Concentration); MBC (Minimum Bactericide Concentration); R=CMB/CMI

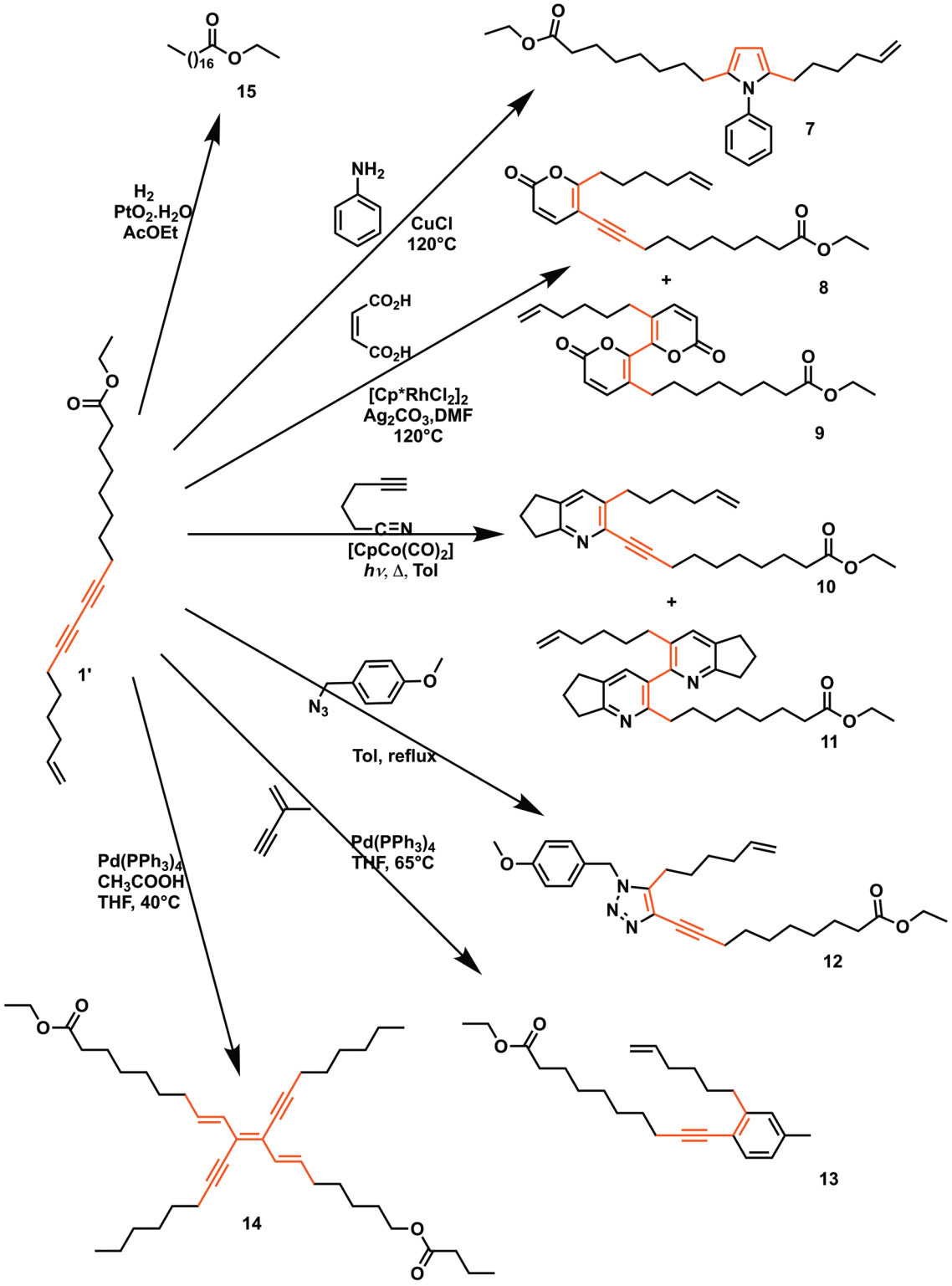

Figure 4| Derivatisation reactions of ethyl ester isanic acid (1')

Table 4| Antifungal activities of derivatives 7-12 expressed in MIC (µg/mL), in MFC (µg/mL) and in ratio CMF/CMI

Derivatives	*C. albicans* ATCC 10233			*G. candidum* ATCC 34614		
	MIC	MFC	R	MIC	MFC	R
7	25	>100	-	1,56	25	16
8	12,5	>100	-	12,5	25	2
9	50	>100	-	6,25	25	4
10	6,25	>100	-	1,56	25	16
11	50	>100	-	3,12	100	32
12	6,25	>100	-	6,25	100	16

Legend: MIC (Minimum Inhibitory Concentration); MBC (Minimum Bactericide Concentration); R=CMB/CMI

As source of antimalarial drugs

The antimalarial activities of three polyacetylenes isolated from isano oil were evaluated [NTUMBA, 2015]. These are compounds 2, 5 and 6 in **Figure 3** above. These tests demonstrated that the hydroxylated fatty acids of isano oil had excellent antimalarial activities because their IC50 values were 1.76 µg / mL and 0.66 µg / mL, respectively (**Table 6**), while the non-hydroxylated compound has no antimalarial activity (IC50 >125 µg/mL). Moreover, the absence of any cytotoxicity observed in vitro towards several cancer cells (IC 50> 90 µM, **Table 7**) confirms that the antimalarial activities observed are indeed specific and selective.

Table 6| Half inhibitory concentrations (IC_{50}) in µg/mL of Fatty Acid Ethyl Esters (FAEEs) 2, 5 and 6

FAEEs	IC_{50} (µg/mL)
1	125
2	1,76
3	0,66

Table 5| Physico chemical properties of B100, B100-H, B20, OGO and GO

Properties (units)	Limitations	Gasoil (GO)	Ongokea gore oil (OGO)	B100	B100-H	B20	Methods
Couleur (code)	5,0 max	4,0	4,0	4,0	4,0	4,0	ASTM D-1500
Density at 15°C	810,0-890,0	867,0	965,0	943,0	928,0	865,9	ASTM D-4052
Viscosity at 37,8°C (mm^2/s oucSt)	2,0-6,0	4,11	-	-	-	5,30	ASTM D-445
Viscosity at 50°C (mm^2/s oucSt)	≤ 15	-	-	4,5	3,2	-	AFNOR NF 60-100
Flash point (°C)	60 min	73	102	88	79	64	ASTM D-93
Pour point (°C)	+5 max	-10	-31	-25	-1	-13	ASTM D-97
Total sulfur (% masse)	0,5 max	0,219	0,025	0,022	0,025	0,140	ASTM D-4294
Ash contents (% masse)	0,01 max	0,01	0,0031	0,0198	0,012	0,0161	ASTM D-482
Water content (% vol)	0,05 max	0,0	0,4	0,0	0,4	0,08	ASTM D-95
Corrosion of Cu (Code)	1 max	1a	1a	1a	1a	1a	ASTM wD-130

Table 7| IC50 (µM) of determined drugs by MTT test

Drugs	Glioma	Carcinoma	Méeanoma	Mean ± SD					
	U373	T98G	A549	LoVo	MCF7	PC-3	SKMEL-28	B16F10	
1	100	100	100	95	100	100	100	75	96±3
2	100	100	100	83	100	100	100	70	94±4
3	100	100	100	97	100	100	100	69	96±4

CONCLUSION

The Ongokea gore seeds appear to have many industrial applications potential. Indeed the probable use of their oil for medicinal purposes such as the treatment of malaria or as starting material for the synthesis of antibacterials and antifungals compounds has been demonstrated. In addition, Ongokea gore could play an excellent role in addressing some of the energy service needs and thus empowering rural communities to generate new jobs. It is therefore important that further research be done on this unconventional plant in order to fully benefit from it while developing industrial exploitation and its large-scale use to meet current needs.

RÉSUMÉ

L'*Ongokea gore* est une plante polyvalente ayant de nombreux attributs et un potentiel considérable. Avant de l'exploiter pour des utilisations industrielles, il est impératif d'avoir des informations complètes sur sa biologie, sa chimie et certaines de ses applications pour qu'elle soit au maximum rentabilisée. La taxonomie, la description botanique de l'*Ongokea gore* ainsi que sa distribution ont été présentées dans cette revue. Les possibilités d'exploitation du potentiel de son huile pour diverses applications ont été explorées. L'abondance relative d'huile des graines d'*Ongokea gore* couplée à la faible connaissance de ses potentialités a incité la nécessité de cette revue.

Mots clés *: Ongokea gore, diynes, acides gras, propriétés physico-chimiques, huiles*

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