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SERVICES FOR SCIENCE AND EDUCATION

Quassia undulata (Guill. &Perr.): Systematic Review

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ABSTRACT

Forest trees are very important resources for living things. They are used in the daily life of human beings whether in the production of wood, in food, in medicine, in cosmetology… Among these forest resources, some are more exploited than others. These unconventional resources, however, hold enormous potential. This is how this document proposes to make the bibliographical review of the plant *Quassia undulata*. The research method used is the collection of information from scientific sites for downloading articles, books, and educational documents such as doctoral and master's theses. The information obtained showed that *Quassia undulata* is used in traditional medicine as well as in modern medicine, especially in the treatment of malaria and cognitive diseases. The fruits are eaten and the seed oil is used in cosmetics and in the production of biodiesel. Its wood is highly prized and the seeds rich in quassinoids are used as a nematicide. However, in view of the many potentialities of the tree, it would be interesting to adopt means of preservation thus making it possible to preserve the important local know-how.

Keywords: *Quassia undulata*, Simaroubaceae, Quassinoids, Senegal, biodiversity.

INTRODUCTION

Forest plants are a very important resource for living beings. Trees as a whole allow populations, especially rural ones, to manage their needs for food, medicine, domestic energy and building materials. Some trees such as *Carapa procera* are most often used in the medicinal context[1] and others are better known for their food uses (*Adansonia digitata*, *Moringa oleifera*) [2] or by the use of their wood (*Pseudocedrela kotschy*, *Albizia adianthifolia*) in construction or energy production[3]. Trees are used in at least two areas as shown by Gning et al., in their studies on the socio-economic value of trees in the Malinké environment in Senegal[4]. The exploitation of certain forest plants is evolving to become an income-generating activity. This is the case of the plant *Vitellaria paradoxa* whose butter extracted from the nuts has become an income-generating activity for women in West Africa [5] as well as palm oil whose exploitation of oil no longer only involves women but also men [6]. In the north of Senegal, the extraction of oil from "Sump" *Balanites aegyptiaca*, is an activity that allows women not only to have cooking oil but also to have income to supplement the ends of the months with the marketing of the oil [7]. Others, on the other hand, are less exploited by rural populations. This is the case of the plant *Quassia undulata* which is found in the south and in the center of Senegal but which is only exploited by the Bassari populations of the south. Thus, in this document, a systematic study of the plant *Quassia undulata* is proposed with a view to having a better knowledge of it.

QUASSIA UNDULATA **(GUILL. & PERR.)**

Quassia undulata (GUILL. & PERR.) belongs to the Simaroubaceae family which includes 32 genera divided into 170 species of trees and shrubs [8] exclusively distributed in tropical and subtropical zones, with the exception of the genera Ailanthus and Picrasma, whose range extends into temperate Asia [8], [9]. It is the closest family of Meliaceae and Rutaceae in the order of Sapindales. Species in this family have alternate leaves that are compound or complete, unpunctuate, with or without spines. Their flowers are generally united in axes presenting free or fused sepals, free petals, stamens with double the number of petals. The ovary is above a short gynophore or above a disk with four or five carpels, usually free at the base (case of *Quassia*) or with two ovules per carpel [8]. Simaroubaceae species have undergone many taxonomic changes over time[10]. This is the case of *Hannoa ferruginea* which was changed to *Quassia sanguinea*, *Hannoa klaineana* to *Quassia silvestris* and *Hannoa undulata* to *Quassia undulata* [11]. The bitter taste of all parts of the plants of this family constitutes one of their botanical identification criteria. These molecules, mainly quassinoids, constitute the taxonomic markers of Simaroubaceae since they are the most abundant molecules in these plants [8],[12]. These molecules are responsible for their pharmaceutical properties and make them a good source of bioactive molecules [8]. Scientific studies on the identification of these bioactive compounds have increased since the 1970s when their role against cancer was demonstrated [13]. Thus more than 200 quassinoids as well as alkaloids, steroids, triterpenes, flavonoids, polyphenols, anthraquinone… have been identified [8]. Compounds isolated from *Brucea antidysenterica* have been shown to be effective against cancer [13].

Species of the Simaroubaceae family are used in traditional medicine as anthelmintics, anti-amoebas, antivirals, anti-leukemic, anti-tuberculosis and antimalarial agents and for the treatment of cancer [14],[15]. *Quassia amara* has been shown to be effective against ulcer [16]. Leaf and wood extracts from *Quassia amara* have been shown to suppress appetite [17]. *Eurycoma longifolia* has shown aphrodisiac, antimalarial, antiulcer, antitumor, antiparasitic and antihypertensive effects [18].

Table 1 gives a summary of the different types of quassinoids identified in plants of the Simaroubaceae family.

Table 1: Summary of chemical compounds identified in species of the Simaroubaceae family

Gender and/or species	Identified chemical compounds	References
Simaba	Quassinoid, Triterpenes, Alkaloids, Coumarins, Steroids, Phenolics, Organic Acids, Flavonoids,	[14],[13]
Brucea javanica	Bruceins A–D, bruceantinol, javanicolides A–D, javanicosides A–F, 1,2-di-demethylquassin	[19],[20]
Soulamea fraxinifolia	Picrasine B, hydroxy-6 picrasine B, Δ-2 picrasine B and isobruceine in the bark, in the stem bark, and leaves	[15]
Soulamea	Soulameanone, soularubinone and chaparrinone	[21]
Quassia undulata	Chaparrinone, glaucarubolone et klaineanone, in the seeds ; ailanthinone and undulatone in the roots ; 15-desacetylundulatone	[22],[23]
Odyendea gabonensis	Ailanthinone, 2'-Acetylglaucarubinone, 2-Hydroxyailanthinone, 2'-Acétylglaucarubine, Odyendane and Odyendene	[24]
Simaruba glauca	Glaucarubolone and glaucarubinone	[25]
Soulamea tormentosa	Iso-brucéine A isolated in the bark of the trunk	[19]
Quassia amara	Simalikalactone E, Simalikalactone D	[23],[26]
Ailanthus altissima	Ailanthone, 6α-tigloyloxychaparrinone, Chaparrinone, 2,12-didemethylquassin	[27],[28]
Picrolemma sprucei	Isobrucéine B	[29]
Castefa texana	Glaucarubolone, chaparrinone, holacanthone, 2,12-didemethylquassin	[28]
Simarouba amara	Chaparrinone, holacanthone, glaucarubinone, 2,12-didemethylquassin	[28]
Eurycoma longifolia	14,15-dihydroxyklaineanone, Eurycomanone	[18]

GENERAL PRESENTATION OF *QUASSIA UNDULATA*

Q.undulata (Figure 1) is a plant that belongs to the Simaroubaceae family and the order of Sapindales [4]. The species *Quassia undulata (Q.undulata*) is present in the wooded savannah from Senegal west to the Central African Republic and south to Zambia and Angola [3]. In Senegal, it is a small tree up to 8 m high with a stem resistant to bush fire [11] and is found in Casamance [30] and in the region of Kedougou [4]. *Quassia undulata* is a tree in Liberia that can reach a height of 33m and a diameter of more than 1m [31]. Indeed, *Quassia undulata* is a very variable species, presenting distinct ecological forms: a low, shrubby and fire-resistant savannah tree (formerly *Hannoa undulata*), and a large high forest tree (formerly *Hannoa klaineana*). These two taxa are generally distinguished by the length of the petioles (*Hannoa undulata* having long petioles) [31],[32].

Figure 1: ***Quassia undulata*** **tree (photo taken in Salemata/Senegal in 2018) [33].**

Figure 2: *Quassia undulata* seeds (lefts pictures show the entire seeds and the rights one the seeds without hulls) [33].

Quassia undulata is a fast-growing, light-demanding species. The tree blooms during the rainy season. The fruit ripens between November and December. Seeds (Figure 2) can be distributed by water while floating as they do not completely fill the endocarp [31]. Its local name varies by area and community. Table 2 gives the different names given to *Q.undulata* according to different countries and different communities.

Table 2: Different names of *Quassia undulata*

Country/community	Name	References
Nigeria/Igala	Umopula	[34]
Nigeria/ Yoruba	Oriji	[35],[36]
Ghana	Akan-asante hotoro	[35],[36]
Nigeria	Gbur	[37]
Nigeria/Haoussa	Takandar giwa	[38]
Ghana	Hotrohotro	[39]
Guinea	Diafrékété	[40]

Botanical Description Taken from Louppe et al., 2008 [3] and Nooteboom., 1962 [41]

It is a medium-sized to fairly large shrub or tree, up to 42 m tall; devoid of branches up to 24 m in height, up to 120 cm in diameter, straight, cylindrical, most often without buttresses. The surface of the bark is smooth or cracked, gray, peeling. The inner bark is white to yellow-brown and fibrous with a rounded, dense crown and hairless twigs. The leaves are alternate, compound with 2-9 pairs of leaflets, 8-55 cm long with petiolules up to 4 cm long [43]; leaflets oblong to elliptical or ovate, 2-20 cm x 1-8 cm, basal and terminal leaflets usually the smallest, rounded to wedge-shaped at base, often oblique, apex notched or rounded to shortly acuminate, margin entire , sometimes slightly wavy, leathery, glabrous, often with pitted glands above, pinnately veined with 6-10 pairs of lateral veins. Inflorescence an axillary or terminal, lax thyrse up to 40 cm long, branches glabrous to pubescent. Flowers unisexual or bisexual, white to yellowish, fragrant; pedicel 1-10 mm long; calyx 2-5-lobed, 2-4.5 mm long, glabrous inside, glabrous to slightly hairy outside; petals 5, free, narrowly ovate to oblong, 3-7 mm x 1-2.5 mm, acute, hairy on both sides; stamens usually 10, up to 7 mm long in male flowers, 1.5-3 mm long in female or bisexual flowers; ovary consisting of 5 free carpels, 1—1.5 mm long in female or bisexual flowers, reduced in male flowers, style 0.5-2 mm long. The fruits consist of l-3(-4) ellipsoid to oblong drupes 1.5-3.5 cm x 1-2.5 cm, often slightly bi-keeled and more or less flattened, purplish or black, shiny, each drupe containing 1 seed. Seedling with epigeal germination; hypocotyl c. 3.5 cm long, epicotyl c. 5 cm long; first 2 leaves opposite, 3-foliolate.

PLANT GROWTH PARAMETERS

Quassia undulata reproduces easily by seed but for good germination seeds should be sown immediately after harvesting as they quickly lose viability. They germinate in 6-22 days. Initial growth in the greenhouse is slow, with 5-month-old seedlings only 11-12 cm tall. Seedlings are ready for transplanting when they are about 14 months old. They are planted in direct sun, in a pure stand or mixed with other light. In West Africa, flowering takes place in July-November, and fruiting in September-February [3]. However, in southeastern Nigeria fruit ripening has been observed between August and September [42]. In Sierra Leone average diameter increments of about 1.2 cm per year have been observed while in Guinea 5-year-old saplings have been observed which averaged 4.1 m in height, but some trees already reached 3.5 m after only 2 years [3].

USE OF QUASSIA UNDULATA (*Q.UNDULATA*)

In Medicine

In traditional medicine *Q.undulata* is widely used. The bark of the roots is used as an infusion against stomach-ache while a combined infusion of the bark of the roots, the bark of the stem and the leaves can cure the disease of jaundice [37]. In addition, *Q.undulata* is prescribed for severe lung infections and uncomplicated diarrhea [12]. In Guinea the leaves of *Q.undulata* are traditionally used in case of urinary disorders and in oral diseases [40]. In Nigeria, *Q.undulata* is used for the treatment of febrile states [40]. *Q.undulata* is thus described as a medicinal plant because it consists of substances that serve as precursors for the synthesis of drugs or substances that have therapeutic purposes [36].

Q.undulata is known for its neuro-protective role [36], [43]. In Nigeria, *Q.undulata* leaves are used in the management of cognitive disorders [43]. This prompted several researchers to study the mechanism of action. Thus, the aqueous extracts of the leaves of *Q.undulata* have been tested for their antioxidant activity as well as for their activity against acetylcholinesterase which is an essential enzyme of the cholinergic nervous system and is commonly associated with neuro-fibrillary degeneration. During the progression of certain neuronal diseases such as Alzheimer's, there is a loss of cholinergic neurons in the brain accompanied by a progressive decline in acetylcholine. Thus, treatments for Alzheimer's are generally based on acetylcholinesterase inhibitors [44]. The results showed acetylcholinesterase inhibition and strong antioxidant activity. The latter may be at the origin of the effectiveness of *Q.undulata* leaves against cognitive diseases [43]. The aqueous extract of *Q.undulata* was then tested in rats previously rendered amnesic by scopolamine in order to improve their memory. The results showed a marked improvement in memory in rats pretreated with the aqueous extract of Q.U [36]. *Quassia undulata* leaves are used in the Togolese cosmetopoeia and to treat dermatosis

[45]. The toxicity of the leaves was also tested on rats and no signs of acute or chronic toxicity were observed [46].

Q.undulata is also known for its role against malaria [36], [43], [47] which is mainly due to the high quassinoids content of the plant [36]. Moreover, in southwestern Nigeria, *Q.undulata* is used there for the treatment of malaria [48]. This is how the leaves and stem of *Q.undulata* were used to test the antimalarial properties of the plant. The results obtained demonstrated that Q.undulata extracts have promising suppressive and curative properties against malaria [49]. *Q.undulata* bark and leaves exhibit antibacterial, antifungal and anti-plasmodial activity [35],[40] and chaparrinone and glaucarubolone isolated from *Q.undulata* seeds exhibit antiviral activity in vitro against the oncogene Rous sarcoma virus [50].

Domestic Uses

A survey carried out in the central zone of Senegal showed that *Q. undulata* is used as food (fruit consumption) but also in the production of wood [3],[2]. The wood is mainly suitable for interior construction, due to its low durability, and the plant is also used as fodder and firewood [3],[4]. In Ghana the wood is used as firewood and for making charcoal, as well as in the paper industry [3]. In Benin, the tree is used in the production of wood [51]. However, *Q.undulata* can only be used outdoors by subjecting it to some form of surface treatment to prevent the infiltration of rain and water vapor as well as fungal attack. For prolonged outdoor use of its wood, it is advisable to apply some form of surface treatment to protect them from structural and microbial damage [39]. *Q.undulata* is also used as an insecticide [44].

The seeds and seed oil are used to make soap [3]. In Nigeria a paste of the boiled bark and crushed seeds is used as a hair pomade, and in Zimbabwe the seed oil is used by women for the same effect. The seed cake is eaten [3].

Other Uses

Q.undulata oil offers good prospects for the production of biodiesel. Iko et al., studied the physicochemical parameters of the oil as well as its fatty acid profile and showed that it offered good prospects for the production of very good quality biodiesel [52, 53]. Further, Odin, et al., produced and characterized biodiesel from the oil of *Q.undulata* The results obtained show a conversion of 98.6% at 60°C of the oil into biodiesel [34].

The quassinoids fraction extracted from *Q.undulata* seeds inhibits the penetration of juvenile *Meloidogyne javanica* into tomato roots [54]. The quassinoids fraction extracted from the seeds of Q*. undulata* consists of a mixture of three polycyclic lactones: chapparinone, glaucarubolone and klaineanone [22] and in the roots ailanthinone and undulatone are present [23].

USE OF *QUASSIA UNDULATA* (*Q.UNDULATA*)

Quassia undulata leaves are rich in essential nutrients that can benefit both humans and animals. Adeniyi and Lawal., [35] determined the content of nutritional and antinutritional compounds in the leaves of *Q.undulata* It comes out that the leaves have a moisture content of 13.24% and an ash content of 13.24%. Fibers which are compounds that help digestion are present in the leaves at 14.94%. There is a very high carbohydrate content (50.34%) and a small amount of lipids (2.56%). Proteins are present in it up to 12.24%. Regarding antinutritional compounds, 03 have been identified. These are phytic acid (951.67mg/100g), oxalate (636.3mg/100g) and cyanogenic glycoside (139.7mg/100g). Antinutritional compounds are substances present in greater or lesser quantities, which can have a significant influence on the digestive or metabolic use of nutrients. Generally, a large amount of nutrients and antioxidants are needed to neutralize them. **Table 1** summarizes the results obtained in this study.

Table 1:Physico-chemical composition of Q.undulata leaves [35]

Compounds	Concentration (%)
Moisture	13.24
Ashes	6.68
Fiber	14.94
Lipids	2.56
Proteins	12.24
Carbohydrates	50.34
Antinutritional compounds (mg/100g)	
Phytic acid	951.67±14.43
Oxalate	636.3±10.39
Glycoside cyanogene	139.7±0.404

Lawal, et al., [32] determined the mineral element composition of the leaves. The leaves are rich in Calcium, Magnesium, Potassium, Phosphorus and Iron with respective contents (mg/100g) of 651, 481, 220, 160 and 135. Zinc, Copper and Manganese are present in small quantities. **Error! Not a valid bookmark self-reference.** gives the mineral element contents found by Lawal, et al.,.

Table 2:Mineral element composition of *Quassia undulata* leaves [32]

Minerals	Composition (mg/100g)
Calcium	656±0.004
Magnesium	481±0.004
Potassium	220±0.020
Phosphore	160±0.030
Sodium	63±0.003
Iron	135±0.002
Zinc	7±0.001
Copper	3±0.001
Manganese	3±0.001

Q.undulata seeds have an average weight of 0.75-1.8g [3]. The studies made so far have only focused on the oil and the quassinoids content. The investigations of Iko, and al. on the physicochemical properties of *Q.undulata* oil from Nigeria showed that the oil content is 35.07%. This oil has a yellowish color, a bitter taste and a pleasant smell. In addition, Mirailles et al. obtained an oil content of 55.6% from seeds from Senegal with organoleptic properties similar to those of Iko, et al.,. Regarding the physicochemical properties of the oil, the results are summarized in **Table 3**.

Table 3: *Quassia undulata* oil physicochemical properties [3], [33],[52] [55], [56]

Parameters	**Composition**
Average seed weight (g)	0.75-1.8
Saponification index mg KOH/g	93.266
Iodine index gI2/100g	132.78
Peroxide index meq O2/g	6.758
Refraction index	0.7142
Physical state at room temperature	Liquid
Acid index mg NaOH/g	3.759
Oil extraction yield	35.07%-56.9%
Color	Yellow
Taste	Bitter taste
Smell	Good
Moisture	5.8%

The bitterness present in the oil and seeds is mainly due to the presence of quassinoids. Mirailles et al., [22] identified 03 types: Klaineanone, Glaucarubolone and Chapparinone present in the seeds respectively at levels of 4%, 62% and 28%. Two others not identified were isolated with contents of 2% and 4%. In the roots, ailanthinone and undulatone have been isolated there[23].

For fatty acid contents, Iko et al., [52] and Mirailles et al., [22] conducted studies on oil content and fatty acid composition. **Error! Reference source not found.** lists the fatty acids that have been identified in the oil from the seeds. It shows that the oil is mainly made up of oleic acid (≈46%) and stearic acid (≈26 to 33%). Other fatty acids found are palmitic acid (10.6%), linoleic acid and/or its isomer margaric acid (10.45%).

Table 4: Fatty acid composition of *Quassia undulata* oil

Compounds	**Mirailles et al 1988 [22]**	**Iko et al 2012 [52]**
Palmitic acid	10.6%	-
Stearic	26.1%	33.44%
Oleic acid	46.0%	46.36
Linoleic acid	10.0%	-
Linolenic acid	0.3%	-
Margaric acid	-	10.45%
Arachidic acid	4.1%	

QUASSINOIDS

Quassinoids are degradation products of triterpenes, derived from the euphol/tirucalol series, highly oxygenated and structurally complex. Most isolated quassinoids have a skeleton of twenty carbons. They can be classified into five groups: C-18 (1), C-19 (2), C-20 (3), C-22 (4) and C-25 (5a,b), although some do not correspond to any given configuration, such as polyandrol, eurylactones A and B, ailanquassines A and B, 6-dehydroxylongilactone [57]. Figure 3 gives the basic structure of quassinoids. At least 351 natural quassinoids have been isolated and described and a large number of semi-synthetic and synthetic analogues have been prepared for synthetic or medicinal chemistry purposes, mainly in the last 30 years [57].

Quassinoids are highly valued compounds in medicine and in the manufacture of insecticides. The quassinoids present in *Brucea javanica* have shown potent lipolytic [19] and hypoglycemic activities [20]. Those isolated from *Ailanthus altissima* and *Quassia amara* showed antimalarial activities [23, 26, 27]. In a study by García-Barrantes et al. 2011, the role of *Quassia amara* against ulcer was shown [58]. Later, 2-methoxycanthin-6-one was found to be responsible for this property [59]. This is also the case of *Simaba ferruginea* which showed anti-ulcer properties caused by canthin-6-one and 4-methoxycanthin-6-one [60]. Isobrucein B isolated from *Picrolemma sprucei* showed anthelmintic activities [29]. It has been shown that quassinoids accumulate in the xylem of shrubs when growing conditions are not favorable [61]. Figure 4 give the chemical structure of the quassinoids identified in *Quassia undulata*

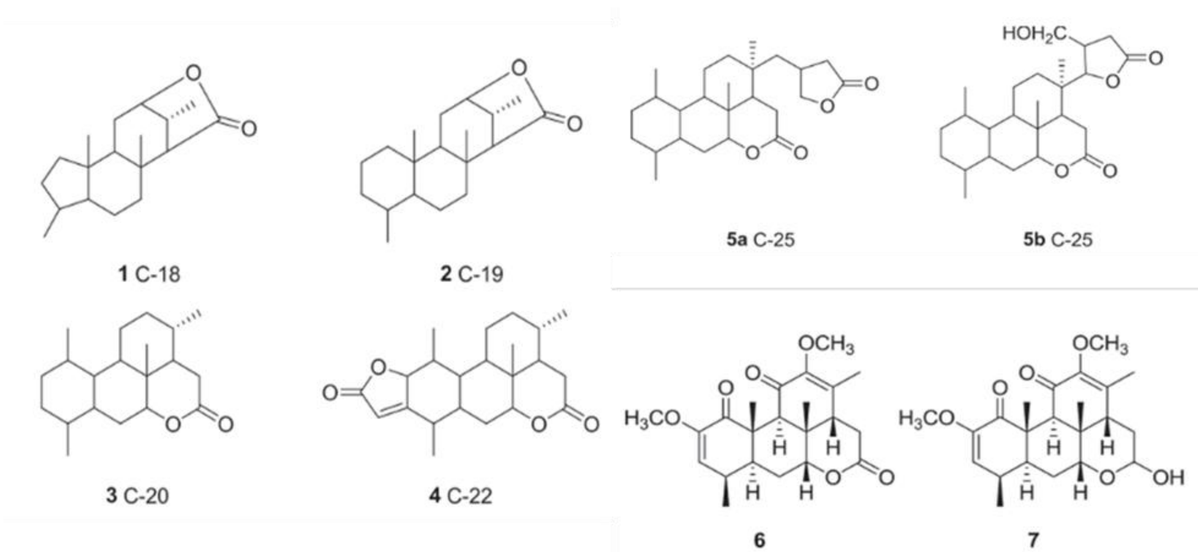

Figure 1: Basic structures of quassinoids [8]

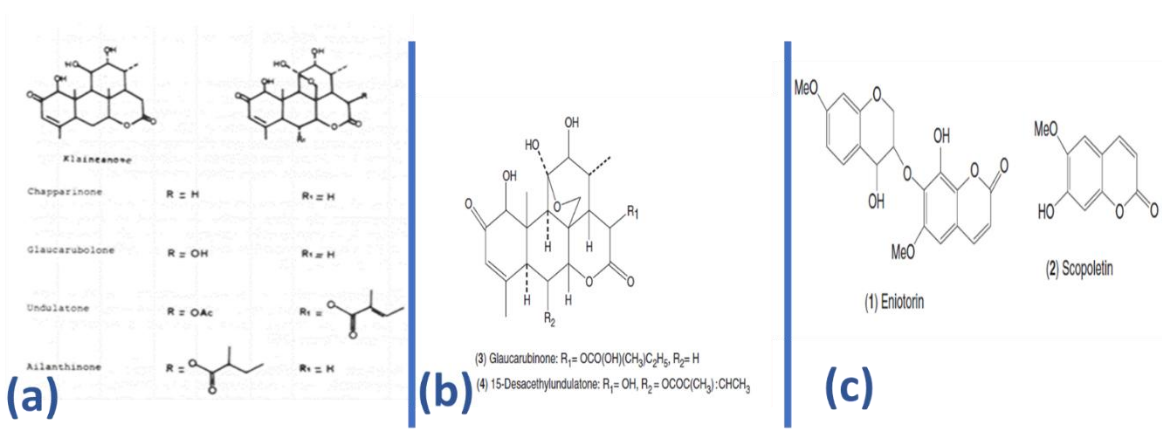

Figure 2: Some chemical structures of quassinoids isolated from *Quassia undulata*
(a) Chemical structures of quassinoids identified in *Quassia undulata* [22][24] ; (b) Chemical structures of Eniotorin and Scopeletin isolated from the bark and roots of *Quassia undulata* [62] ; (c) Chemical structures of Glaucarubinone and 15-Deacetethylundulatone present in the stem and bark of *Quassia undulata* [62].

CONCLUSION

The species *Quassia undulata* is a very variable species that is used in several fields including medicine, food, cosmetics, energy and crafts. In Senegal, its exploitation is limited to the production of wood and the consumption of fruits. In other countries, the oil is used as an ointment for skin and hair. Therefore, the plant gives many perspectives regarding its interesting characteristics.

In a professional context it often happens that private or corporate clients corder a publication to be made and presented with the actual content still not being ready. Think of a news blog that's filled with con.

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