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Ethnobotanical Study of Plants Used to Treat Diabetes, in Traditional Medicine, by Abbey and Krobou People of Agboville (Côte-d'Ivoire)

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Abstract

Diabetes is a disease which affects 3 to 7 % of the population in Côte-d'Ivoire and approximately 6 % in the world. This is a worrying prevalence rate. In the search of means of fighting, man used the medicinal properties of many plants to combat this alarming metabolic affection. During an inventory of medicinal plants in 14 villages of Agboville Department (Côte-d'Ivoire), we discovered that 32 traditional healers used 28 species of plants to develop 27 medicamentous receipts for purpose antidiabetic. The monospecific receipts, 26 of them (96.29 %), are mainly used. Like drugs, in fact leaves (50 %) are requested. The preparation of the medicamentous receipts utilizes mainly decoctions (75 %). The majority of the remedies are employed by oral way, particularly out of drink (100 %). To cure diabetes, the traditional doctors use often the natural resources (plants, animals, minerals). Diabetes is sometimes perceived like a disturbance due to a wizard, a genius or the spirit of the ancestors. In such a situation, it is treated by a fetichor. In its magico-sacerdotal approach, healers associate to natural resources, rites, incantations, carrying pendants and heteroclite objects. The phytochemical screening shows that the antidiabetic effect would be the fact of the following chemical groups: citric acid, malic acid, cyanhidric acid, alkaloids, essential oils (allicine, nerolidol), pectins, peptides (insulin), polyterpenes, proteins (bixine), sterols and triterpenes.

Keywords: Ethnomedicine, Glycaemia, Medicinal plants, Traditional Healers

1. Introduction

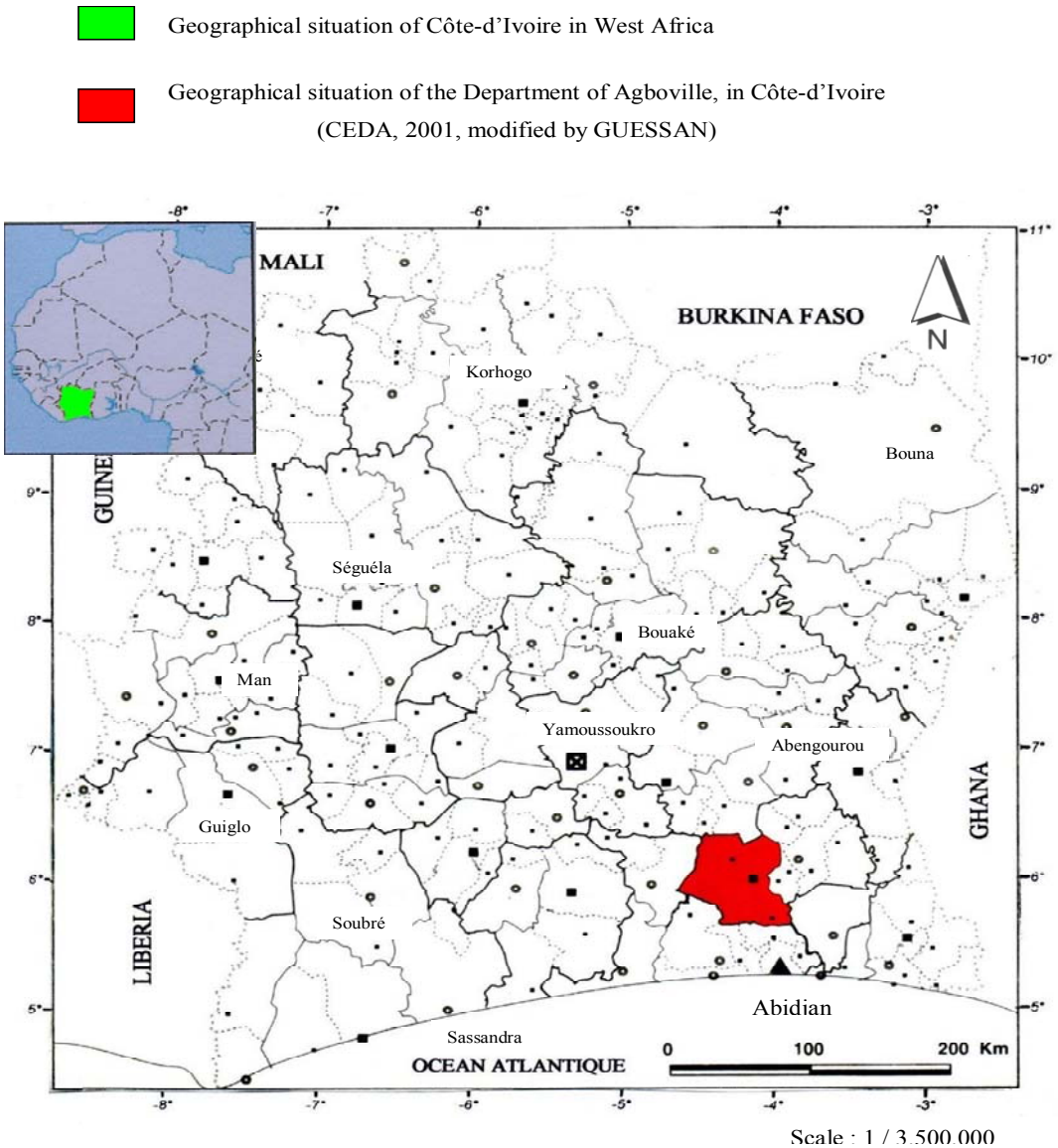
Diabetes is a metabolic disease which exists everywhere in the world and interests approximately 6 % of the world population. Côte-d'Ivoire has 3 to 7 % of diabetics (DJÉDJÉ, 2002). This prevalence rate places the diabetes like most frequent of endocrinien diseases (GENTILINI, 1993). This disorder concerns genetic and exogenic factors (viral, chemical) and damages the β cells of Langerhans, in the pancreas (KADJA, 1998). As a result, the body becomes unable to produce insulin, a pancreatic hypoglycaemic hormone. This disorder is characterized by polyuria (frequent and abundant urines), glycosuria (presence of glucose in urines) and hyperglycaemia (glucose rate on an empty stomach higher than 1.2 g/l in plasma blood and confirmed in at least two occasions). Diabetes comes with other complications (kidney, eye). Diabetes is a major cause of disability and death (DIÈYE *et al*., 2008). Currently, diabetes therapy is based on the use of hypoglycaemics (sulfonamides, biguanides, insulin), on hygieno-diet measures and exercises (REICHARD *et al.*, 1993). If the injections of insulin or other products make it possible diabetic to remain in life, they cannot, however, make it possible to face the many abrupt fluctuations of the insulin rate which the organization needs. Moreover the diabetes requires a life long treatment, which the patients have of the evil to support. In the search of means of fighting, people recognized and used the medicinal properties of many cultivated or wild plants to fight the disease. In Africa and in most of the developing countries, plants' properties are empirically appreciated. In connection with the cure's techniques, they require plants and mystic powers. Despite these traditional health care methods, African medicine is used by 80 % of the rural populations and appears like a sure mean of eradication of diseases (SOFOWORA, 1996). Also, many urban populations turn to treatments using plants. The reason is that traditional medicine is a medicine of proximity, less constraining and non expensive (GBÉASSOR *et al*., 1989; POUSSET, 1989). In the search of fighting means against this metabolic disorder, ethnomedicinal investigations were conducted in Africa and in most of the developing countries (A.C.C.T., 1986; BOUQUET & DEBRAY, 1974; KERHARO J. & ADAM J.G., 1974; NACOULMA, 1996; KONÉ, 2005; NEUWINGER, 1996). Abbey and Krobou people recognized the medicinal virtues of several species of plants they use to treat diabetes. Diabetes seems to be an alarming disease. This study aims at finding new affordable therapies, able to normalize glycaemia and provide scientific evidence of the effectiveness of the traditional use of plants having antidiabetic effect.

2. Material and methods

Study site

Our investigations took place in villages of Agboville Department (figure 1). Located at 80 km of Abidjan, Agboville is part of the Southern forest of Côte-d'Ivoire (West Africa), in the guinea field of the mesophilic sector, characterized by dense moist semi-deciduous forest (CHEVALIER, 1948). Currently, the original vegetation has been degraded by human activities (N'GUESSAN, 2008). Annual average pluviometry is about 1400 mm of water. Its climate, warm and humid, is characterized by two seasons: a dry season from December to February and a long rainy season from March to November, with two peaks: one is the largest recorded in June, the rainy month and the other in October; between the two peaks, there is a period of less rainfall during August. The Department of Agboville had 220,050 inhabitants (SODEFOR, 1999). Abbey and Krobou are two ethnic entities of the Akan group, in the great group Kwa (SOURNIA and ARNAUD, 1978). Nearby the Abbey and Krobou, native people, there is a community of non-natives coming from all the other areas of Côte-d'Ivoire and also a community of foreigners for the most part coming from the West African sub-region and non-African communities (French, Lebanese and Syrian).

Figure 1: Study site



Vegetable and technical material

The vegetable material is represented by all the plants that are subject of this study. As technical equipment, we used a classic material that allowed us to have access to the plants and take some samples to build up a collection of dried plants.

Chemicals

To carry out the phytochemical screening, we used solvents (ether of oil, methanol and distilled water) and various classic reagents. The detail referring to the reagents used is reported in table 1.

3. Methods

Ethnomedicinal survey

The investigation on the traditional use of plants having antidiabetic effect was conducted among 14 native villages in the Department of Agboville (Côte-d'Ivoire). As approach, we met the healers and organized semi-structured interviews. Each of them was met 2 times, at different moments, to answer the same questions. This helped us check the informations we had already collected. During this

ethnomedicinal investigation, we collected informations relating to the plants used to treat diabetes, the different parts used as drugs, their methods of collection and the modes of preparation and administration of the medicamentous receipts. From the collected samples and specimens of the herbarium of the National Floristic Center (C.N.F.), we identified the plants, by their scientific name and we determined their botanical characteristics.

Preparation of the rough extracts

Various drugs were dried during 2 weeks, in the shade, in aired atmosphere, in order to avoid the contamination by the moulds. Then we pulverized them, using an electric crusher and we obtained 200 g of fine powder. We carried out, on this powder, 3 extractions, according to the protocol developed by NEMLIN and BRUNEL (1995). The rough extracts were obtained by successive extractions, with solvents of increasing polarities. In this order, we used oil ether, methanol and water. For the extraction with oil ether, we dissolved 20 g of powder in 60 ml of oil ether. The unit was homogenized by manual agitation during 10 min. The mixture was then filtered. The filtrate obtained was named etheric filtrate 1. On residual marcs, we added 60 ml of oil ether; after 10 min of agitation then filtration, we obtained the etheric filtrate 2. The same operation made it possible to obtain the etheric filtrate 3. These 3 filtrates were gathered and concentrated in to 25 ml on a sand bath. This series of operations led to a concentrated solution which we called etheric extract. After exhaustion with oil ether, residual marcs were dried. The powder obtained was recovered in 60 ml of methanol. Ten (10) min of homogenisation by manual agitation made it possible to obtain the methanolic filtrate 1. The same operation was taken again and it gave the methanolic filtrate 2. The 2 methanolic filtrates joined together were filtered and concentrated in to 25 ml, with a sand bath, to give the methanolic extract. After exhaustion with methanol, residual marcs were dried. The powder obtained was recovered in 50 ml of distilled water. The unit was homogenized by manual agitation during 15 min. The mixture was then filtered. The filtrate obtained was named aqueous extract.

Characterization of the chemical groups

Classical methods described in works of RONCHETTI and RUSSO (1971), HEGNAUER (1973), WAGNER (1983), BÉKRO *et al.* (2007) were used to characterize the chemical groups. The detail concerning the used reagents and the characteristic reactions of the chemical groups is in table 1.

Table 1: Reagents and tests of characterization of the chemical groups

Chimical Groups		Reagents	Reaction indicating that the test is positive
Alkaloids		Dragendorff	Precipitate or orange colouring
		Buchard	Reddish-brown precipitate
Flavonoids		Cyanidine	Heat then pink-orange or purplished colouring
Polyphenols		Ferric chloride	Blackish-blue or green ± dark colouring
Quinones		Bornstraegen	Red or purple colouring
Saponosides		Foam Test	Persistent foam, higher than 1 cm
Sterols and Polyterpenes		Liebermann	Crimson or purple ring, changing blue then green.
Tanins	Catechic	Stiasny	Precipitate in large flakes
	Gallic	Stiasny	blue-black deep colouring

4. Results and discussion

Botanical characteristics of the studied plants

The ethnomedicinal investigations that we conducted in the Abbey and Krobou areas, with several traditional healers from villages located in the Department of Agboville in Côte-d'Ivoire, made it

possible to identify 28 species of plants used in traditional medicine to treat diabetes. These species of plants (table 2) belong to 27 genera and 22 families. There are 17 orders, 07 sub-classes, 2 classes (Monocotyledons and Dicotyledons), 01 sub-phylum (Angiosperms) and 01 phylum (Spermaphytes). Spermaphytes constitute the essence of the antidiabetic arsenal, in the present study. The 26 Dicotyledons, representing 96.42 % have the highest number of plants. The family of Euphorbiaceae, with 03 individuals, is the best represented. This representation was not also observed during ethnomedicinal investigations in other areas of Côte-d'Ivoire and in Africa, concerning the plants exerting antidiabetic properties. Comparing our results to other works show variability in the number of individuals listed from one study to another. In OUATTARA's study (2006), 03 plants species representing 1.78 % of the plants identified during the ethnomedicinal study conducted in the area of Divo with the Dida people (South of Côte-d'Ivoire), have antidiabetic effect. The Spermaphytes constitute the greater part of the antidiabetic therapeutic means in this study as well in OUATTARA's (2006). In his study related to the populations of Issia (Mid-West of Côte-d'Ivoire), ZIRIHI (1991) did not mention the use of any plant having antidiabetic effects. TRA BI (1997) does not mention any plant with the antidiabetic effects, in his study relating to the census of the plants used by the man, in the classified forests of Haut-Sassandra and of SCIO, in Côte-d'Ivoire. ADJANOHOUN and AKÉ-ASSI (1979) undertook a significant study on the medicinal plants of Côte-d'Ivoire; however no plant exerting an antidiabetic effect was mentioned. In their study devoted to the medicinal plants of Senegal, KERHARO and ADAM (1974) report that 09 species of plants are employed in the combat of diabetes. NEUWINGER (1996) indicated the use of 09 species of plants exerting antidiabetic properties. An ethnobotanical study undertaken in Caribbean indicated that 06 species of plants are used for their antidiabetic effects. We note, from one study to another, a variability of the number of antidiabetic plants. This variability would be due to the variations in the methods of investigation; it could be also explained by the differences of locality or habits.

From the viewpoint of Morphological Types, we divided the taxons we identified in 05 groups: trees, shrubs, sub-shrubs, lianas and herbs (table 3). The shrubs (32.14 %) are mainly employed. This result is very different to that obtained by OUATTARA (2006) who indicated that only the trees are used in the treatment of the diabetes, by Dida people, in Côte-d'Ivoire. The massive use of shrubs is due to the fact that these plants can be found everywhere, in the immediate environment of the users and their different organs are easily accessible.

Table 2: Systematic groups of studied plants

Plants species used	Family	Order	S/C	Classes
Allium sativum	Liliaceae	Liliales	Liliidae	Monocotyledons
Anchomanes difformis	Araceae	Arales	Arecidae	Monocotyledons
Annona muricata	Annonaceae	Magnoliales	Magnoliidae	Dicotyledons
Azadirachta indica	Meliaceae	Sapindales	Rosidae	Dicotyledons
Bixa orellana	Bixaceae	Violales	Hamamelidae	Dicotyledons
Blighia sapida	Sapindaceae	Sapindales	Rosidae	Dicotyledons
Cassia occidentalis	Caesalpiniaceae	Fabales	Rosidae	Dicotyledons
Chromolaena odorata	Asteraceae	Asterales	Asteridae	Dicotyledons
Chrysophyllum cainito	Sapotaceae	Ebenales	Dilliniidae	Dicotyledons
Citrus aurantifolia	Rutaceae	Sapindales	Rosidae	Dicotyledons
Cleistopholis patens	Annonaceae	Magnoliales	Magnoliidae	Dicotyledons
Clerodendrum inerme	Verbenaceae	Lamiales	Asteridae	Dicotyledons
Combretum paniculatum	Combretaceae	Myrtales	Rosidae	Dicotyledons
Crescentia cujete	Bignoniaceae	Scrophulariales	Asteridae	Dicotyledons
Daucus carota	Apiaceae	Apiales	Rosidae	Dicotyledons
Jatropha curcas	Euphorbiaceae	Euphorbiales	Rosidae	Dicotyledons
Jatropha gossypiifolia	Euphorbiaceae	Euphorbiales	Rosidae	Dicotyledons
Mangifera indica	Anacardiaceae	Sapindales	Rosidae	Dicotyledons
Momordica charantia	Cucurbitaceae	Violales	Hamamelidae	Dicotyledons
Nauclea latifolia	Rubiaceae	Rubiales	Asteridae	Dicotyledons
Persea americana	Lauraceae	Laurales	Magnoliidae	Dicotyledons
Picralima nitida	Apocynaceae	Gentianales	Asteridae	Dicotyledones
Psidium guajava	Myrtaceae	Myrtales	Rosidae	Dicotyledons
Ricinus communis	Euphorbiaceae	Euphorbiales	Rosidae	Dicotyledons
Solanum lycopersicum	Solanaceae	Solanales	Asteridae	Dicotyledons
Spathodea campanulata	Bignoniaceae	Scrophulariales	Asteridae	Dicotyledons
Terminalia catappa	Combretaceae	Myrtales	Rosidae	Dicotyledons
Vernonia colorata	Asteraceae	Asterales	Asteridae	Dicotyledons
Total : 28 Espèces	**22 Familles**	**17 Ordres**	**07 S/Classes**	**02 Classes**

Table 3: Morpho-Biological Types and Chorological Affinities of the listed plants

Plants species used	Morphological Types	Biological Types	Chorological affinities	Status
Allium sativum	Herb	Hemicryptophyte	I	Cultivated
Anchomanes difformis	Herb	Cryptophyte	GC	Wild
Annona muricata	Shrub	Microphanérophyte	I	Cultivated
Azadirachta indica	Shrub	Microphanérophyte	I	Cultivated
Bixa orellana	Shrub	Microphanérophyte	I	Cultivated
Blighia sapida	Tree (medium)	Mesophanérophyte	GC-SZ	Wild
Cassia occidentalis	Sub-Shrub	Nanophanérophyte	GC-SZ	Wild
Chromolaena odorata	Herb	Nanophanérophyte	GC	Wild
Chrysophyllum cainito	Tree (small)	Microphanéphyte	I	Cultivated
Citrus aurantifolia	Shrub	Microphanérophyte	I	Cultivated
Cleistopholis patens	Tree (medium)	Mesophanérophyte	GC	Wild
Clerodendrum inerme	Liana	Microphanéphyte	I	Cultivated
Combretum paniculatum	Liana	Mesophanérophyte	GC	Wild
Crescentia cujete	Shrub	Microphanérophyte	I	Cultivated
Daucus carota	Herb	Nanophanérophyte	I	Cultivated
Jatropha curcas	Sub-Shrub	Nanophanérophyte	I	Cultivated
Jatropha gossypiifolia	Sub-Shrub	Nanophanérophyte	I	Cultivated
Mangifera indica	Tree (medium)	Mesophanérophyte	I	Cultivated
Momordica charantia	Liana	Nanophanérophyte	GC	Wild
Nauclea latifolia	Liana	Microphanérophyte	GC-SZ	Wild
Persea americana	Tree (small)	Microphanéphyte	I	Cultivated
Picralima nitida	Tree (small)	Microphanéphyte	GC	Wild
Psidium guajava	Shrub	Microphanérophyte	I	Cultivated
Ricinus communis	Shrub	Microphanérophyte	I	Cultivated
Solanum lycopersicum	Herb	Therophyte	GC-SZ	Cultivated
Spathodea campanulata	Tree (medium)	Mesophanérophyte	GC	Wild
Terminalia catappa	Tree (small)	Microphanéphyte	I	Cultivated
Vernonia colorata	Shrub	Microphanérophyte	GC-SZ	Wild
Total : 28 Espèces	**05**	**04**	**03**	**02**

Note: Signification of symbols: I: Introduced; GC: Guineo-Congolais; SZ: Soudano-Zambesienne

Four Biological Types (Cryptophytes, Hemicryptophytes, Phanerophytes, Therophytes) were listed (table 3). The Phanerophytes are in the majority (89.28 %). Among Phanerophytes, the Microphanérophytes (50 %) are the best represented. Sixteen (16) introduced plants, representing 57.14 %, are mainly used. There are 12 Spontaneous wild plants that's to say 42.85 %; this does not represent the majority. This is because human beings do harm to their immediate environment, and these harms obviously result in the disappearance of original structures. These aggressions have as corollary the disappearance of the original formations, consequently, a regression of the wild spontaneous species. Another reason which could explain why these wild spontaneous plants do not constitute the majority, lies in the fact of the long distance to traverse, to get these medicinal products, in the event of need.

Ethnomedicinal characteristics of identified plants

During this Ethnomedicinal study conducted in the Department of Agboville, we met 32 traditional healers, native of 14 villages who agreed to collaborate with us by providing informations on antidiabetic plants (table 4). They were 17 men and 15 women. The oldest person of these healers is a man who is about 70 years and the youngest one is 30 years old. We met a lot of traditional doctors who treat diabetes (06 or 18.75 %) in Aboudé-Mandéké.

The ethnomedicinal characteristics of the plants, the different parts used as drugs, the methods of preparation and administration of medicamentous receipts, are consigned in table 5. There are different ways of acquiring the art of medicine (night visions, revelations of spirits, purchase of medicinal formulas, intuition, observations on animals, conversations, meetings of exorcism). For

making a diagnosis, the healers proceed by questioning the patient, general observation, examination with the hands, instruments, examination of an animal, examination of urine, stools, eyes, saliva, the use of cowries, communication with the spirits. Healing requires sometimes, rites and incantations as well as wearing pendants and heteroclite objects.

We note that 27 medicamentous receipts are developed to treat diabetes. The monospecific receipts (26), representing 96.29 %, are mainly used. This result is similar to that of OUATTARA (2006) who indicated that all the medicinal formulas are monospecific. The monospecific formulas are in the majority in the two studies in question. This preponderance of monospecific receipts is in the patients' interest. Combining ill-matched plants is sometimes dangerous. In Africa, about 30 % of fatal accidents are caused by mixtures (El-SAID *et al*., 1969).

The following organs are used as drugs: bulb, flower, fruit, leaf, rhizome, root bark, seed, stem bark and tuber. The leaves (50 %) are the most used. This result is in the line with OUATTARA's (2006); he showed that the leaves are mostly used in 66.66 % of the cases. Therefore, there is an important sampling of the leaves. This sampling is not harmful to the plant, according to

Table 4: Overview of interviewed traditional healers per visited village

Villages	Traditional healers (Number)	Sex		Age (years)
		Male	Female	
Aboudé-Kouassikro	01	01	00	45
Aboudé-Mandéké	06	04	02	30-68
Allahin	02	01	01	45-50
Azaguié-Ahoua	01	00	01	52
Erimankouguié 1	03	01	02	32-70
Gbessé	02	00	02	33-60
Grand-Yapo	01	01	00	36
Guessiguié 1	02	01	01	40-50
Kassiguié	04	03	01	37-58
Loviguié 1	03	02	01	39-55
Offa	02	01	01	41-54
Offoriguié	03	01	02	33-62
Offoumpo	01	01	00	50
Oress-Krobou	01	00	01	54
Total: 14 villages	**32**	**17**	**15**	**30-70**

Tableau 5: Indications on the methods of preparation and administration of medicines

Plants species used	Part used	Modes of Preparation	Medicamentous Forms	Modes of Adminitration
Allium sativum	Bulb	Maceration	Macerated	Drink
Anchomanes difformis	Rhizome	Maceration	Macerated	Drink
Annona muricata	Leaf	Infusion	Infused	Drink
Azadirachta indica	Stem bark	Decoction	Decocte	Drink
Bixa orellana	Leaf	Decoction	Decocte	Drink
Blighia sapida	Leaf	Decoction	Decocte	Drink
Cassia occidentalis	Leaf	Decoction	Decocte	Drink
Chromolaena odorata	Root bark	Decoction	Decocte	Drink
Chrysophyllum cainito	Leaf	Decoction	Decocte	Drink
Citrus aurantifolia	Fruit	Expression	Juice	Drink
**Cleistopholis patens*	Leaf	Kneading + water	Paste	Drink
Clerodendrum inerme	Leaf	Decoction	Decocte	Drink
Combretum paniculatum	Root bark	Decoction	Decocte	Drink
Crescentia cujete	Leaf	Decoction	Decocte	Drink
Daucus carota	Tuber	Grated, Expression	Juice	Drink
Jatropha curcas	Leaf	Decoction	Decocte	Drink
Jatropha gossypiifolia	Root bark	Decoction	Decocte	Drink
Mangifera indica	Leaf	Decoction	Decocte	Drink
Momordica charantia	Leaf	Decoction	Decocte	Drink
Nauclea latifolia	Stem bark	Decoction	Decocte	Drink
Persea americana	Seed	Decoction	Decocte	Drink
Picralima nitida	Seed	Decoction	Decocte	Drink
Psidium guajava	Leaf	Decoction	Decocte	Drink
Ricinus communis	Flower	Infusion	Infused	Drink
Solanum lycopersicum	Fruit	Decoction	Decocte	Drink
Spathodea campanulata	Stem bark	Decoction	Decocte	Drink
**Terminalia catappa*	Leaf	Decoction	Decocte	Drink
Vernonia colorata	Leaf	Decoction	Decocte	Drink

Note: Symbole:*: Bispecific receipt: Association *Cleistopholis patens* and *Terminalia catappa*

POFFENBERGER *et al*. (1992) who said that sampling 50 % of the leaves of a plant does not significantly affect its survival.

There are different methods of sampling. For the underground system (roots), the sampling is made with a hoe. Easily accessible specimens (leaves) are usually picked by hand. The flowers and the inflorescences are pulled by hand or harvested with special tools. The fruits are harvested when they are completely ripe, by using hands or with a billhook. For the epidermis of stem, the procedure consists in scraping with knives, broken glasses or snail shells; concerning the stems and roots of woody specimens the barking is done with machetes. For rather high specimens, people loop the branches off, thanks to special tools (billhooks); the ax is used for the cutting down of large, high and inaccessible specimen; in some cases, the sampling is made with the teeth. The uprooting, the looping off of branches, the cutting down, the barking, are harvesting methods reported by OUATTARA (2006) in his study on medicinal plants in Divo (Southern forest of Côte-d'Ivoire). The author stated that, most of the times, the barking leaves huge scars through which these plants are, later on, attacked by fungi, birds and caterpillar's infestation. The uprooting, the looping of branches, the cutting down, the barking, prove to be harmful because these methods of sampling prevent the plant from blooming, induce infections and are the source of the threat of species extinction (ANOMA and AKÉ-ASSI, 1989).

The mortar, the flat stone, the pebble, the canary, the saucepan, the gourd are used to prepare medicines. There are different modes of preparation: decoction, expression, infusion, maceration, kneading and grated. The decoction (75 %) is the most widespread method of preparation. This result is not similar to OUATTARA's (2006) who showed that the trituration is applied in 100 % of cases in the Department of Divo (Côte-d'Ivoire). Gourds, goblets, jugs, ladles, spoons, glasses (liqueur or beer),

cups are used to administer the medicines by oral routes. The fruits of *Lagenaria siceraria* (Cucurbitaceae) are used to administer medicines by rectal route for the purging purpose. The drink is the only mode of administration. This result tallies with that of OUATTARA (2006) who indicated that drink (66.66 %) is the most used method of administration of medicines.

According to some studies, we notice interesting similarities with some plants which antidiabetic use; their effect is recognized by other ethnic groups. (NEUWINGER, 1996) indicated that the Ibo in Southeast Nigeria produce medication from the seeds of *Picralima nitida* (Apocynaceae) for diabetes; in Benin, diabetics drink the tuber (rhizome) decoction of *Anchomanes difformis*, to fight diabetes; the stem bark decoction of *Spathodea campanulata* (Bignoniaceae) is used in Rwanda to treat diabetes. The Wolof of Senegal use fruit powder of *Momordica charantia* (Cucurbitaceae) as excellent hypoglycaemics and several of the polypeptides with a high molecular weight isolated from the seeds proved to be highly effective in many experiments as substances similar to insulin (KERHARO and ADAM, 1974; NEUWINGER, 1996). In the Caribbean, people use the decoction of *Annona muricata* leaves in the treatment of diabetes (A.C.C.T., 1989). The decoction of stem bark of *Chrysophyllum cainito* (Sapotaceae) is used to fight diabetes by the Dida people in the area of Divo in Côte-d'Ivoire (OUATTARA, 2006). The decoction of leaves of *Blighia sapida* (Sapindaceae) is recommended for drinking in Burkina Faso (NACOULMA 1996).

Rituals for the collection of medicines, diagnosis and cure of the patient

Diabetes is sometimes perceived as a disturbance caused by a wizard, a genius or the spirit of ancestors. In such a situation, it is treated by a fetichor. Some fetish healers proceed by libation of palm wine to foretell the patient's fate. The signs on the ground or the floor are then interpreted. It may mean an agreement or disagreement of the ancestors, in which case the patient will be cured or not. In most cases, the diagnosis of a mystical illness occurs through a divination gear with various elements that can vary by one fetish healer to another. It may consist in water or a mirror showing the face of the wizard or the criminal, the interpretation of the position of cowries thrown on the floor or on a mat, palmistry or examination of fingerprints and horns, bones, masks and statuettes which the healer talks to and receives informations. All this gear shows that the diagnosis is divine and that the healer is a just a medium, an intermediary between gods (spirits, ancestral spirits) and men. This gear has a psychological effect of security and trust, which also makes the patient regain strength. The methods of consultation sometimes include songs, dances and trances. The fetish healer must communicate with the gods personified by the ancestral spirits, and the wizards who are possessor of the evil forces in order to fall into a trance state and indicate the supernatural origin of the disease. He is painted with kaolin and powder and holds an egg in his left hand, an oxtail in the right hand. His special clothes consisting in a white dress, necklaces, bracelets and legs-white pearls is a sign of purity. Following inaudible words by the assistance and special songs with the tam-tam, the fetish healer dances, go into a trance; the consultation may then begin, sometimes in a foreign language, which requires a translation by a member around him. During this magic ritual, the fetish healer asks forgiveness from the gods for the cure of his patient, sometimes he succeeds in driving away the evil spirit. The means and the fees for recovery are then fixed. It may be a potion prepared by the traditional doctor; this potion will be used for drinking and for ablution. It is stored in a clay pot or a gourd, never in a metal bowl. The patient may be asked to confess his sins, speak magic words and sprinkle with some extracts or juice of a plant. Generally people use a potion prepared with the leaves of *Scoparia dulcis* (Scrophulariaceae), which is supposed to drive away evil spirits; it may also consist in offering an animal (chicken, sheep) as a sacrifice; the collected blood is used to sprinkle the altar of the sanctuary, the animal is cooked and the meal offered on this altar or put on the grave of a deceased parent. Sometimes people have to offer powder, liqueur, eggs or give a modest sum (5 FCFA, 100 FCFA or a little more). The fetish healer may recommend the patient to wear heteroclite objects (bones of

crocodile, duck or other animal, a piece of metal), pendants (piece of wood), cowries, pearls in order to protect the victim against the evil spirits.

Rituals are sometimes necessary before sampling some plants, that's the case for the leaves of *Blighia sapida* (Sapindaceae). It is thought that spirits live in this tree that people worship. It is said that this tree can become a human being when people try to cut it down in order to sample its seeds. Sampling this tree is therefore not simple to make. Sacrifices must be offered, and this can be an old coin (1 FCFA or 2 FCFA for example), in that case, the coin shall be put at the base of the tree. Other times a bloody sacrifice consisting in sprinkling the base of the trunk of the tree with the blood of chicken or sheep is required. In some cases, the treatment comes with incantations or puns that being associated with the prepared drugs constitute the medicine. Blessings are called on the medicine through the incantations. For example, that's the case when people use the seeds of *Picralima nitida* (Apocynaceae). For fear of curse, it is recommended not to collect the organs of *Morinda lucida* (Rubiaceae) at night. Concerning the status of the collector, he is ordered to refrain from having sex 24 hours before making the sample. A mixture made up of a powder of *Cassia occidentalis*'s seeds roasted and then crushed is used in a drink. The obtained powder is stored in animal horns, especially in the horns of a gray hind or *Cephalophus maxwellii* H. Smith, 1827 (Cephalofinae). In this case, the powder is kept in a dark place. If it is thought that the disease is caused by a sorcerer spirit, this powder will be stored in small bottles surrounded by a stream of cowries, to prevent the wizard from neutralizing the therapeutic efficiency of the powder.

Phytochemical and pharmacological characteristics

Experimental validation for the medicinal activity of plants using phytochemistry

We performed a primary validation of the traditional medical practices, by looking for the chemical groups that explain the antidiabetic effect for some plants. Eight (08) plants of this study have been the subject of a phytochemical screening we have already carried out (N'GUESSAN, 2008). Table 6 gives the obtained results. We note that the antidiabetic effect would come from the following chemical groups: alkaloids, sterols and triterpenes.

Non experimental validation for the medicinal activity of plants using phytochemical / pharmacogical literature

According to the literature, we present below, the pharmacological activity and the phytochemical composition that confirm the traditional use of some antidiabetic plants of this study (table 7). We note that the antidiabetic effect results from several chemical elements: alkaloids, citric acid, cyanhidric acid, malic acid, essential oils (allicine, nerolidol), pectins, peptides (insulin), proteins (bixine), sterols and triterpenes.

Tableau 6: Experimental validation for the medicinal activity of plants using phytochemistry

Plants species	Validation of antidiabetic effect using phytochemistry (N'GUESSAN, 2008)
Chromolaena odorata	Alkaloids: Stimulatives of the hepatic glycogenogenesis
Chrysophyllum cainito	Alkaloids: Stimulatives of the hepatic glycogenogenesis
Clerodendrum inerme	Alkaloids: Stimulatives of the hepatic glycogenogenesis
Jatropha curcas	*Sterols, triterpenes: Stimulatives of the insulin release*
Jatropha gossypiifolia	Sterols, triterpenes: Stimulatives of the insulin release
Mangifera indica	Sterols, triterpenes: Stimulatives of the insulin release
Persea Americana	Sterols, triterpenes: Stimulatives of the insulin release
Terminalia catappa	Alkaloids: Stimulatives of the hepatic glycogenogenesis

Tableau 7: Non experimental validation for the medicinal activity of plants using phytochemistry or pharmacology

Plants species	Phytochemistry/Pharmacology	Literature
Allium sativum	Essential oil (allicine): Hypoglycaemic effect	Pinkas et al. (1986)
Anchomanes difformis	Alkaloids: Stimulate the hepatic glycogenogenesis	Neuwinger (1996)
Annona muricata	Sterols: Stimulatives of the insulin release	A.C.C.T. (1989)
Azadirachta indica	Alkaloids: Stimulate the hepatic glycogenogenesis	Nacoulma (1996)
Bixa orellana	Protein (Bixine) : Stimulate insulinogenesis	A.C.C.T. (1989)
Blighia sapida	Sterols: Decrease the rate of blood glucose	Nacoulma (1996)
Cassia occidentalis	Triterpenes: Stimulatives of the insulin release	Neuwinger (1996)
Citrus aurantifolia	Citric acid: Stimulatives of the insulin release	A.C.C.T. (1989)
Cleistopholis patens	Alkaloids: Stimulate the hepatic glycogenogenesis	Bouquet (1974)
Combretum paniculatum	Sterols: Stimulatives of the insulin release	Nacoulma (1996)
Crescentia cujete	Cyanhidric acid: Stimulatives of the insulin release	A.C.C.T. (1989)
Daucus carota	Pectin: Stimulatives of the insulin release	Garnier et al. (1961)
Momordica charantia	Peptides (insuline): Hypoglycaemic effect	Anonyme (1997)
Nauclea latifolia	Sterol (β-sitostérol): Stimulate of the insulin release	Nacoulma (1996)
Picralima nitida	Alkaloid (Picraline): Hypoglycaemic effect	Anonyme (1996)
Psidium guajava	Essential oil (nérolidol): Hypoglycaemic effect	A.C.C.T. (1989)
Ricinus communis	Sterols: Decrease the rate of blood glucose	Nacoulma (1996)
Solanum lycopersicum	Malic acid: Stimulatives of the insulin release	A.C.C.T. (1989)
Spathodea campanulata	Triterpenes: Hypoglycaemic effect	Neuwinger (1996)
Vernonia colorata	Triterpene (vernolide): Hypoglycaemic effect	Kerharo (1974)

Conclusion

The ethnomedicinal investigations conducted in the Department of Agboville (Côte-d'Ivoire) show that 28 species of plants are used by Abbey and Krobou people for the treatment of diabetes. The drugs (bulb, flower, fruit, leaf, rhizome, root bark, seed, stem bark and tuber) are used to develop many medicinal preparations by decoction, expression, infusion, maceration, kneading and grating. The decoction (75 %) is the most widespread method of preparation used by healers. The drink is the only mode of administration. The treatment of diabetes is a matter for two kinds of healers: the traditional doctors using only natural resources, essentially plants and the healers using fetish. When the disorder is supposed to be mystical, the fetish healer is called in to beg the god's forgiveness. In his priestly magic approach he uses the natural resources that he closely associate with rituals, incantations and the wearing of pendants and disparate objects.

According to some studies, we found similarities with many species of plants which antidiabetic effect is recognized by other ethnic groups. The antidiabetic effect would results from several chemical elements: alkaloids, citric acid, cyanhidric acid, malic acid, essential oils (allicine, nerolidol), pectins, peptides (insulin), proteins (bixine), sterols and triterpenes. The phytochemical and informations indicate the rightfulness of the traditional use of the studied plants as antidiabetics.

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