Original Research Article

Antioxydant and Ethnobotanical study of *Strychnos icaja* Baillon (Loganiaceae) from Gabon

ABSTRACT

Aim: Oxidation is a phenomenon linked to life itself: oxidation provides the energy necessary for our cells and to defend themselves against external aggressions. However, it is the combination with oxygen that causes the appearance of free radicals in our body, unstable molecules greedy for electrons and which cause biochemical chain reactions. These free radicals, so useful because they allow the homeostasis of the organism, at the same time cause oxidative stress which inexorably causes the aging of this organism. There is a large amount of vitamin (A, B, C, E), mineral (Zn, Cu, Se) and biochemical (glutathione, taurine, phenol acids) substances which also have a well-known antioxidant power. These substances are found in plants: knowing them allows us to affirm that phytotherapy has its place in the fight against aging caused by oxidative stress and the oxidative component of acute pathologies: infectious, traumatic, inflammatory and allergic. This is why we are interested in *Strychnos icaja* Baillon (Loganiaceae) which is a tropical shrub common in the tropical forest of Central Africa. This *Strychnos* species is mainly used by the local population as an arrow or ordeal poison, to treat haemorrhoids but also been used by Pygmies tribes from Cameroon to treat persistent malaria, it's also used for his magic-medical property.

Methodology: Extracts of alkaloids, aqueous, ethyl acetate, dichloromethane and butanol were evaluated for their antioxidant properties. An ethnobotanical survey of 20 traditional therapists was carried to obtain the medicinal uses of the root of

Strychnos icaja.

Results: 1,1-diphenyl-2-picryl-hydrazyl (DPPH) test shows good antiradical activity. Antioxidant activity by the ferric reducing antioxidant power (FRAP) test, show that *Strychnos* total alkaloids of the roots have a value of 5.94 ± 0.14mmol EAA/g that is significantly close from Ascorbic acid (5.86 ± 0.51 mmol EAA/g). Our survey of traditional therapists allowed us to identify six indications of this plant, namely in the treatment of haemorrhoids, against ear infections, male urethritis, rheumatic and dental pain and sterility in women.

Conclusion: The *Strychnos icaja* have a good antioxidant activity, it is also used in the treatment of inflammatory diseases.

Keywords: Strychnos icaja, antioxidant, medicinal plant, inflammatory diseases

1. INTRODUCTION

Gabon is located astride the equator. It has an area of 267,667 km ² with a forest that covers 80% of the territory. This forest contains many species that are used by people in therapy to prevent or cure certain conditions [1]. The majority of these people had faith in traditional medicine, some people use it in any exclusivity while others adopt in addition to modern medicine. It concerns the treatment of common ailments and has an alternative to the failures of modern medicine. In addition to these uses, many attribute magical properties to certain medical-species which are used not only during the various ceremonies rite (marriage, bereavement, initiation, etc.) but also to treat conditions such as spells, bad eye, etc. In general, traditional medicine is used today as it once was, despite the rise of modern medicine, and especially since the emergence of' "so-called incurable diseases." Hence our interest in *Strychnos icaja* is a plant commonly used by people who attribute properties therapeutic and magic [2]. The *Strychnos icaja* Baillon, is known by the vernacular names: Ikaza (Mpongwè), Ikadja kwaï (Benga), Kasé (Bakèlè), Mbundu (Galoa, Nkomi, Oroungu, Ngowé, Eshira, Bavarama, Bavoungou, Bapunu, Balumbu, Bavili, Baduma, Banzabi, Loango, Masangu, Mindumu), Mbondo (Ivea, Bavové, Bakota), Molela (Apindji), Mvya (mitsogo), Bilon (Fang) [3]. It belongs to the Loganiaceae family, is a liana that can reach a height of 20-40 m and a length of 20-100 m with a stem of 4-15 cm in diameter. The *Strychnos icaja* Baillon occurs in the forests of Central Africa (Congo, Cameroon, Rwanda, and Gabon). It is a plant of dense forests and secondary [4]. Root barks are used as an arrow poison by some pygmy tribes of Cameroon. This toxicity was attributed to the strychnine and hydroxystrychnine mono-indole alkaloids isolated from the roots by Sandberg et al. [5, 6, 7]. They are also used in the treatment of malaria. Root barks are used in sitz baths against haemorrhoids. Dry root bark powder, mixed with palm oil, is applied topically to affected areas in dry or oozing skin dermatoses [8]. It would be aphrodisiac at low doses. It is also used as an emetic, to " wash the belly " and against ear infections. In addition to its therapeutic use, the root is frequently used by populations for its pharmacological properties. The macerated root rasp is used in the treatment of measles, the decoction of liana against beriberi, the calcination of leaves against back pain and diabetes, the decoction of leaves

and roots against epilepsy [9]. *The Strychnos icaja* been the subject of several studies, particularly on alkaloids; vomicine; 19,20-α-epoxinovacin; 19,20-α-epoxy, 15-hydroxynovacin; strychnine; isostrychnine; bisnordihydrotoxiferrin: sungucine; isosungucine; 18-hydroxysungucin; 18-hydroxyisosungucin were isolated from the roots of Strychnos icaja from Congo [10, 11]. These compounds, in particular 18-hydroxy isosungucine, are moderately active against Plasmodium falciparum. Another compound, Strychnogucin B is cytotoxic against the human KB cell line of cancer and human fibroblasts WI38 [12]. Lusakibanza M et al [13] have also shown that the methanolic and dichloromethane extracts of the root bark had a very good selectivity index on falciparum strains. In addition to this interesting antimalarial activity, it showed moderate in vitro antitrypanosomal activit [14]. We know that free radicals are responsible for degenerative diseases like Alzheimer and Parkinson's or chronic diseases like diabetes, cancer, inflammatory diseases. Thus we hypothesize that this plant which has demonstrated anti-cancerous properties and which is used in the treatment of epilepsy by traditional therapists could have antioxidant properties. Our work aims are to determine the uses nowadays of this plant today and to assess its antioxidant potential.

2. MATERIALS AND METHODS

2.1 Plant materiel

The harvest was conducted between January and March 2020. Plants were harvested in the forest of the Cap Mondah Esterias. The identification of plant material has been made on the ground and the National Herbarium of Gabon. Drying takes place in the shade at room temperature for 2-3 weeks. A voucher specimen was deposed in this department (Maesen et al.5907; A.J.M. Leuwenberg.11470; J.M.et B. Reitsma.2137; R. Sita.5172). Data collection
The surveys were conducted on three cities: Libreville, Lambarene and Cap Esterias. In total 20 traditional therapists and users were surveyed. During these interviews, we asked those surveyed what were nowadays the medicinal uses of Strychnos.

2.2 Preparation of the aqueous extract

The spraying was done after drying the harvested plants. We used a flail chopper (Model SK 100) for the coarse powder. The study covered the entire plant and we crushed separately leaves, stems and roots. The aqueous extract of the root where obtained by macerating 100 mg of root in 500 ml of water during 24H. After filtration the marc is returned two more time. Filtrates were collected and frozen (Laborota 4002-Control Heidolph, Germany), then lyophilized.

2.3 Preparation of extracts by solvents of increasing polarity

50 g of Strychnos icaja roots powder is macerated for 24 hours with acetone/water (80:20). After filtration, acetone is removed in a rotavapor at 40°C. The aqueous extract is taken with butanol and shook in a funnel. Then the butanol fraction is evaporated in a rotavapor at 40°C to obtain the butanol fraction. After that, the residue is shaken again with dichloromethane and evaporated to obtain the dichloromethane fraction. Finally, the last residue is shaken with ethyl acetate and evaporated to obtain the ethyl acetate fraction.

2.4 Alkaloids extraction

The drug used is the stem and root powder for all tests. Introduce 100 g of dry, coarsely pulverised drug into a brewer. Add dilute sulfuric acid (1: 20 concentrated H2SO4 with distilled water) in a ratio of 5: 1 to 10: 1 (volume of acid: the weight of the plant) and then stop. Stir and let macerate for 24 hours at laboratory temperature. Filter on paper and wash with water to obtain about a filtrate. Then alkalinise the filtrate with ammonia to pH 8-9 and put in a separatory funnel. Add chloroform and stir without emulsification. After decantation,

remove the organic phase. Repeat this operation until the alkaline solution no longer precipitates with the Dragendorff reagent. Combine the organic phases and dry over anhydrous sodium sulphate, filter and transfer to a calibrated evaporation flask to dry rotavapor under reduced pressure.

2.5 Reducing powered with FRAP method

The FRAP method (Ferric Reducing Antioxidant Power) is based on the ability of extracts to reduce ferric ion (Fe3+) by ferrous ion (Fe2+). Total antioxidant capacity of each plant extract was determined by the method Benzie and Strain [15]. And 1 ml of an aqueous solution of each extract (10 mg/ml diluted 100th for 0.1 mg/ml), ascorbic acid, was mixed with 2.5 ml of phosphate buffer (0.2 M, pH 6.6) and 2.5 ml of the aqueous solution (1%) of potassium hexacyanoferrate [K3 Fe (CN)6]. After 30 min of incubation at 50 ° C, 2.5 ml of trichloroacetic acid (10%) was added. The mixture was then centrifuged at 3000 rpm/min for 10 min. 2.5 ml of the supernatant were then mixed with the same volume of water, and 0.5 ml of a freshly prepared aqueous solution of FeCl3 (0.1%) was added. The absorbances were read at 700 nm against a calibration curve obtained from ascorbic acid (0-100 mg / l). The reducing power is expressed in ascorbic acid equivalent (AAE) (mmol ascorbic acid / g of dry extract).

2.6 Antiradical activity by the method of inhibition of DPPH radical

The antiradical activity of plant extracts reflects their ability to scavenge free radicals from the body. The radical scavenging activity was evaluated on the different fractions of Strychnos icaja. The extracts were dissolved in methanol to obtain concentrations of mothers of 10 mg/ml. This concentration is diluted to 100 for the second test. The method spectrophotometric 2.2-diphenyl-1-picrylhydrazyl (DPPH) as described by Popovici et al. [16] is used with some modifications. Introduce 1.5 ml of a methanol solution of DPPH at 20mg / l in test tubes containing 0.75 ml of extracts prior to the test. A control containing no plant extract is also prepared. The absorbances were read at 700 nm against a calibration curve obtained from ascorbic acid (0-200 mg / l). Each test was performed in triplicate. Antiradical power was expressed as ascorbic acid equivalent (AAE) (mmol ascorbic acid / g of dry extract). The concentration of reducing compounds (antioxidants) in the extract is expressed in mmol ascorbic acid equivalent (AAE) / g of dry extract.

2.7 Antiradical activity by the method of inhibition of the radical cation ABTS

The method described by Pellegrini et al. [17] is used. It is based on the discolouration of a stable radical cation, ABTS + (2.2 '-azinobis- [3-acid-6-sulfonic ethylenzothiazoline]) to ABTS in the presence of antioxidant compounds at 734 nm. The radical cation ABTS + was generated by reacting an aqueous solution of ABTS (7 mM) with 2.5 mM potassium persulfate (final concentration), the mixture is kept in the dark at room temperature for 12 hours before use. The mixture was diluted with ethanol to give an absorbance of 0.70 ± 0.02 to 734 nm using the spectrophotometer. For each extract, a methanol solution (10 mg/ml) is diluted to 100th in ethanol µl of sample and 10 (solution), the reference substance (ascorbic acid) was mixed with 990 µl of a fresh solution of ABTS +. The set is stored away from light for 15 minutes, and absorbances were read at 734 nm in a spectrophotometer against a standard curve of ascorbic acid precisely 6 min after initial mixing. The concentration of compounds having a reducing effect on the radical cation ABTS + is expressed in mmol ascorbic acid equivalent (AAE) / g of dry extract. The concentration of reducing compounds (antioxidants) in the extract is expressed in mmol ascorbic acid equivalent (AAE) / g of dry extract.

2.6 Statistical analysis

All data represent the average of three trials. For the comparison of the results, analysis of the variance, ANOVA and Dunnett test (GraphPad Instat) are used, and the degree of data significance is taken at the probability $P \leq 0.05$.

3. RESULTS

3.1 Ethnobotanical survey

Interviews with some traditional healers (January 2020 to March 2020 in Libreville, Lambarene and Cap Esterias) allowed us to know that among the uses the most common use against haemorrhoids and most important. The *Strychnos icaja* is any plant designated to prevent harmful influences of witches and other spirits bad. All those who use it for its magic properties are unanimous about the almost total protection which ensures they feel secure so they put root at the entrance to their home as the top of the door, or they bury it across their concession or put it in their car and the other more suspicious focuses on them as a talisman. For them, the plant represents the original judge, is the plant which since time immemorial has the power to judge men and to punish. To find this plant should go into the deep forest. It is very difficult to harvest the vine because once she wraps the top of tall trees, it is possible to recognize it unless it has a branch which is still under a shrub. The *Strychnos icaja* users say it must pronounce certain words and talk to the plant when the roots are dug up if you want to avoid it breaks. It is indeed true that the orally administered itself Mbundu people suspected of witchcraft, but in certain rituals had to dig up the root without it breaks if they were considered unclean. During our interviews, we exposed ourselves to the reluctance of traditional healers. The only use they were willing to disclose was that of protection. Having a woman as their interlocutor made them more and more skeptical about the use to be made of the plant; the plant is very poisonous so some fear that it is used to kill a spouse, a rival or to commit suicide. And when we tried to question them through a man, whether he was not initiated or if he was but still a novice there was the same reluctance. When we were looking for people who knew where to find the plant in abundance there was also a suspicion due to the fact that the root is in high demand for sale in the markets. During our visit to the markets, we found stalls where many roots were exposed. Nevertheless, despite the difficulties encountered, we were able to obtain some recipes: in the treatment of haemorrhoids, against ear infections, male urethritis, rheumatic and dental pain and sterility in women (table 1).

Table 1: Recipe obtained from traditional therapists

Recipe 1 Treatment of haemorrhoids Part used: root barks Product added: Kaolin (red clay)	Use: The root barks were mixed with the Kaolin previously moistened with water. We realize suppository and they are dried. Used daily, the disease disappears after one week.
Recipe 2 Treatment of otitis Part used: root bark Product added: Banana leaf	Use: The bark of roots is steeped in water a few moments. They are then recovered and introduced into a funnel made with a piece of banana leaf previously spent on the fire. We put a few drops in the ear until healing. NB: You can use other leaves instead of banana leaves.
Recipe 3 Dental bread Part used: root bark Product added: Capsicum frutescens	Use: Crush the pepper and mix with the root bark then apply the mixture on the decayed tooth.
Recipe 4 Treatment of urethritis in men or that does not cure (according to the local expression) Part used: internal part of the grated bark Product added : - *Aframonum melegueta*: 5 seeds, powdered - *Citrus limonum*: lemon juice	Use: Mix well and let stand an hour or two, then filter for a liquid without solid particles. The liquid is to be administered once in intra-urethral injection with a syringe (without needle). It's very painful for the patient, but treatment would cure urethritis with the evacuation of more or less solid debris (stripping)
Recipe 5 Rheumatic Pain in osteoarthritis Part used: grated bark Product added : - *Solanum mammosum*: fruit - *Solanum torvum*: fruits and leaves - *Sparganophorus vaillantii*: stems + leaves - *Acanthus montanus*: leaves NB: This is also here to scarify grass. - *Citrus limonum*: lemon fruit juice. - *Costus lucanusianus*: crushed juice of the stem	Use: The remaining water after rain in the hollow of a tree trunk or a rock. Sweeps of bark, leaves, stems, fruits are crushed and mixed with finely enough lemon juice and the juice of *Costus* in a pot. Scarification is done on the diseased areas (joints or others) with a branch of *Acanthus* which one whips the skin and one apply morning and evening this paste until the improvement of osteoarthritis pain. NB: In the past we used as pot the fruit of *Strychnos aculeata*
Recipe 6 Difficulty giving birth Part used: grated root bark in tiny doses Product added: *Buchholzia coriacea* (Onion gorilla): fruit	The bark is crushed with onion gorillas, add water, then let macerate filtered and administers enemas

3.2 Antioxidant activities by inhibition of DPPH

Antiradical activity by the method of inhibition of DPPH radical has a content of 13.33 ± 0.16 mmol AAE/g for St (*Strychnos*) total alkaloids roots; 12.82 ± 0.10 mmol AAE/g for St dichloromethane; 12.97 ± 1.05 mmol AAE/g for St ethyl acetate; 12.80 ± 0.04 mmol AAE/g for St butanol; 5.21 ± 0.01 mmol AAE/g for St aqueous root extract and 13.76 ± 0.26 mmol AAE/g for quercetin (Table II).

Table II: Evaluation of the antioxidant activity of Strychnos icaja extracts in comparison with quercetin and ascorbic acid by different methods

Extract type	DPPH (mmol AAE/g)	FRAP (mmol AAE/g)	ABTS (mmol AAE/g)
St alkaloids total roots	13.33±0.16	5.94±0.14	6.74±0.14**
St dichloromethane roots	12.82±0.10	2.78±0.10**	3.83±0.15**
St ethyl acetate roots	12.97±1.05	2.81±0.01**	3.77±0.20**
St butanol roots	12.80±0.04	2.16±0.06**	2.24±0.57
St extracted aqueous roots	5.21±0.01**	0.46±0.27**	0.86±0.25
Quercetin	13.76±0.26	Nd	Nd
Ascorbic acid	Nd	5.86±0.51	1.78±0.58

Values are expressed as mean ± SE of three replicates
NB: ** p <0.01: the difference is very significant
* p <0.05: the difference is significant
Nd: not determined
St (Strychnos)

3.3 Reducing powered with FRAP method

Reducing powered with FRAP method has a content of 5.94 ± 0.14 mmol AAE/g for St total alkaloids roots; 2.78 ± 0.10 mmol AAE/g for St dichloromethane; 2.81 ± 0.01 mmol AAE/g for St ethyl acetate; 2.16 ± 0.06 mmol AAE/g for St butanol; 0.46 ± 0.27 mmol AAE/g for St aqueous root extract and 5.86 ± 0.51 mmol AAE/g for ascorbic acid (Table II).

3.4 Antiradical activity by inhibition of ABTS +

Antiradical activity by the method of inhibition of the radical cation ABTS + has a content of 6.74 ± 0.14 for St total alkaloids roots, 3.83 ± 0.15 for St dichloromethane, 3.77 ± 0.20 for St ethyl acetate, 2.24 ± 0.57 for St butanol, 0.86 ± 0.25 for St aqueous root extract and 1.78 ± 0.58 for ascorbic acid (Table II).

4. DISCUSSION

Our study on *Strychnos icaja* Baillon belongs to the Loganiaceae family. It is a vine reaching a height of 20 to 40 m and a length of 20 to 100 m. It is found in the forests of Central Africa. This Strychnos is used in the past by the populations as an arrow poison or test. During our investigation most traditional healers agreed to recognize the plant as a protective power against certain practices of witchcraft. We were able to obtain some recipes from some traditional healers and users of the plant, namely: against otitis, male urethritis, rheumatism, dental pain and sterile women. Previous work carried out on the upper plateau by Frederich et al, [11] only the alkaloids of the roots from which isosungucin, 18-hydroxyisosungucine, pseudo strychnine and many other alkaloids were isolated. They also carried out antimalaria tests and found that strychnogucin had a good inhibitory concentration against Plasmodium falciparum (0.617 µm), which is almost half that of quinine (0.269 µm). Denoel et al, [18] found alkaloids in barks of stems, roots and leaves. The use of this plant against dental pain can be explained by the analgesic properties of alkaloids [19]. Many authors have shown that medicinal plants have excellent anti-inflammatory properties. This is the case of *Curcuma longa* [20], *Carica papaya* [21]. The existence of tannins in the plant could explain its use against haemorrhoids and cutaneous dermatoses especially that the tannins have the property to agglutinate [22]. More on them has also found antimicrobial, antiviral and hypoglycemic [23]. Besides the tannins, there are flavonoids. The presence of flavonoids could justify their venotropic properties (against varicose veins and haemorrhoids) [23]. These compounds arouse great interest due to their numerous beneficial effects for health: their antibacterial, antiviral, antiplatelet, antiallergic, anti-inflammatory, anti-tumor properties and their antioxidant activities are the subject of in vitro and epidemiological studies in a therapeutic goal in the treatment of certain cancers, inflammatory, cardiovascular and neurodegenerative diseases. Some of them are also used as additives in food, pharmaceuticals and cosmetics [24, 25, 26]. The second part of our work consisted of evaluating the antioxidant activity of *Strychnos*. We evaluated their antioxidant capacity because antioxidants are documented in several publications to mitigate the inflammatory processes and this activity has been ascribed to the phenolic compounds present in it, particularly flavonoids and tannins [27, 28, 29, 30]. Antiradical activity by the method of inhibition of DPPH radical shows that St alkaloids root and St alkaloids stem have the best inhibition of radical DPPH followed with St dichloromethane, St ethyl acetate, St butanol and much less for St root aqueous extract. Those values except St root aqueous extract are significantly close to that quercetin (13.76 ± 0.26 mmol AAE/g). Reducing powered with FRAP method show the same result, with high value to St alkaloids root and low value to St aqueous extract compared to ascorbic acid (5.86 ± 0.51 mmol AAE/g). The FRAP test makes it possible to evaluate the antioxidant power of foods by determining this capacity for reducing ferric ions to ferrous ions. The antioxidant content is determined by the solutions containing the known concentrations of ferrous ions. FRAP is expressed in mmol of antioxidants per 100 g of food. Here is how to interpret the FRAP values of foods: 0 <FRAP index <1.5: low antioxidant capacity; 1.5 <FRAP index <3: average antioxidant capacity; 3 <FRAP index <10: high antioxidant capacity; FRAP index> 10: very high antioxidant capacity [31]. So, St alkaloids total roots have a high antioxidant capacity and St aqueous extract a low antioxidant capacity extract. Antiradical activity by the method of inhibition of the radical cation ABTS show high value compared to ascorbic acid reference substance (1.78 ± 0.58 mmol AAE/g). Free radicals are harmful substances generated by the body that damage cells, causing premature ageing and the development of certain diseases. Thus, the role of antioxidants is to combat the oxidation caused by these free radicals. However, they are more or less held in check by the body's natural antioxidants. Some factors can, however, break this balance. If free radicals come to exceed the body's ability to neutralise them, they can contribute to the onset of many diseases, including cardiovascular disease, certain types

of cancer and other diseases associated with ageing [32]. Lansiaux et al. [33] have isolated from *Strychnos icaja* root, and a compound named Strychnogucin B, who's cytotoxic against the human KB cell line of cancer and against human fibroblasts WI38. Many chemicals in foods are called antioxidants because they have the property of preventing harmful chain reactions caused by free radicals. They are bulletproof for the body. The main natural antioxidants are bioflavonoids, carotenoids, vitamins C and E, and selenium [34]. Compared to quercetin or vitamin C, our extracts have excellent antioxidant activity. Aworet and al., 2020 [35] have shown that *Strychnos icaja* contains phenolic compounds. These results are consistent with what is reported in the literature by several authors that the potential for antioxidant activity of an extract depends on its content of phenolic compounds [36, 37, 38, 39, 40]. The dosage of this plant confirms that it is rich in phenolic compounds which are able to trap free radicals and therefore reduce oxidative stress.

5. CONCLUSION

Our study aimed to identify the traditional uses of *Strychnos icaja* by showing the different uses of the plant and that its properties are due to its excellent antioxidant power. Thus, we have noticed that *Strychnos icaja* is frequently used by populations (in town as well as in village) both for its magical properties and to treat various ailments, despite its toxicity. This work illustrates the case of plants deemed to be toxic, the uses of which are mastered by traditional therapists, and whose pharmacological research shows that they have proven therapeutic properties.

ETHICAL APPROVAL

It is not applicable

REFERENCES

1. Reitsma JM. Végétation forestière du Gabon.1988. 142p.

2. Neuwinger HD. African Ethnobotany, Poisons and Drugs. Chapman & Hall, London, 1996. p569-576.

3. Walker A et Sillans R. Les Plantes Utiles du Gabon. Editions Paul Lechevalier, Paris. 1961. 614 p.

4. Aubreville A et Jean F. Flore du Gabon-19-loganiacées. Muséum National d'Histoire Naturelle, Paris (France). 1972. 153 p.

5. Sandberg F, Roos K, Ryrberg KJ, Kristiansson K. A new alkaloïd, 4- hydroxystrychnine, from African specie *Strychnos icaja* Baillon. Tetrahedron Lett. 1968; 59, 6717-8.

6. Sandberg F, Roos K, Ryrberg KJ, Kristianson K. The pharmacologically active alkaloids of Strychnos icaja Baillon strychnine and a new alkaloïd, 4-hydroxystrychnine. Acta Pharm Suec. 1969; 6,103-8.

7. Sandberg F and Kristianson K. A comparative study of the convulsant effects of *Strychnos* alkaloids. Acta Pharm.Suec.1970; 7, 329-336.

8. Adjanohoun EJ et al. Contribution aux études ethnobotaniques et floristiques en République du Congo. Col Médecine traditionnelle et pharmacopée, 1988. Paris.605p.

9. Konda Ku Mbuta C, Kabakura M, Mbembe B, Itufa Y, Mahuku K., Mafutam M, et al. Medicinal plants of traditions Province of Ecuador, 2012, p326.

10. Frederich M, De Pauw MC, Llabres G, Tits M, Brandt V, Penelle J, Hayette M, De Mol P, Angenot L. New antimalarial and cytotoxic sungucine derivates from *Strychnos icaja* roots. Planta Med. 2000; 66, 262-9. doi: 10.1055/s-2000-8559.

11. Frederich M, De Pauw M, Prosperi C, Tits M, Brandt V, Penelle J, Hayette M, DeMol P, Angenot L. Strychnogucines A and B, two new antiplasmodial bisindole alkaloids from *Strychnos icaja*. J Nat Prod. 2001; Jan; 64(1):12-6. doi: 10.1021/np000285t.

12. Lansiaux A, Bailly C, Houssier C, Colson De Pauw-Gillet MC, Frederich M, Tits, M, Angenot L. Apoptosis of HL-60 leukemia cells induced by the bisindole alkaloids sungucine and isosungucine from *Strychnos icaja*. Planta med. 2002; 68, 591-5. doi: 10.1055/s-2002-32889. doi: 10.1055/s-2002-32889.

13. Lusakibanza M, Mesia G, Tona G, Karemere S, Lukuka A, Tits M, Angenot L, Frédérich M. In vitro and in vivo antimalarial and cytotoxic activity of five plants used in Congolese traditional medicine. J Ethnopharmacol. 2010; Jun 16; 129(3):398-402. doi: 10.1016/j.jep.2010.04.007.

14. Beaufay C, Ledoux A, Jansen O, Bordignon A, Zhao S, Teijaro CN, Andrade RB, Quetin-Leclercq J, Frédérich M. In vivo Antimalarial and Antitrypanosomal Activity of Strychnogucine B, a Bisindole Alkaloid from *Strychnos icaja*. Planta Med. 2018; Aug; 84(12-13):881-885. doi: 10.1055/a-0644-2723.

15. Benzie IFF, Strain JJ. The ferric reducing ability of plasma (FRAP) as a measure of ‘‘antioxidant power”: The FRAP assay. Analytical Biochemistry. 1996 ; 239, 70-76. doi: 10.1006/abio.1996.0292.

16. Popovici C, Saykova I, Tylkowski B. Evaluation de l’activité anti oxydante des composés phénoliques par la réactivité avec le radical libre DPPH. Revue de Génie Industriel. 2009 ; 4, 25-39.

17. Pellegrini Re R, Proteggente NA, Pannala A, Yang M, Rice-Evans C. Antioxidant activity applying an improved ABTS radical cation decolorization assay. Free Radic. Biol. And Med. 1999; 26, 1231-1237. doi: 10.1016/s0891-5849(98)00315-3.

18. Denoël. Le *Strychnos icaja* Baillon du Congo Belge. Journal de Pharmacie de Belgique, Bruxelles. 1950 ; Vol.5 no3/4 pp.59-77.

19. Bufo SA, Blythe LL, Zbigniew Adamski, Milella L. Biological Activities of Alkaloids: From Toxicology to Pharmacology, 2020. Printed Edition of the Special Issue Published in Toxins.

20. Julie JS. Anti-inflammatory properties of curcumin, a major constituent of *Curcuma longa*: a review of preclinical and clinical research; Altern Med Rev. 2009 Sep; 14(3):277.

21. Pandey S, Cabot PJ, Shaw PN, Hewavitharana AK. Anti-inflammatory and immunomodulatory properties of *Carica papaya*. J Immunotoxicol. 2016, Jul;13(4):590-602. doi: 10.3109/1547691X.2016.1149528.

22. Bruneton J. Pharmacognosie - Phytochimie, plantes médicinales, 4e éd., revue et augmentée, Paris, Tec & Doc - Éditions médicales internationales. 2009 : 1288 p.

23. Paris M., Hurarielle M., 1981 Abrégé de matière médicale. Masson. 339p.

24. Ross JA, Kasum CM. Dietary flavonoids: bioavailability, metabolic effects, and safety. Annu Rev Nutr. 2002; 22:19-34. doi: 10.1146/annurev.nutr.22.111401.144957.

25. Cazarolli LH, Zanatta L, Alberton EH, Figueiredo MS, Folador P, Damazio RG, Pizzolatti MG, Silva FR. Flavonoids: prospective drug candidates. Mini Rev Med Chem. 2008 Nov;8 (13):1429-40. doi: 10.2174/138955708786369564.

26. Burta O, Tirlea F, Ligia Burta O and Minnatullah Qadri S. Phytotherapy in cardiovascular diseases: from ethnomedicine to evidence based medicine. Journal of Biological Sciences, 8: 242-247. doi: 10.3923/jbs.

27. Pereira NA, Pereira BMR, DO Nascimento MC, Parente JP, Mors WB. Pharmacological screening of plants recommended by folk medicine as snake venom antidotes; IV. Protection against Jararaca venom by isolated constituents. Planta Med. 1994; 60: 99-00.

28. Hutt MJ, Houghton PJ. A survey from the literature of plants used to treat scorpion stings. J Ethnopharmacol. 1998; 60: 97-10. doi: 10.1016/s0378-8741(97)00138-4.

29. Sakai A, Hirano T, Okazai R, Okimoto N, Tanaka K, Nakamura T. Large-dose ascorbic acid administration suppresses the development of arthritis in adjuvant-infected rats. Arch Orthop. Trauma Surg. 1999; 119: 121-126. doi: 10.1007/s004020050374.

30. Ozgov AS, Hermanek J, Gut I. Different antioxidant effects of polyphenols on lipid peroxidation and hydroxyl radicals in the NADPH-, Fe-ascorbate- Fe-microsomal systems. Biochem. Pharmacol. 2003; 66: 1127-1137. doi: 10.1016/s0006-2952(03)00425-8.

31. Pouyat-Leclère J. Guide des aliments antioxydants. Thierry Souccar Editions. 2013.

32. Wu X, Beecher GR, Holden JM, Haytowitz DB, Gebhardt SE, Prior RL. Lipophilic and hydrophilic antioxidant capacities of common foods in the United States. J Agric Food Chem. 2004; Jun 16; 52(12):4026-37. doi: 10.1021/jf049696w.

33. Lansiaux A, Bailly C, Houssier C, Colson De Pauw-Gillet MC, Frederich M, Tits M, Angenot L, 2002. Apoptosis of HL-60 leukemia cells induced by the bisindole alkaloids sungucine and isosungucine from *Strychnos icaja*. Planta med. 2002; 68, 591-5. doi: 10.1055/s-2002-32889.

34. Davalos A, Gomez-Cordoves C, Bartolome B. Extending applicability of the oxygen radical absorbance capacity (ORAC-fluorescein) assay. J Agric Food Chem. 2004; Jan 14;52 (1):48-54.7. doi: 10.1021/jf0305231.

35. Aworet Samseny RRR, Mengome LE, Aboughe Angone S. Phytochemical study of Gabon *Strychnos icaja* Baillon (Loganiaceae). 2020; 9 (11): 54-68. DOI: 10.20959/wjpps202011-17606.

36. Amri O, Elguiche R, Tahrouch S, Zekhnini A, Hatimi A. Antifungal and antioxidant activities of some aromatic and medicinal plants from the southwest of Morocco. Journal of Chemical and Pharmaceutical Research. 2015; 7(7): 672-678.

37. Guettaf S, Abidli N, Kariche S, Bellebcir L, Bouriche H. Phytochemical screening and antioxidant activity of aqueous extract of *Genista saharae* (Coss. & Dur.). Der Pharmacia Lettre. 2016; 8 (1):50-60.

38. Kalia K, Sharma K, Singh HP, Singh B. Effects of extraction methods on phenolic contents and antioxidant activity in aerial parts of *Potentilla atrosanguinea* Lodd and quantification of its phenolic constituents by RP-HPLC. J. Agric. Food Chem. 2008; 56: 10129–10134. doi: 10.1021/jf802188b.

39. Katsube T, Tabata H, Ohta Y, Yamasaki Y, Anuurad E, Shiwaku K. Screening for antioxidant activity in edible plant products: Comparison of low-density lipoprotein oxidation assay, DPPH radical scavenging assay and Folin–Ciocalteu assay. J Agri Food Chem. 2004; 52: 2391–2396. doi: 10.1021/jf035372g.

40. Stagos D, Portesis N, Spanou C, Mossialos D, Aligiannis N, Chaita E. Correlation of total polyphenolic content with antioxidant and antibacterial activity of 24 extracts from Greek domestic Lamiaceae species. Food and Chemical Toxicology. 2012; 50: 4115-4124. doi: 10.1016/j.fct.2012.08.033.