Ethnobotanical Study of Medicinal Plants Used for the Treatment of Malaria in the Plateau Region, Togo

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ABSTRACT

Background: In Togo, malaria constitutes a major public health problem but, until now, the population still mostly relies on herbal medicine for healing. This study aimed to document medicinal plants used for malaria therapy in the Plateau region of the country. Methodology: Semi-structured questionnaire interviews were used to gather ethnobotanical and sociodemographic data from traditional healers of the study area. Results: A total of 61 plants species belonging to 33 families were found to be in use for malaria therapy in the Plateau region. Caesalpiniaceae were the most represented family with 7 species, followed by Euphorbiaceae and Poaceae with 4 species each. According to the relative frequency of citation (RFC), Newbouldia laevis Seem. (RFC = 0.52), Senna siamea Lam. (RFC = 0.48), Acanthospermum hispidum DC. (RFC = 0.43), and Senna siamea (Lam.) H.S. Irwin and Barneby (RFC = 0.40) were the most cited in the treatment of malaria in the traditional medicine in the Plateau region. The parts of plants used could either be the barks, roots, leaves, or whole plants. The recipes also could be a combination of various species of plants or plant parts. Conclusion: This study highlights the potential sources for the development of new antimalarial drugs from indigenous medicinal plants found in the Plateau region of Togo. Such results could be a starting point for in vitro antimalarial screenings.

Key words: Caesalpiniaceae, malaria, medicinal plants, relative frequency of citation

SUMMARY

- 61 plants species from 33 families are use for malaria therapy in the Plateau region of Togo
- The main families are Caesalpiniaceae Euphorbiaceae and Poaceae
- The most used species are Newbouldia laevis Seem. (RFC = 0.52), Senna siamea Lam. (RFC = 0.48), Acanthospermum hispidum DC. (RFC = 0.43), and Senna siamea (Lam.) H.S. Irwin and Barneby (RFC = 0.40)

INTRODUCTION

Malaria is a global disease that is predominant in the tropics and caused by blood parasites, Plasmodium falciparum, Plasmodium ovale, Plasmodium malariae, Plasmodium vivax, and Plasmodium knowlesi.[¹] About 3.3 billion people worldwide are at risk of malaria. In 2013, there were about 216 million cases and approximately 528,000 malaria deaths (range: 315,000–689,000). Globally, 90% of all deaths from the disease were recorded in the World Health Organization (WHO) African Region, mainly in children under five years of age.[²]

In Togo, malaria was on average 40% of outpatient visits and 26% of hospitalizations in public health facilities in 2010 with an average hospital stay of 5 days. The hospital mortality rate of malaria was 21% in 2010 and children of 0–5 years old were the most affected in a proportion of 48%.[³] Currently, the programs against malaria integrate several areas including the prevention and the treatment. Since the declaration of WHO Alma-Ata in 1978,[⁴] the WHO recognizes and encourages the use of resources of medicine and traditional pharmacopeia in primary health care. Despite the scientific advances made by modern medicine, the WHO estimates that 80% of Africa’s population still use traditional medicine for primary health care.[⁵]

An effective management of malaria requires the use of all resources available, accessible, and culturally acceptable.[⁶] Worldwide, the traditional pharmacopeia has played and continues to play a very significant role in the treatment and control of malaria.
important role in the discovery of new molecules of therapeutic interest and particularly in the fight against malaria. With the emergence of resistance of the parasite *P. falciparum* to conventional synthetic drugs, the research for new therapeutic targets by ethnopharmacological methods is an interesting approach, including the search for new antimalarial drugs.[13]

In Togo, few studies had focused on medicinal plants used in the treatment of malaria.[10–11] Koumaglo et al. evaluated the antimalarial activity of compounds isolated from *Azadirachta indica* and *Morinda lucida*. Other studies conducted by Gbeassor et al. concerned the crude extracts of some widely used plants;[16,17] however, these screenings were not preceded by an ethnobotanical survey. Only the study of Koudouvo et al. was a complete study including the survey and the *in vitro* screening of the most cited plants.[16,17] This study was conducted in the maritime region of the country and until now; there is no published data on the medicinal plants used to treat malaria in the four other regions of Togo. Therefore, this study was conducted in the Plateau region of Togo, to further explore these antimalarial plants and to assess for the validity of their traditional therapeutic uses through phytochemical information and pharmacological characteristics.

**METHODOLOGY**

The study area

Togo is the West African country located in the tropics (6°6′N to 11°8′N) bounded on the North by Burkina Faso, to the south by the Atlantic Ocean, to the East by Benin and West by Ghana [Figure 1]. The country is divided into five economic regions from North to South: The savannah region, Kara region, central region, Plateau region, and Maritime region.

The survey was conducted in the Plateau region from May to July 2014. This region covers an area of 16,980 km² that represent about 30% of Togo area. Its administrative center is Atakpamé. It prevails in the region a tropical humid climate. There are two rainy seasons and two dry seasons. The longest rainy season is from April to July and the lowest September–October. Annual rainfall average is about 1200–1600 mm. In South-West is a mountainous zone where there are still tropical and subtropical forests, despite expansion of coffee and cocoa plantations. Three major ethnic groups are native to the area: The Adja-Ewe, Ana-Ife, and Akposso-Akébou.

**Ethnobotanical survey**

The ethnobotanical survey was conducted using a full oral questioning of traditional healers.

Questions were focused on the sociodemographic profile of the traditional healer and the knowledge of medicinal plants used in to fight malaria:

- Traditional healer identity, i.e., name and surname, sex, age, and educational level
- Knowledge origin
- Diagnosis, i.e. main symptoms
- Remedy: Local names of the plants, used parts, period of harvest of plants materials, remedy formulation, administration route, dosage, and duration of the treatment.

Plant samples were collected in the field and pictures were taken to aid in the identification. Identification was made by Botany Department of Lomé University by comparison with available voucher specimens. Nomenclature of species was done using the online data base of IPNI website: [http://www.ipni.org/ipni/plantnamesearchpage.do](http://www.ipni.org/ipni/plantnamesearchpage.do).

**Data analysis**

Microsoft Excel was used to calculate the different average and to draw graphics. The importance of each plant in the treatment of malaria was assessed by the relative frequency of citation (RFC) calculated using the following formula:[12]

\[ RCF = \frac{FC}{N} \]

where FC was the number of people who mentioned the use of the species and N the total number of individuals.

**RESULTS**

Demographic data and knowledge about malaria

Investigations were conducted with 62 respondents who had knowledge of antimalarial plants including 22 women and 40 men. The knowledge of plants uses was received from parents and society, by learning from other traditional healers or in academic or professional studies [Table 1].

**Table 1**: Demographic data of the informants (*n*=62)

| Group               | N   | %  |
|---------------------|-----|----|
| **Gender**          |     |    |
| Male                | 40  | 64.52 |
| Female              | 22  | 35.48 |
| **Age**             |     |    |
| Less than 30 years  | 18  | 29.03 |
| 30–40               | 28  | 41.16 |
| 41–50               | 8   | 11.90 |
| 51–60               | 6   | 9.68 |
| More than 61 years  | 20  | 32.26 |
| **Educational background** |   |    |
| Illiterate          | 24  | 38.71 |
| Primary level       | 15  | 24.19 |
| Secondary level     | 3   | 4.84 |
| High educational level | 55  | 88.71 |
| **Mode of acquisition of the knowledge** |    |    |
| Inheritance         | 30  | 48.38 |
| Learning            | 3   | 4.84 |
| Personal experience | 9   | 14.52 |
Malaria diagnosis in patients was done with some clinical signs that include fever (82.25%), headache (70.97%), shivering (51.61%), weakness (29.03%), and lack of appetite (16.13%). However, 7 respondents (11.29%) asserted that they used parasitological diagnostic of malaria before the treatment.

Plants used for the treatment of malaria
A total of 61 plant species belonging to 33 families were mentioned by respondents as curing malaria. Caesalpiniaceae family, with 7 species was the most represented, followed by Euphorbiaceae and Poaceae with 4 species each. For the rest, 19 families were represented by only one species [Figure 2]. The calculated RFC indicated that species such as Newbouldia laevis (RFC = 0.52), Sarcocephalus latifolius (RFC = 0.48), Acanthospermum hispidum Dc (RFC = 0.43), and Senna siamea (RFC = 0.40) were the most used in the treatment of malaria in traditional medicine in the Plateau Region [Table 2].

A bibliographic research was made to seek for previous citations of the recorded species in similar studies. The results revealed are presented in Table 2. According to these results, only four plants namely Bambusa vulgaris, Imperata cylindrica, Nephrolepis undulata, and Senna latifolius were not previously cited in similar studies. In addition, the bibliographic research focused the screened species cited by the healers in the Plateau region was achieved. This allowed assessing the recorded inhibitory concentrations (ICs) of extracts through in vitro test against Plasmodium strains [Table 3]. According to this bibliographic data, Sida acuta, S. latifolius, and Combretum micranthum are the cited plants with IC50 values below 1 µg/mL.

Used parts, method of preparation and administration of drugs
In healers’ habit of Plateau region, the most used parts of plants in recipes preparation are leaves (60%), roots (11%), and stem bark (11%) [Figure 3]. Recipes are prepared as decoction, infusion, maceration, and kneading in water or sauce [Figure 4]. The main route of administration is oral. However, some are taken by simple bath or steam bath. These plants are used alone or in combination in the preparation of recipes. The dosage is ranging from one to four doses per day and up to 10 days of treatment depending on recipe, severity of malaria, and patient’s age.

DISCUSSION
The issue of this investigation revealed that plants of families Caesalpiniaceae, Euphorbiaceae, Poaceae, Rubiaceae, and Rutaceae were particularly well known by the people interviewed. They were widely used and contribute to malaria treatment, used either alone or in combination with other species. In a similar study conducted in the Maritime region of Togo, Koudouvo et al.[11] had identified 52 species of plants used in traditional malaria treatment belonging to 29 families.[10] Caesalpiniaceae, Euphorbiaceae, Rubiaceae, and Rutaceae were generally predominant as families with the greatest number of species treating malaria in previous studies 2009.[11,21,30] These plants were similar to those used in the treatment of malaria in Benin,[24] Nigeria,[19,22,23] Ivory Coast,[17] Ghana,[36] and Guinea.[10] The Rubiaceae and Caesalpiniaceae were often cited for their antimalarial properties due to their alkaloids contents (Karou et al.,[39,50] Amoa Onguéné et al.[15]). The four most cited plants S. siamea, S. latifolius, N. laevis, and A. hispidum were also well documented in several studies: N. laevis, A. hispidum, and S. siamea by Yetein et al.[14] The species B. vulgaris, G. celosioides, I. cylindrica, and Nephoropis undulata were not found in the literature for their antimalarial uses and need be explored. Antimalarial properties of some recorded species in this study were also reported by previous studies.
| Botanical name (family) | Local name | Voucher specimen n° | Used part | Mode of preparation/Administration | Citation | Reference to similar ethnopharmacology use |
|------------------------|------------|---------------------|-----------|-------------------------------------|----------|--------------------------------------------|
| Acanthuspermum hispidum Dc. (Asteraceae) | Damaeleatsunugon ou Adeki | Togo 00747 | Le | Dec/Orl | 26 | 0.43 | (Ganfon et al., 2008) |
| Adansonia digitata L. (Bombacaceae) | Adoditsi | Togo 02476 | Le | Dec/Orl | 12 | 0.19 | (Moshi, 2012) |
| Alchornea cordifolia Müll.Arg. (Euphorbiaceae) | Avolvo | Togo 03021 | Le | Dec/Orl | 09 | 0.15 | (Koudouvo et al, 2011) |
| Aloe vera (L.) Burm. F. (Liliaceae) | Aloes | Togo 11615 | Le | Jui/Orl | 17 | 0.27 | (Soejerto, 2012) |
| Ampelocissus bombeyica (Bak) Planch. (Vitaceae) | Adidoyo | - | Le | Dec/orl | 20 | 0.32 | (Uzodimma, 2013) |
| Ananas comosus L. (Bromeliaceae) | Atoto | Togo 02007 | Fr | Dec/orl | 17 | 0.27 | (N’Guessan, 2009) |
| Anacardium occidentale L. (Anacardiaceae) | Yovotsan | Togo 01768 | Le , Stb | Dec/orl | 15 | 0.24 | (Koyode, 2006; Tchacondo et al, 2011) |
| Antuna muricata L. (Annonaceae) | Votsi | Togo 02267 | Le | Dec/orl | 10 | 0.16 | (N’Guessan et al., 2009) |
| Antuna senegalensis Pers. (Annonaceae) | Dzogbinyibli | Togo 01981 | Le | Dec/orl | 21 | 0.34 | (Ajaiebo et al., 2007) |
| Azadirachta indica A. Jus (Meliaceae) | Kinitsi | Togo 04649 | Le | Inf/Vp | 23 | 0.37 | (Koumaglo et al., 1992; Odugbemi et al., 2007) |
| Bambusa vulgaris Schrad. ex J.C.Wendl (Poaceae) | Pamplotsi | - | Fl | Dec/orl | 03 | 0.049 | - |
| Bredelia ferruginea Benth (Euphorbiaceae) | Kolou | Togo 03068 | Le , Stb | Dec/orl | 12 | 0.19 | (Tchacondo et al., 2012) |
| Boerhavia diffusa L. (Nyctaginaceae) | Babakou | Togo 05308 | Le | Sau/orl | 09 | 0.15 | (N’Guessan et al., 2009) |
| Caesalpinia bonduc (L.) Roxb. (Caesalpinaceae) | Adikou | Togo 00151 | Rt | Inf/orl | 11 | 0.18 | (Yeten et al., 2013) |
| Caesalpinia pulcherima Sw. (Caesalpinaceae) | Orgueil de Chine | Togo 00152 | Le | Dec/orl | 06 | 0.098 | (Yeten et al., 2013) |
| Carica papaya L. (Caricaceae) | Adibatsi | Togo 00341 | Le | Dec/orl | 19 | 0.31 | (Odugbemi et al., 2007; Lakouetene et al., 2009) |
| Citrus aurantifolia (Christm.) Swingle (Rutaceae) | Donsi | Togo 02480 | Fr | Jus/orl | 24 | 0.39 | (N’Guessan et al., 2009) |
| Citrus maxima (Burm.) Merrill (Rutaceae) | Pamplesoumoss | - | Fr | Jus/orl | 09 | 0.15 | (N’Guessan et al., 2009) |
| Cleome viscosa L. (Capparaceae) | Sombtisou | Togo 00306 | Wp | Pet/orl | 11 | 0.18 | (N’Guessan et al., 2009) |
| Coco nucifera L. (Arecaceae) | Netsi | Togo 02481 | Rt | Dec/orl | 19 | 0.31 | (Adabayo et al., 2012) |
| Cola millenii K. Schum (Sterculiaceae) | Kpodntsi | Togo 08606 | Le | Dec/orl | 25 | 0.40 | (Yeten et al., 2013) |
| Combretum micranthum G. Don (Combretaceae) | Kinkeliba | Togo 00582 | Le | Dec/orl | 17 | 0.27 | (Ancolio et al., 2002) |
| Cymbopogon citratus staff. (Poaceae) | Tsigbe | Togo 10749 | Le | Dec/orl | 20 | 0.32 | (Barrows, 2012) |
| Dracaena arborea (Dracaenaceae) | Anyantsi | Togo 09453 | Le | Dec/orl | 14 | 0.22 | (Ajibesin et al., 2008) |
| Elaeis guineensis Jacq (Arecaceae) | Detsi | Togo 02485 | Le | Dec/orl | 07 | 0.11 | (Kayode, 2006) |
| Eucalyptus camaldulensis Dehnh. (Myrtaceae) | Kalitsi | - | Le | Dec/orl | 08 | 0.13 | (Zofou et al., 2011) |
| Ficus exasperata (Moraceae) | Sampepa/Sappalapa | Togo 05094 | Le | Dec/orl | 13 | 0.21 | (N’Guessan et al., 2009) |
| Fluggea virosa (Roxb. Ex Wild.) Voigt (Caesalpinaceae) | Tsakatsaka | - | Le | Dec/orl | 21 | 0.38 | (Diablo et al., 2013) |
| Gliricidia sepium (Jacq.) Kunth ex Walp (Fabaceae) | Gbbonduitsi | Togo 06137 | Le | Dec/orl | 13 | 0.21 | (Thomas et al., 2014) |
| Gomphrena celosioides C.Mart. (Amaranthaceae) | Amegatahe | Togo 01731 | Wp | Dec/orl | 15 | 0.24 | - |
| Heliotropium indicum L. (Boraginaceae) | Agamashike | Togo 02508 | Le | Dec/orl | 08 | 0.13 | (Tardio and Pardo-De-Santayana, 2008) |
| Hibiscus sabdensis L. (Malvaceae) | Kponde | Togo 04423 | Wp | Dec/orl | 16 | 0.26 | - |
| Imperata cylindrica (L) Rauesch. (Poaceae) | Ebe | Togo 10999 | Rt | Dec/orl | 02 | 0.033 | - |
| Indigofera pulchra Willd. (Fabaceae) | Okamon/Hunbe | Togo 06308 | Le | Dec/orl | 09 | 0.15 | - |
| Jatropha gossypifolia L. (Euphorbiaceae) | Babatsidi | - | Wp | Dec/orl | 09 | 0.15 | (Tchacondo et al., 2012) |
| Khaya senegalensis (Meliaceae) | Mawg’ni | Togo 04673 | Le , Stb | Dec/orl | 14 | 0.26 | (Lakouetene et al., 2009) |
| Mangifera indica L. (Anacardiaceae) | Mangotsi | Togo 07197 | Le | Inf/Mac/orl | 15 | 0.24 | (Lakouetene et al., 2009) |
| Morinda lucida Benth (Rubiaceae) | Kaklan | Togo 07503 | Wp | Dec/orl | 12 | 0.19 | (Tor-Anty et al., 2003) |
| Moringa oleifera Lam. (Moringaceae) | Yovovitsi | Togo 05252 | Le | Dec/orl | 17 | 0.27 | (Shuaibu et al., 2008) |
| Nephrolepis undulata (Afzel. Ex Sw.) J. Sm. (Nephrolepideaceae) | Fougére de palmier | Togo 12492 | Le | Dec/orl | 01 | 0.016 | - |
| Newbouldia laevis (P. Beauv.) Seeman ex Bureau (Bignoniaceae) | Kpatsima, Avahi | Togo 02453 | Le | Pet/orl | 32 | 0.52 | (Adodo, 2004) |

Contd...
focused on in vitro antiplasmodial activity of these species. For example, the aqueous extract of root of *S. latifolius* tested in vitro against the strains of *P. falciparum* FCB1 was active with IC50 = 0.6 µg/ml. Leaves were the most used part of the plant (60%). The same result was found by Lakouetene in 2008 with 60%,[25] 68% by Yetein *et al.* in 2013.[24] Therefore, it was noted an intense collection of leaves, levy that did not have at all an important danger to the plant, according to Poffenberger *et al.*[36] According to these authors, the levy of 50% of the leaves of a plant does not significantly affect its survival, while uprooting and debarking participate in the destruction of the plant. In addition, to the preference of leaves is that they are the main photosynthetic organs and, therefore, tanks and photosynthesizes exudates containing secondary bioactive compounds that protect against external aggressions. These compounds have medicinal values for human body.[24,37]

Samples were collected in forests, fields, and home gardens that grow rare species.

Most recipes used were prepared by decoction (77%) followed distantly by infusion and maceration. In general, plant material amount and the volume of water used and preparation duration were not precisely defined. The oral route of administration was the most used in the Plateau region for taking antimalarial traditional recipes (97%). Koudouvo *et al.* also had obtained in the Maritime region in Togo this mode as the principal (82.05%).

The drugs were taken with gourds, glass (beer or liquor), spoon, or cup. In general, the amount administered to the patient is not very accurately measured, and the dosage is very difficult to estimate. In all cases, there was a wide variation depending on the experience of each traditional therapist. These inaccuracies make difficult the standardization of the use of these plants. The direct consequence is the development of resistance of *Plasmodium* toward drug use.

Traditional medicine of the Plateau region sometimes had used combinations of plants to increase the efficiency of the recipe in the treatment of malaria and its symptoms such as fever, headache, vomiting, and anemia. These plants associations, mismatched, are sometimes dangerous. In Africa, for example, about 30% of the fatal accidents were caused because of mixtures that were complex remedies.[38] These products create in the long-term complications such as kidney and liver failure.

Only 7/62 respondents had used parasitological diagnostic of malaria (thick blood film, blood smear, and rapid diagnostic test) before treatment. The rest had used signs such as fever, headache, vomiting, conjunctival pallor, diarrhea, chills, and generalized tiredness. This raised the problem of definitive diagnosis before treatment because other diseases had almost same clinical signs as malaria.

Informants ranged from 29 to 75 years old. Younger informants were less represented than old ones. From 62 traditional herbalists, 1.61% was aged less than 50 years old. This is in agreement with previous results described by Traore.[39] Consequently, there is an urgent need for documentation of this invaluable knowledge since there is a persistent gap in knowledge of herbal practice between the younger and older generations. The educational level of the interviewees was low: 32.26% had some primary schooling, and 24.19% had some secondary schooling. Only 4.84%
had attended a higher education institution. Many traditional medical practitioners (38.71%) were illiterate and consequently could not document their practice. Inheritance (88.70%) was the major source of knowledge acquisition. It is advocated that knowledge of treatment of the disease acquired by inheritance and training must be documented for future generation.[30]

**CONCLUSION**

Investigations results had identified 61 species commonly used in Togolese traditional medicine to treat malaria. Given the high prevalence of malaria and the widespread use of traditional medicine, it is capital to rationalize the use of these medicinal plants. These medicinal plants may probably contain yet undiscovered antimalarial properties, which can serve as a template for the production of cheap antimalaria drug from indigenous plants in Togo. There is a need for a multidisciplinary approach to develop potentially effective drugs while noting dangerous drugs and practices that should be discarded.

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**Table 3:** Bibliographic record of ethnopharmacological work done on some of the most cited species during the ethnobotanical survey

| Plant species | Used part | Extract | In vitro activity (IC50 µg/ml) | Authors |
|---------------|-----------|---------|-------------------------------|---------|
| Acanthospermum hispidum D.C. | Leaves | Lactone | 2.33 (3D7) | (Tardio and Pardo-Dantas, 2008) |
| | | Dichromethane | 4.8 (W1) | (Bero et al., 2009)[42] |
| | | Methanol | 9.02 (3D7) | |
| | | | 2.82 (Dd2) | |
| Annona muricata | Leaves | Aqueous extract | 20 (F32) | (Bild a et al., 2004)[43] |
| Azadirachta indica A. Jus | Leaves | Aqueous extract | 2.50 (D6) | (Isah et al., 2003)[52] |
| Carica papaya L. | Leaves | Aqueous extract | 15.19-18.09 (strain FCK2) | (Bhat et al., 2001)[44] |
| Citrus aurantifolia | Leaves | Methanol | 40.0±2.1 | (Messia et al., 2008)[40] |
| Combretum micranthum | Leaves | Aqueous extract | 0.8 (W2) | (Ancolio et al., 2002) |
| Gymnopuson citratus (DC.) Stapf | Leaves | Methanol | 42.2 | (Messia et al., 2008) |
| Mangifera indica | Leaves | Chloroform/ethanol (1:1) | 20 (F32) | (Bilda et al., 2004)[45] |
| | | Chloroform/methanol (1:1) | 20 (F32) | (Bilda et al., 2004)[45] |
| | | | >50 (Fcb1) | (Zirhi et al., 2005)[46] |
| Sarcophaus latifolius | Root | Aqueous extract | 0.6 (FCB1) | (Menan et al. 2006)[47] |
| | | Ethanol | (8.9)Columbian CQR Pf strain | (Zirhi et al., 2005)[48] |
| Ocimum gratissimum L. | Leaves | Aqueous extract | 2.50 (D6) | (Bhat et al., 2001)[44] |
| Psidium guajava | Stem bark | Aqueous extract | 29.5 (F32) | (Ngemenya et al., 2005)[49] |
| Securininga virosa | Leaves | Aqueous extract | 10-20 (D10 stain) | (Nundikumar et al., 2002)[50] |
| | | Aqueous extract | 7.8 | (Willcox et al., 2011)[51] |
| Sida acuta | Leaves | Ethanol extract | 3.9-5.4 (Fcm29-Cameroon) | (Banzouzi et al., 2004)[52] |
| | | Aqueous extract | 0.92 (Fm M1) | (Karou et al., 2003) |
| Spondias mombin L. | Leaves | Aqueous extract | 7.89 | (Willcox et al., 2011)[51] |
| | | Aqueous extract (decoction) | 7.8 | (Willcox et al., 2011)[51] |
| | | Aqueous extract (maceration) | 7.66 | |
| Tamarinus indica | Fruit | Aqueous extract | 4.786 (fresh isolates of Pf) | (Koudouvo et al., 2011)[53] |
| | | Leaves | Methanol | 55.544 (fresh isolates of Pf) | (Karou et al., 2003) |
| | | Aqueous extract | 11.2 (fresh isolates of Pf) | (Sha'a et al., 2011)[54] |
| | | Aqueous extract (decoction) | 13.6 (Fresh isolates of Pf) | (Omoregie et al., 2011)[41] |
| | | Aqueous extract | 9.82 (FcM29-Cameroon) | |
| | | Ethanol extract | 7.81 | |
| | | Hydroalcohol | 41.69 (3D7) | |
| | | | 44.03 (3D7) | |

**Conflicts of interest**

There are no conflicts of interest.

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