Cameroonian medicinal plants: pharmacology and derived natural products

Victor Kuete1,2 and Thomas Efferth2*

1 Department of Biochemistry, Faculty of Science, University of Dschang, Dschang, Cameroon
2 Department of Pharmaceutical Biology, Institute of Pharmacy, University of Mainz, Mainz, Germany

Many developing countries including Cameroon have mortality patterns that reflect high levels of infectious diseases and the risk of death during pregnancy and childbirth, in addition to cancers, cardiovascular diseases and chronic respiratory diseases that account for most deaths in the developed world. Several medicinal plants are used traditionally for their treatment. In this review, plants used in Cameroonian traditional medicine with evidence for the activities of their crude extracts and/or derived products have been discussed. A considerable number of plant extracts and isolated compounds possess significant antimicrobial, anti-parasitic including antimalarial, anti-proliferative, anti-inflammatory, anti-diabetes, and antioxidant effects. Most of the biologically active compounds belong to terpenoids, phenolics, and alkaloids. Terpenoids from Cameroonian plants showed best activities as anti-parasitic, but rather poor antimicrobial effects. The best antimicrobial, anti-proliferative, and antioxidant compounds were phenolics. In conclusion, many medicinal plants traditionally used in Cameroon to treat various ailments displayed good activities in vitro. This explains the endeavor of Cameroonian research institutes in drug discovery from indigenous medicinal plants. However, much work is still to be done to standardize methodologies and to study the mechanisms of action of isolated natural products.

Keywords: medicinal plants, ethnopharmacology, Africa

PUBLIC HEALTH CONCERN AND DISEASES IN CAMEROON

Health care is a basic service essential in any effort to combat poverty, and is often promoted with public funds in Africa to achieve this aim (Castro-Leal et al., 2000). Nevertheless, curative health spending is not always well targeted to the poorest, representing about 50.5% of Cameroonian (Edmondson, 2001). Many developing countries including Cameroon have mortality patterns that reflect high levels of infectious diseases and the risk of death during pregnancy and childbirth, in addition to cancers, cardiovascular diseases and chronic respiratory diseases that account for most deaths in the developed world (WHO, 2009). In Cameroon, 3 out of 20 patients are able to buy prescribed drugs in hospitals and one out of every 1000 patients are able to see a specialist. Health care activities are coordinated by the Ministry of Public Health which receives the second highest budgetary allocation per ministry each year (Speak Clear Association of Cameroon, 2004). Health facilities are either run as government services or private services managed by the various churches and other private individuals. There are also traditional doctors that play a great role as far as the provisions of health care services are concerned. The major diseases associated with high degree of risk within the population include food or waterborne diseases (bacterial and protozoal diarrhea, hepatitis A and E, and typhoid fever), vector borne diseases (malaria and yellow fever), water contact diseases (schistosomiasis), respiratory diseases (meningococcal meningitis), and animal contact diseases (rabies) (Index mundi, 2008). Very often, there is a coexistence of many infectious diseases. Ammah et al. (1999) demonstrated that high proportion of patients (33%) had malaria coexisting with typhoid (Salmonella typhimurium, Salmonella paratyphi, and Salmonella typhi infections). In the Cameroonian population, the lifetime risk of developing active tuberculosis once infected, in absence of HIV infection, is about 10%, meanwhile this increases tenfold in HIV infected individuals (Noeske et al., 2004). Malaria remains the leading cause of morbidity in Cameroon, and among the top five causes of mortality. Malaria represents approximately 45–50% of health consultations, and 23% of admissions (Edmondson, 2001). The unsatisfactory management of all diseases throughout the continent as well as in Cameroon, which allows partially treated and relapsed patients to become sequentially resistant, may play a significant role in the development of resistance for infectious diseases (Jones et al., 2008; McGaw et al., 2008). Effective treatment of diseases is challenging for various reasons, including lack of accessibility and elevated expense of drugs and low adherence owing to toxicity of second-line drugs. It is all too likely that the emergence of resistance will be experienced in the future, exhausting the current arsenal of chemical defenses at our disposal. For this purpose, new drugs are urgently needed, and research programs into alternative therapeutics including medicinal plants investigations should be encouraged.

BIODIVERSITY AND PROTECTED AREA IN CAMEROON

The biodiversity of Cameroon in term of protected land area, number of plant and some animals groups with threatened species are summarized in Table 1 and Figure 1.

Cameroon has a rich biodiversity, with about 8,620 plants species and several animal groups (EarthTrends, 2003), encountered in both protected (about 8 %), and unprotected areas. About 155 plant species are classified by the International Union for the Conservation
Table 1 | Biodiversity and protected area in Cameroon, Sub-Saharan Africa, and the World (Source: EarthTrends, 2003).

| PROTECTED AREA (000 HA) | Cameroon | Sub-Saharan Africa | World |
|-------------------------|----------|-------------------|-------|
| Total land areas        | 47544    | 2,429,241         | 13,326,979 |
| Extent of protected areas by IUCN Category (000 ha), 2003 | | | |
| (Categories I–V)         |          |                   |       |
| Total protected area     | 3,741    | 264,390           | 1,467,674 |
| Marine and Littoral      | 389      | –                 | 417,970 |
| Protected areas as a     | 8.0%     | 10.9%             | 10.8% |
| percent of total land area |          |                   |       |
| Biosphere reserves in 2002 | 3        | 46                | 408   |
| Number of sites          | 876      | –                 | 439,000 |
| Total area (000 ha)      |          |                   |       |

NUMBER AND STATUS OF SPECIES

| Higher plants             |          |                   |       |
| Total known species       | 8,260    | –                 | –     |
| Number of threatened      | 155      | –                 | 5,714 |
| species                  |          |                   |       |
| Mammals                  |          |                   |       |
| Total known species       | 409      | –                 | –     |
| Number of threatened      | 40       | –                 | 1,137 |
| species                  |          |                   |       |
| Breeding birds            |          |                   |       |
| Total known species       | 165      | –                 | –     |
| Number of threatened      | 15       | –                 | 1,192 |
| species                  |          |                   |       |
| Reptiles                 |          |                   |       |
| Number of total           | 210      | –                 | –     |
| known species             |          |                   |       |
| Number of threatened      | 1        | –                 | 293   |
| species                  |          |                   |       |
| Amphibians                |          |                   |       |
| Number of total           | 171      | –                 | –     |
| known species             |          |                   |       |
| Number of threatened      | 1        | –                 | 157   |
| species                  |          |                   |       |
| Fish                      |          |                   |       |
| Number of total           | 138      | –                 | –     |
| known species             |          |                   |       |
| Number of threatened      | 27       | –                 | 742   |
| species                  |          |                   |       |

IUCN, International Union for the Conservation of Nature and Natural Resources; Categories I, Nature Reserves, Wilderness, Areas; Categories II, National Parks; Category III, Natural monument; Category IV, Habitat/species management area; Category V, Protected landscape/seascape.

1Marine and littoral protected areas are not included in the “Total area protected” above. 2Includes IUCN categories I–V; marine and littoral protected areas are excluded from these totals.

(–): data not available.

Ethnobotanical uses of medicinal plants in Cameroon

Traditional healing plays an integral role in black African culture as it provides primary health care needs for a large majority (about 80%) of the population (WHO, 2002). In Cameroon, there is a rich tradition in the use of herbal medicine for the treatment of several ailments. Unfortunately, the integration of traditional medicine in the health system is not yet effective, due to its disorganization (Nkongmeneck et al., 2007). However, the government strategies of health envisage the organization of traditional medicine in order to provide the main trends for the development and its integration (Anonymous, 2006). Adjnahoun et al. (1996) provided a useful review of the traditional use of medicinal plants in Cameroon, although much work remains to be done regarding the documentation of existing ethnobotanical knowledge. Jiofack et al. (2010) also documented the traditional use of 289 plants species belonging to 89 families against 220 pathologies. Thirty eight percent of the documented plants are used to treat more than twenty important diseases. They are used as decoction, infusion, maceration, powder, powder mixtures, plaster, calcinations, and squeeze in water, boiling, cooking with young cock or sheep meat or groundnut paste, direct eating, juice, fumigation, and sitz bath (Jiofack et al., 2010). The most recurrent diseases or disorders treated are typhoid, male sexual disorders, malaria, gonorrhea, gastritis, rheumatism, fever, dysentery, diarrhea, dermatitis, boils, cough, wounds, syphilis, sterility, sexually transmitted diseases, ovarian cysts, and amoebiasis, with more than two hundred plants being used to cure these diseases or disorders (Jiofack et al., 2010). INVESTIGATION OF THE PHARMACOLOGICAL POTENTIAL OF MEDICINAL PLANTS OF CAMEROON

Antimicrobial activity

Plants are widely used traditionally for the treatment of microbial infections. A review of the antimicrobial potential of Cameroon medicinal plants (Kuete, 2010a) reported more than 58 species in vitro active extracts or isolated compounds. Cut-off points for activity in term of IC₅₀-values were set to 100 μg/ml for extract and 25 μM for compounds of Nature and Natural Resources (IUCN) as threatened species. Threatened species used as medicinal plants include Theecaros annobonicae Pax & K. Hoffm (Euphorbiaceae) (Cheek, 2004), Pausinystalia johimbe (K. Schum) (Rubiaceae) (Ngo Mpeck et al., 2004), Prunus africana (Hook. f.) Kalkm (Rosaceae) (Focho et al., 2009). Ancistrocladus korupensis D. W. Thomas & Gereau (Anoncistocladaceae), Carpolobia lutea G.Don (Polygonaceae), Daecryodes edulis (G. Don) H. J. Lam. (Burseraeceae), Enantia chlorantha Oliv (Annonaceae), Garcinia mannii Oliv, (Clusiaceae), Garcinia cola Heckel (Clusiaceae), Gnetum africamum Welw. (Gnetaceae), Irvingia gabonensis Baill. (Irvingiaceae), Massularia acuminata (G. Don) Ballooc (Rubaceae), Pentaclethra macrophylla Benth. (Leguminosae), Baillonella toxasperma Pierre var. obovata Aubrev. & Pellegr. (Sapotaceae), Calamus decoratus Mann & Wendl. (Palmae), Cola acuminata (P.Beauv.) Schoot et Endl. (Sterculiaceae), Eremonspatha macrocarpa (Mann & Wendl.) Wendl. (Palmae), Raphia regalis Becc. (Palmae), Raphia vinifera P.Beauv. (Palmae) and Ricinodendron heudelotii (Bail.) Pierre (Euphorbiaceae) (Kone, 1997). Protected zones include both land (3,741 ha) and marine areas (389 ha) (EarthTrends, 2003).
(Cos et al., 2006). However, in the case of antimicrobial evaluation of extracts and compounds, determination of IC\textsubscript{50} is not the optimal parameter for significance, most of the reported data being given as MIC values. Kuete (2010a) also set the bar as follows for extract: significant (MIC < 100 μg/ml), moderate (100 < CMIC ≤ 625 μg/ml) or weak (CMIC > 625 μg/ml). For compounds, this stringent endpoints criteria were: significant (MIC < 10 μg/ml), moderate (10 < MIC ≤ 100 μg/ml), and low or negligible (MIC > 100 μg/ml) (Kuete, 2010a). More than 50 microorganisms were found to be sensitive to such extracts and significant activity with minimally inhibiting concentrations (MIC) of less than 100 μg/ml (Kuete, 2010a). Some of the extracts including those from Bersema engleri, Dorstenia angusticornis, Dorstenia burteri, Diospyros canaliculata, Diospyros crassiflora, and Newbouldia laevis, and Ficus cordata exhibited a wide range of activity on both bacteria and fungi (Kuete, 2010a).

Some of the bioactive compounds such as diospyrone (23), crassiflorene (24), newbouldiaquinone (25), newbouldiaquinone A (26), laurentianthone A (30), laurentianthone B (31), smethanthone B (32), cheffouxanthone (33), gangbangxanthone A (34), globulixanthone C (35), D (36) and E (37), moracin T (43), and U (44), nkolbisine (59), nonerythrosuveolide (60), were isolated and characterized for the first time from Cameroonian medicinal plants (Kuete, 2010a). Other compounds such as plumbagin (27), lapachol (28) (found to be inactive in vitro in some cases), isobavachalcone (47), 4-hydroxylobolinocarpin (48), kanzonol C (49) exhibited interesting activities and were suggested as potential candidates for new antimicrobial drug (Kuete, 2010a). Though compound 28 is known to possess good antimicrobial activity in vitro, it will be necessary to assess its in vivo efficacy. However this compounds was active in vitro against intracellular amastigotes of Leishmania braziliensis and inactive in vivo using hamster infected model (Lima et al., 2004). *Thecacoris cf. annobonae* Pax & K. Hoffm (Euphorbiaceae) exhibited significant antimicrobial (MIC<10 μg/ml) activities against *Mycobacterium tuberculosis* H37Rv, *Bacillus cereus* and *Pseudomonas aeruginosa* (Kuete et al., 2010b). The extract from *T. annobonae* was reported to induce *E. coli* death through the inhibition of H\textsuperscript{+}-ATPase-mediated proton pumping (Kuete et al., 2010b). Investigations the mode of resistance of the microorganisms to bioactive compounds isolated from Cameroonian medicinal plants have shown that efflux by AcrAB-ToIC pumps was one of the likely mechanisms of defense of Gram-negative bacteria to compounds 23 and 47 (Kuete et al., 2010c).

**ANTIMALARIAL ACTIVITY**

In Cameroon, several plant species are used to treat malaria. A review on traditionally used plants reported up to 217 species (Titanji et al., 2008). Some of these plants were screened in vitro for their activity against *P. falciparum* and more than 100 bioactive compounds were isolated (Titanji et al., 2008), most of which, however, showed only low or modest antimalarial activities. In the present review, we focus only on plant extract and compounds that exhibited considerably high activities. The proposed cut-off points for in vitro activity of antimalarial extracts based on their IC\textsubscript{50} values can be categorized as follows: IC\textsubscript{50} < 0.1 μg/ml (very good); 0.1–1 μg/ml (good); 1.1–10 μg/ml (good to moderate); 11–25 μg/ml (weak), 26–50 (very weak), >100 μg/ml (inactive) (Willcox et al., 2004a). The following inhibition percentages were proposed for in vivo activity of antimalarial extracts at a fixed dose of 250 mg/kg/day: 100–90% (very good activity); 90–50% (good to moderate); 50–10% (moderate to weak); 0% (inactive) (Willcox et al., 2004a). Several plant extracts from Cameroonian medicinal plants were reported for their antimalarial activities (Table 2), the most active (IC\textsubscript{50} < 1 μg/ml) being that from *Enantia chlorantha* (Boyom et al., 2009).

Some isolated compounds were also reported for their antimalarial activities (Table 2). An IC\textsubscript{50} of 1.5 μM was chosen as cut-off point for several compounds (Calas et al., 1997). The threshold for in vitro chloroquine resistance has been defined as IC\textsubscript{50} > 100 nM (Ringwald et al., 1996). According to Mahmoudi et al. (2006), compounds with IC\textsubscript{50} > 5 µM were considered as inactive against parasite development, compounds with IC\textsubscript{50} between 0.06 and 5 µM being active, and values of IC\textsubscript{50} < 0.06 µM implying the drugs to be very toward *P. falciparum*. We will take into consideration up to IC\textsubscript{50} < 20 μg/ml to report on the activity of antimalarial compounds isolated from Cameroonian medicinal plants. So far, active compounds isolated belong to three main groups of secondary metabolites, terpe-
Table 2 | Plants used in Cameroon to treat malaria, with evidence of their activities.

| Family          | Species*                     | Traditional treatment                          | Plant part used                  | Bioactive (or potentially active) compoundsa | Screened activity                                                                 |
|-----------------|------------------------------|-----------------------------------------------|----------------------------------|---------------------------------------------|-----------------------------------------------------------------------------------|
| Acanthaceae     | Thomandersia hensii De Wild and Th. Dur (LB Th 0301) | Malaria, diarrhea, colitis, furuncles, abscesses, syphilis, ulcers, urogenital disorders, intestinal parasites, debility, tiredness, edema, rheumatism, eye inflammations (Letouzey, 1985; Ngadjui et al., 1994). | Bark, leaves, pulp, sap, roots | Not identified                          | IC50 < 30 μg/ml reported for hexane extract from the stem bark on P. falciparum W2 (Indochina I/CDC) chloroquine-resistant strain (Bickii et al., 2007b) |
| Annonaceae      | Uvariopsis conglobana (De Wild) Fries (37016/HNC) | Malaria (Boyom et al., 2009)                  | Bark, leaves                     | Not identified, but plants of this family were reported to contain acetogeninsa | IC50 < 5 μg/ml reported for the crude extract from the leaves and bark on P. falciparum strain W2 (Boyom et al., 2009) |
|                 | Polyalthia oliveri Engl. (19416 SRF/Cam) | Malaria (Boyom et al., 2009)                  | Bark                            |                               | IC50 < 5 μg/ml reported for the crude extract from the bark on P. falciparum strain W2 (Boyom et al., 2009) |
|                 | Enantia chlorantha Oliv. (32065/SRF/Cam) | Malaria (Boyom et al., 2009)                  | Bark, leaves                     | Not identified                          | IC50 < 1 μg/ml reported for the crude extract from the leaves and bark on P. falciparum strain W2 (Boyom et al., 2009) |
| Apocynaceae     | Picralima nitida Stapf (LB Pn 0301) | Malaria, diarrhoea, intestinal worms, gonorrhoea, inflammation (Letouzey, 1985; Ezeamezie et al., 1994; Fakeye et al., 2000) | Bark, roots, seeds; fruits      | Not identified                          | IC50 < 30 μg/ml reported for the methanol and dichloromethane–methanol 1:1 extracts from the seeds and bark on P. falciparum W2 (Indochina I/CDC) chloroquine-resistant strain (Bickii et al., 2007b) |
| Euphorbiaceae   | Croton zambesicus Muell. Arg. (8204/ SRFCam) | Malaria (Boyom et al., 2009)                  | Bark                            | Not identified                          | IC50 < 10 μg/ml reported for the crude extract from the bark on P. falciparum strain W2 (Boyom et al., 2009) |
|                 | Neoboutonia glutinosa Müll. Arg. Prain (7433/SRFCam) | Malaria (Boyom et al., 2009)                  | Bark, leaves                     | Not identified                          | IC50 < 10 μg/ml reported for the crude extract from the leaves and bark on P. falciparum strain W2 (Boyom et al., 2009) |
| Guttiferae      | Symphonia globulifera Linn. f. (50788/HNC) | Stomach and skin aches, laxative for pregnant women, general tonic, Malaria (Aubreville, 1950; Irvine, 1961; Ngouela et al., 2006). | Bark                            |                               | IC50 <20 μM on P. falciparum reported for compounds 38–40 and 50 (Ngouela et al., 2006). |
| Lauraceae       | Beilschmiedia zanerbi Engl. | Not reported                                   | Bark                            |                               | IC50 <5 μM on chloroquine-resistant P. falciparum reported for pipyahyne (Lenta et al., 2009) |
| Meliaceae       | Entandrophragma angolense Welwitsch C.D.C. (29933/HNC) | Malaria (Bickii et al., 2007a) | Bbark                           |                               | IC50 < 20 μg/ml on P. falciparum W2 strain reported for compounds 8–10. The dichloromethane–methanol (1:1) extract of the stem bark of that plant exhibited IC50 of 18.8 μg/ml (Bickii et al., 2007a) |

(Continued)
| Family       | Species* | Traditional treatment          | Plant part used | Bioactive (or potentially active) compoundsa | Screened activity                                                                 |
|--------------|----------|-------------------------------|-----------------|---------------------------------------------|-----------------------------------------------------------------------------------|
| Khaya        | grandifoliola C.D.C. (P.M 098/95/HNC) | Malaria (Obih et al., 1985; Bray et al., 1990; Weenen et al., 1990). | Bark and seeds | Methylangolenolate (1); 6-methyhydroxyangolenolate (2); gedunin (3); catedhin; 7-deacetylkhiviron (4); 1-deacetylkhiviron (5); swietenolide (6); 6-acetylswietenolide (7) (Bickii et al., 2000) | IC<sub>50</sub> < 20 μg/ml on P. falciparum W2 strain reported for bark and seeds extracts; compounds 1–7. Compound 3 exhibited an additive effect when combined with chloroquine (Bickii et al., 2000) |
| Turreanthus africanus | Malaria and other fevers (Zhou et al., 1997) | Bark, seeds, leaves | 16-oxolabda-8 (17), 12(E)-dien-15-oic acid; methyl-14, 15-epoxylabda-8 (17), 12(E)-dien-16-oate; turreanin A (Ngemenya et al., 2006) | None of the active compounds exhibited IC<sub>50</sub> < 20 μg/ml on P. falciparum F 32, chloroquine sensitive strain (Ngemenya et al., 2006) |
| Moraceae     | Artocarpus communis J.R. & G. Forst (43982 HNC) | Malaria (Boyom et al., 2009) | Bark, leaves | Not identified | IC<sub>50</sub> < 10 μg/ml reported for the crude extract from the leaves and bark on P. falciparum strain W2 (Boyom et al., 2009) |
| Zingiberaceae| Aframomum zambesiacaum (Baker) K. Schum (37737HNY) | Malaria (Kemmogne et al., 2006) | Seeds | Aulacocarpin A (11); aulacocarpin B; 3-deoxyaulacocarpin A (12); methyl-14,15-epoxy-3β-hydroxy-8(17), 12-elabadien-16-oate; galanolactone; zambesiacolactone A (13); zambesiacolactone B (14); afromodial (Kemmogne et al., 2006) | IC<sub>50</sub> < 20 μM on P. falciparum reported for compounds 11–14 (Kemmogne et al., 2006) |
|              | Reneilmia cincinnata (K. Schum.) Bak. | Malaria (Tchuendem et al., 1999) | Fruits | Oplodiol (17); 5E,10(14)-Germacradien-1β,4β-diol (16); 11(10)E,5E-germacradien-4β-ol (15) (Tchuendem et al., 1999) | IC<sub>50</sub> < 5 μM reported on P. falciparum D6 and W2 strains for compounds 15–17 on P. falciparum D6 strain (Tchuendem et al., 1999) |

1HNC or SRFK: Cameroon National herbarium code; LB, Laboratory of Botany, Yaoundé.

2Compounds characterized for the first time in Cameroonian medicinal plant are underlined.

3Annonaceous acetogenins are inhibitors of complex I (NADH: ubiquinone oxidoreductase) in mitochondrial electron transport systems (Lewis et al., 1993), and NADH oxidase of plasma membranes (Morré et al., 1995), two enzymes found in Plasmodium falciparum.

Naphtholignoids (Figure 2), phenolics (Figure 3), and alkaloids (Figure 4). Antimalarial terpenoids including sesqui-, di-, and triterpenoids are the most frequently isolated compounds from Cameroonian plants. Several natural products were reported as being active against Plasmodium falciparum, with IC<sub>50</sub> values below 20 μg/ml, including methylangolenolate (1); 6-methyhydroxyangolenolate (2); gedunin (3); 7-deacetylkhiviron (4); 1-deacetylkhiviron (5); swietenolide (6); 6-acetylswietenolide (7) (Bickii et al., 2000); 24-methylenecycloartenol (8); 7α-acetoxydihyromomulin (9); 7α-obacunylacetate (10) (Bickii et al., 2007a); aulacocarpin A (11); 3-deoxyaulacocarpin A (12); zambesiacolactone A (13), and B (14) (Kemmogne et al., 2006); 1(10)E,5E-germacradien-4β-ol (15); 5E,10(14)-germacradien-1β,4β-diol (16); oplodiol (17) (Tchuendem et al., 1999); IC<sub>50</sub> < 5 μg/ml were obtained for compounds 3 (1.25 μg/ml), and 10 (2 μg/ml) (Bickii et al., 2000, 2007a), while values below 5 μM were recorded for compounds 12 (4.97 μM) (Kemmogne et al., 2006), 15 (1.54 μM); 16 (1.63 μM) and 17 (4.17 μM) (Tchuendem et al., 1999).

Phenolic compounds (Figure 3) such as gaboxanthone (38); symphonin (39); globuliferin (40); guttiferone A (50) (Ngouela et al., 2006) also exhibited antimalarial activities when tested on...
Kuete and Efferth Cameroonian medicinal plants

It is estimated that about 200 million people worldwide are currently affected by schistosomiasis, a disease caused by flatworms belonging to the genus *Schistosoma*. The disease is usually chronic and debilitating, with severe consequences on the urinary tract where *S. haematobium* is the organism involved and major damage to the intestinal tract where *S. mansoni*, *S. intercalatum* or *S. japonicum* are involved (Jatsa et al., 2009). In humans, *Toxoplasma* infections are widespread and lead to severe diseases in individuals with immature or suppressed immune system. Consequently, toxoplasmosis became one of the major opportunistic infections of the AIDS epidemic (Luft and Remington, 1992). Toxoplasmosis also affects *T. gondii*-negative women during pregnancy and is a serious threat for embryos. Despite the huge impact of these parasitic diseases, the drugs used for their treatment are often toxic, marginally effective, administered by injection only, expensive, and/or compromised by the development of resistance (Ouellette et al., 2004; Croft et al., 2005). Only few researchers in Cameroon focused on antitrypanosomal and antileishmanial compounds from medicinal plants. Available published data on traditionally used medicinal plants are compiled in Table 3. Herein, similar cut-off points as indicated above for antimalarials have been considered for activities against trypanosomal, leishmanial and schistosomal pathogens. Compounds with good antileishmanial activities were isolated from *Garcinia lucida* (Clusiaceae), with IC$_{50}$

---

**Other Anti-Parasitic Activities**

Parasitic trypanosomatids cause a number of important diseases, including human African trypanosomiasis, Chagas disease, and leishmaniasis. More than 60 million people living in 36 sub-Saharan Africa countries are at risk of contracting sleeping sickness, caused by *Trypanosoma brucei gambiense* and *T. b. rhodesiense* (WHO, 2007). It is estimated that currently 300,000–500,000 people were infected in 2001, with 50,000 deaths annually (Fairlamb, 2003; WHO, 2007). *Leishmania* species cause a spectrum of disease ranging from self-healing cutaneous lesions to life-threatening visceral infections, with 2 million new cases occurring annually (WHO, 2005).

---

**Figure 2** | Bioactive terpenoids. Activity (a) antimalarial, (b) anti-inflammatory, (c) antitrypanosomal; Glc, glucosyl group; Ac, acetyl group.
values of 2.0 and 6.6 μg/ml, respectively, for dihydrochelerythrine (62) and 6-acetonyldihydrochelerythrine (63) against *L. donovani* (Fotie et al., 2007). Significant antitrypanosomal activities were also reported for stigmastane derivatives, vernoguinoside (33,39-dimethoxy-49-O-β-D-xilopyranosylellagic acid) (58) (Figure 3) exhibited considerable anti-proliferative activities toward HepG2 (IC_{50} of 3.84 μg/ml) and DU-145 (IC_{50} of 6.24 μg/ml) cells (Kuete et al., 2009). Compound 28, the main constituent of a Cameroonian medicinal plant, *Newbouldia leavis* (Bignoniaceae) was found to be very active against DU-145 cells with an IC_{50} of 64.59 nM (Eyong et al., 2008). Wighteone (53) and alpinumisoflavone (54) isolated from *Erythrina indica* (Leguminosae) were reported to be cytotoxic (effective dose of 0.78 and 4.13 μg/ml, respectively) when tested against KB nasopharyngeal cancer cells (Nkengfack et al., 2001). Globulixanthones A (41) and B (42) isolated for the first time in the Cameroonian medicinal plant, *Symphonia globulifera* L. f. (Clusiaceae), showed good anti-proliferative activities against human KB cells, with IC_{50} values of 2.15 and 1.78 μg/ml, respectively (Nkengfack et al., 2002).
47 isolated from *Dorstenia barteri* (Ngameni et al., 2007) and *D. turbinata* (Ngameni et al., 2009) was cytotoxic toward a wide spectrum of tumor cell lines, including ovarian carcinoma OVCAR-8 cells, prostate carcinoma PC3 cells, breast carcinoma MCF-7 cells, and lung carcinoma A549 cells (Jing et al., 2010). Compound 47 significantly ablated Akt phosphorylation at Ser-473 and Akt kinase activity in cells, which subsequently led to inhibition of Akt downstream substrates and evoked significant levels the mitochondrial pathway of apoptosis (Jing et al., 2010). Nishimura et al. (2007) demonstrated that compound 47 induced apoptotic cell death with caspase-3 and -9 activation and Bax upregulation in neuroblastoma cell lines. Compound 47 inhibited MMP-2 secretion from U87 glioblastoma cells (Ngameni et al., 2007). Compounds 48 and 49 also isolated from *Dorstenia turbinata* (Moraceae), inhibited the matrix metalloproteinase (MMP)-2 secretion from brain tumor-derived glioblastoma cells (Ngameni et al., 2006).

**ANTI-INFLAMMATORY AND ANALGESIC ACTIVITIES**

Pain is one common health problem with substantial socioeconomic impact because of its high incidence. It is a symptom of many diseases and it is estimated that 80–100% of the population experience back pain at least once in the life time (Jain et al., 2002). The treatment of pain requires analgesics including inflammatory products. Hence, most of the non-steroidal anti-inflammatory agents also have analgesic activity. The inhibition of prostaglandin E2 (PGE2) and nitric oxide (NO) production has been proposed as a potential therapy for different inflammatory disorders (Nowakowska, 2007).

Although, many analgesics and anti-inflammatory agents are present on the market, modern drug therapy is associated with some adverse effects like gastrointestinal irritation (Jain et al., 2002; Osadebe and Okoye, 2003), fluid retention, bronchospasm, and prolongation of bleeding time. Therefore, it is necessary to search for new drugs with less adverse effects. Medicinal plants have been used for the development of new drugs and continue to play an invaluable role for the progress of drug discovery (Raza et al., 2001). Plant extracts can be an important source of safer drugs for the treatment of pain and inflammation. Several medicinal plants and derived products were screened for their anti-inflammatory and analgesic properties (Table 4). Bark extract as well as terpenoids from *Combretum molle* (Combretaceae), β-D-glucopyranosyl 20,3β,6β-trihydroxy-23-galloylolean-12-en-28-oate (18); combregenin (19); arjungenin (20) (Figure 2) showed good activities against carrageenan-induced paw edema in rat (Ponou et al., 2008). A naphthoquinone, 2-acetyl-7-methoxynaphthol[2,3-b]furan-4,9-quinone (29), isolated from the anti-inflammatory crude extract of *Millettia versicolor* inhibited 12-O-tetradecanoylphorbol 13-acetate (TPA)-induced acute ear edema and phospholipase A<sub>2</sub> (PLA) acute mouse paw edema (Fotsing et al., 2003). Isoflavones, griffonianone D (55) (Figure 3) isolated from *Millettia griffoniana* (Yankep et al., 2003), warangalone (56) isolated from the bark of *Erythrina addisoniae* (Talla et al., 2003), and erycristagallin (57) isolated from the root of *Erythrina mildbraedii* (Njamen et al., 2003), showed marked effectiveness as an anti-inflammatory on PLA<sub>2</sub>-induced paw edema and on TPA-induced ear edema in mice (Njamen et al., 2003; Talla et al., 2003). Flavonoids sigmoidin A (51) and B (52) (Figure 3) isolated from *Erythrina sigmoidea*, and compound 57 were also effective against TPA-induced ear edema (Njamen et al., 2003, 2004).

**ANTI-DIABETIC ACTIVITY**

Diabetes mellitus is a group of metabolic disorders with one common manifestation, hyperglycemia (WHO, 1980, 1985). Chronic hyperglycemia causes damage to eyes, kidneys, nerves, heart, and blood vessels (Mayfield, 1998). It is caused by inherited and/or acquired deficiency in insulin production of the pancreas, or by unresponsiveness toward insulin. It results either from inadequate secretion of hormone insulin, an inadequate response of target cells to insulin, or a combination of these factors (Malviya et al., 2010). Diabetes is projected to become one of the world’s main disablers and killers within the next 25 years (Malviya et al., 2010). The management of diabetes is a global problem and a successful treatment
Table 3 | Plants used in Cameroon to treat some parasitic infections with evidence of their activities.

| Family       | Species*                      | Traditional treatment                             | Plant part used | Bioactive (or potentially active) compounds** | Screened activityc |
|--------------|-------------------------------|---------------------------------------------------|-----------------|---------------------------------------------|--------------------|
| Annonaceae   | Polyalthia suaveolens Engl. & Diels (1227/SRFK) | Rheumatic pains (Surville, 1955)                  | Not specified   | Polyveoline; 3-O-acetyl greenwayodendrin; polysin; greenwayodendrin-3-one (Ngantchou et al., 2010) | Antirypnosomal activity: weak activity for polyveoline (IC<sub>50</sub>: 32 μM); 3-O-acetyl greenwayodendrin (IC<sub>50</sub>: 54 μM); mixture of polysin and greenwayodendrin-3-one (IC<sub>50</sub>: 18 μM) against T. brucei (Ngantchou et al., 2010) |
| Asteraceae   | Vernonia guineensis Benth. (BUD 301) | Anthelmintic, anti-poison, malaria, jaundice (Iwu, 1993) | Leaves          | Vernoguinosterol (21); vernoguinoside (22) (Tchinda et al., 2002) | Antirypnosomal activity: significant for compounds 22 and 23 against four strains of bloodstream trypomastigotes T. b. rhodesiense with IC<sub>50</sub> values in the range 3–5 mg/ml (Tchinda et al., 2002) |
| Guttiferae   | Garcinia lucida Vesque (5768/HNC) | Gastric infections, anti-poison (Nyemba et al., 1990) | Bark            | Dihydrochelerythrine (62); 6-acetonyldihydrochelerythrine (63); lucidamine A (Fotie et al., 2007) | Antileishmanial activity: Significant activity for compounds 62 and 63 and moderate for lucidamine A against L. donovani. Also, 100% Inhibition of promastigote at 100 μg/ml were reported for all the above compounds (Fotie et al., 2007) |
| Meliaceae    | Turraeanthus africanus (Welw. ex C.D.C.) Pellegr (8233/HNC) | Asthma, stomachache, intestinal worms, and inflammatory diseases (Ekwalla and Tongo, 2003) | Aerial parts, roots | Turraeanthin C; sesamin (Vardamides et al., 2008) | Antitoxoplamal activity: Moderate activity for turraeanthin C and low activity for crude bark extract and sesamin. Inhibition of parasite growth at 10 μg/ml was found to be 55% for turraeanthin C, 20% for sesamin and 40% for crude extract (Vardamides et al., 2008) |
| Verbenaceae  | Clerodendrum umbellatum Poir (7405/HNC) | Epilepsy, headache, intestinal helminthiasis, irregular menstruation, infectious dermatitis, asthma, metaphysical powers, whitlow, vulvovaginitis (Adjanoahun et al., 1996; Jatsa et al., 2009) | Not specified   | Not identified but, flavonoids, saponins, saponosides, tannins, and triterpenes were detected in the leaves aqueous extract (Jatsa et al., 2009) | Antischistosomal activity: 100 % reduction rate reported for mice infected with S. mansoni when treated with 160 mg/kg body weight of aqueous leaves extract (Jatsa et al., 2009) |

*HNC or SRFK: Cameroon National herbarium code; BUD, Herbarium of the Botany Department of the University of Dschang, Cameroon. 

**Compounds characterized for the first time in Cameroonian medicinal plant are underlined. 

Screened activity: Leishmania donovani (L. donovani); Schistosoma mansoni (S. mansoni); Toxoplasma gondii (T. gondii); Trypanosoma brucei rhodesiense (T. b. rhodesiense); Trypanosoma brucei (T. brucei).
Table 4 | Plants used in Cameroon as anti-inflammatory and analgesic agents, with evidence of their activities.

| Family       | Species*                           | Traditional treatment                                    | Plant part used | Bioactive (or potentially active) compounds* | Screened activity¹ |
|--------------|------------------------------------|----------------------------------------------------------|-----------------|---------------------------------------------|--------------------|
| Acanthaceae  | Acanthus montanus (Nees) T. Anderson (1652/SRF61CAM) | Cough, hypertension, skin infection, boil, witches, dysmenorrhea, pain, epilepsy, miscarriages, heart troubles, rheumatic pain, syphilis (Burkill, 1985; Adjanohoun et al., 1996; Babu et al., 2001; Nouni and Foci, 2003; Igoli et al., 2009; Nana et al., 2008) | Leaves          | Not identified                             | Leave extract showed analgesic and anti-inflammatory properties and the proposed mechanism was the inhibition of the prostaglandins pathway at 200 mg/kg in rats. Also, this extract at 200 mg/kg body weight in rats reduced carrageenan-induced edema, and formalin-induced pain (Asongalem et al., 2004). |
| Anacardiaceae| Sclerocarya birea (A. Rich.) Hoehst (7770/HNC) | Boils and blood circulation problems, rheumatism, infectious diseases, inflammation (Mojeremane and Tshwenyane, 2004; Fotio et al., 2009) | Bark            | Not identified                             | Bark extract inhibited albumin-induced paw edema (Ojewole, 2004), Formalin- or Freund’s adjuvant (CFA)-carrageenan, histamine, or serotonin-induced paw edema (Fotio et al., 2009) in rats |
| Caesalpiniae | Erythrophleum suaveolens, Guillemin & Perrottet (HN001AD) | Anti-poison, dermatitis, infectious disease, convulsion, inflammation due to snake bite, cardiac problems, headaches, migraines edema, rheumatism, asthma (Dalziel, 1937; Bouquet, 1969; Leiderer, 1982; Neuwinger, 1999) | Bark            | Not identified                             | Extract from the bark and fractions at 19.2 μg/ml showed inhibition of carrageenan-induced paw edema in rats; Hexane fraction inhibited the 5-lipoxygenase activity (Dongmo et al., 2001) |
| Combretaceae | Combretum molle R.Br ex G.Don (6518/SRF/CAM) | Fever, abdominal pains, convulsion, worm infections, AIDS (Bessong et al., 2004) | Bark            | 18-20                                      | Bark extract, compounds 18-20 showed good activity against carrageenan-induced paw edema in rat (Ponou et al., 2008) |
| Crassulaceae | Kalanchoe crenata Andr. (50103/YA/HNC) | Earache, smallpox, headache, inflammation, pain, asthma, palpitation, convulsion, general debility (Dimo et al., 2006) | Not specified   | Not identified                             | n-Butanol fraction inhibited carrageenan-, histamine-, serotonin-, and formalin-induced paw edema in rats (Dimo et al., 2006) |
| Euphorbiaceae| Bridelia scleroneura (42088/HNC) | Abdominal pain, contortion, arthritis, inflammation (Watt and Breyer-Brandwijk, 1962; Théophile et al., 2006) | Bark, roots      | Not identified                             | Crude bark extract showed peripheral and central analgesic and anti-inflammatory activity against acute inflammation processes in rats (Théophile et al., 2006) |
| Euphorbiaceae| Uapaca guineensis (41501/HNC) | Fever, inflammation, pain, skin diseases, and sexual dysfunction (Vivien and Faure, 1996) | Not specified   | Not identified                             | Bark crude extract showed analgesic activity, and inhibited carrageenan-induced inflammation in rats (Nkeh-Chungag et al., 2009) |

(Continued)
| Family           | Species*                  | Traditional treatment                                                                 | Plant part used | Bioactive (or potentially active) compoundsβ | Screened activityγ |
|------------------|---------------------------|----------------------------------------------------------------------------------------|-----------------|---------------------------------------------|--------------------|
| Guttiferae       | Allanblackia monticola    | Amoebic dysentery, diarrhea, indigestion, pulmonary infections, skin diseases, headache, inflammation, and generalized pain (Raponda-Waker and Sillans, 1961) | Bark            | Betulinic acid, lupeol, and amangostin (Nguemfo et al., 2009) | Crude extract from the bark, lupeol, betulinic acid, and a-mangostin inhibited paw carrageenan-induced edema rat (Nguemfo et al., 2007, 2009) |
|                  | Staner L.C. (61168/HNC)   |                                                                                        |                 |                                             |                    |
| Leguminosae      | Erythrina addisoniae      | Dysetery, asthma, venereal diseases, boils, and leprosy (Talla et al., 2003)           | Bark            | Warangalone (56) (Talla et al., 2003)       | Bark extract and compound 56 showed an anti-inflammatory on the PLA$_2$-induced paw edema and 12-O-tetradecanoylphorbol 13-acetate-induced ear edema in mice (Talla et al., 2003) |
|                  | Hutchinson & Dalziel (41617/HNC) |                                                                                        |                 |                                             |                    |
|                  | Erythrina mildbraedii    | Dysetery, stomach pains, venereal diseases, asthma, female sterility, ulcers, boils and various types of inflammations (Oliver-Bever, 1986) | Bark, roots     | Erycristagallin (57) (Njamen et al., 2003)  | Root bark extract inhibited the carrageenan-induced mouse paw whilst compound 57 inhibited the PLA$_2$-induced mouse paw edema and mouse ear edema induced by 2-O-tetradecanoylphorbol 13-acetate (Njamen et al., 2003) |
|                  | Harms (50452/HNC)         |                                                                                        |                 |                                             |                    |
|                  | Erythrina sigmoidea Hua  | Female infertility, stomach pain, and gonorrhea (Giner-Larza et al., 2001)             | Bark            | Sigmoidin A (51) and B (52) (Njamen et al., 2004) | Compound 51 inhibited PLA$_2$-induced paw edema in mice, while both compounds 51 and 52 were found to be effective 12-O-tetradecanoylphorbol 13-acetate-induced ear edema (Njamen et al., 2004) |
|                  |                            |                                                                                        |                 |                                             |                    |
|                  | Millettia versicolor      | Intestine parasitosis, rheumatism, pain, infertility (Adjanohoun et al., 1988; Bouquet, 1969) | Not specified   | 2-acetyl-7-methoxynaphthol[2,3-b] furan-4,9-quinone (29) (Fotsing et al., 2003) | CH$_2$Cl$_2$ fraction from methanol crude bark extract inhibited carrageenan-induced paw edema and TPA-induced acute ear edema in mouse as well as compound 29 (Fotsing et al., 2003) |
|                  | Welw. (32315/HNC)         |                                                                                        |                 |                                             |                    |
|                  | Millettia griffoniana Baill. (32315/SRF/HNC) | Boils, insects bits, inflammatory affections like pneumonia, and asthma, infertility, amenorrhea, menopausal disorders (Sandberg and Cronlund, 1977) | Bark, roots     | Griffonianone D (55) (Yankep et al., 2003) | Extract of the root bark and compound 55 showed anti-inflammatory effects via inhibition of PLA$_2$-induced mouse paw edema and TPA-induced acute mouse ear edema (Yankep et al., 2003) |
| Solanaceae       | Solanum torum Swartz.     | Fever, wounds, tooth decay, haemostatic properties, pain, anti-inflammation (Henty, 1973; Ndebia et al., 2007) | Leaves          | Not identified                             | Crude extract from the leaves inhibits both acetic acid- and pressure-induced pain at 300 mg/kg body weight of rats, and also anti-inflammatory activity on carrageenan-induced paw edema (Ndebia et al., 2007) |
|                  | (21103/HNC)               |                                                                                        |                 |                                             |                    |

*HNC or SRFK: Cameroon National herbarium code.  
βCompounds characterized for the first time in Cameroonian medicinal plant are underlined.  
γScreened activity: TPA (2-O-tetradecanoylphorbol 13-acetate); PLA$_2$ (phospholipase A$_2$).
reported to be useful in diabetes worldwide and have empirically been used as anti-diabetic and anti-hyperlipidemic remedies. Anti-hyperglycemic effects of these plants were attributed to their ability to restore the function of pancreatic tissues by increasing insulin output, inhibiting the intestinal absorption of glucose, or enhancing metabolism of insulin-dependent processes. Several plant preparations were traditionally used in Cameroon to treat diabetes. Some of them were screened for their bioactivity, but most of the studies were not pursued until the isolation of active principles. Plants with hypoglycaemic activities include Anacardiococcum occidentale, Sclerocarya birrea, Ageratum conyzoides, Ceiba pentandra, Kalanchoe crenata, Bridelia ndellensis, Irvingia gabonensis, Bersama engleriiana and Morinda lucida (Table 5).

ANTIOXIDANT ACTIVITIES

The common link between oxidants and inflammatory reactions, infections, cancer, and other disorders has been well established (Mongelli et al., 1997; Wang et al., 1999). However, this may not really be of therapeutic relevance, but more of a preventive medicine. In chronic infections and inflammation as well as in other disorders, release of leukocytes and other phagocytic cells readily defends the organism from further injury. The cells do this by releasing free oxidant radicals, and these by-products are generally reactive oxygen species (ROS) such as super oxide anion, hydroxyl radical, nitric oxide, and hydrogen peroxide that result from cellular redox processes (Ames et al., 1993; Mongelli et al., 1997). At low or moderate concentrations, ROS exert beneficial effects on cellular responses and immune function. At high levels, however, free radicals and oxidants generate oxidative stress, a deleterious process that can damage cell structures, including lipids, proteins, and DNA (Pham-Huy et al., 2008). Oxidative stress plays a major role in the development of chronic and degenerative ailments such as cancer, autoimmunity disorders, rheumatoid arthritis, cataract, aging, cardiovascular, and neurodegenerative diseases (Willcox et al., 2004b; Pham-Huy et al., 2008). Antioxidants act as free radical scavengers by preventing and repairing damages caused by ROS and, therefore, can enhance the immune defense and lower the risk of cancer and degenerative diseases (Ames et al., 1993; Pham-Huy et al., 2008).

In recent years, there is an increasing interest in finding antioxidant phytochemicals, because they can inhibit the propagation of free radical reactions, and thereby protect the human body from diseases (Téarao and Piskula, 1997). Several medicinal plants of Cameroon were screened for their antioxidant properties and a number of bioactive compounds was isolated (Table 6). Omosore et al. (2005) considered the cut-off point for antioxidant activity as 50 μg/ml. Samples with IC₅₀ > 50 μg/ml were classified as being moderately active, while samples with IC₅₀ < 50 μg/ml were judged as having high antioxidant capacity. In the present paper, samples will be considered to have high or significant antioxidant capacity with IC₅₀ < 50 μg/ml (extract) or IC₅₀ < 10 μg/ml (compounds), moderate antioxidant capacity with 50 < IC₅₀ < 100 μg/ ml (extract) or 10 < IC₅₀ < 20 μg/ml (compounds) and low antioxidant capacity with IC₅₀ > 100 μg/ml (extract) or IC₅₀ > 20 μg/ml (compounds). Extracts from 42 medicinal plants of Cameroon used for the treatment of anemia, diabetes, AIDS, malaria, and obesity were recently screened for antioxidant properties, with a considerable number showing good activities (Agbor et al., 2007). Many of them exhibited high inhibition percentages on the basis of Folin, Ferric reducing antioxidant power (FRAP), and DPPH (1,1-diphenyl-2-picrylhydrazyl) assays. Plants with good activities included Alchornea cordifolia (Euphorbiaceae), Dacyrodes edulis (Burseraceae), Ocimum basilicum (Lamiaceae), Harungana madagascariensis (Hypericaceae), Cylindococcus gabunensis (Mimosaceae), Coleus caprosolifolius (Lamiaceae) (Agor et al., 2007). Arylbenzo furans isolated from the bark of Morus mesozzygia (Moraceae), moracin T (43), moracin U (44), moracin S (45); moracin R (46) also showed strong DPPH scavenging capability with IC₅₀ values of 4.12, 5.06, 6.08, and 7.17 μg/ml, respectively (Kapche et al., 2009). The activity of the crude extract of this plant was also reported as significant (IC₅₀: 5.92 μg/ml), by means of the DPPH scavenging assay (Kapche et al., 2009).

OTHER ACTIVITIES

Other studies involving Cameroon medicinal plants include their action on human fertility and enzymatic activities. However, few studies have focused on these activities, explaining the scarcity of published data.

Some plants with positive effects on the reproductive system based on studies using experimental rats have been reported. They include Aloe buettneri (Liliaceae), Justicia insularis and Dichiptera verticillata (Acanthaceae) and Hibiscus macranthus (Malvaceae), locally used to regulate the menstrual cycle and to treat dysmenorrhea or infertility in women (Telefo et al., 1998); Basella alba (Basellaceae) (Moundipa et al., 2005), and Mondia whitei (Periplocaceae) traditionally claimed to increase libido (Watcho et al., 2001).

Some compounds from Cameroonian plants were investigated for the ability to interfere with the activity of some enzymes such as xanthine oxidase, phosphodiesterase I, or prolyl endopeptidase. Xanthine oxidase catalyzes the oxidative hydroxylation of hypoxanthine or xanthine using oxygen as a cofactor, and the resulting end products are superoxide anion (O₂⁻) and uric acid. The inhibitors of xanthine oxidase enzyme can prevent the generation of excess superoxide anions (Chung et al., 1997). Phosphodiesterase I successively hydrolyzes 5′-mononucleotides from 3′-hydroxyl-terminated ribo- and deoxyribo-oligonucleotides. The enzyme has been widely utilized as a tool for structural and sequential studies of nucleic acids. The 5′-nucleotide phosphodiesterase isozyme-V test is useful in detecting liver metastasis in breast, gastrointestinal, lung, and various other forms of cancers (Lei-Injo et al., 1980). Prolyl endopeptidase catalyzes the hydrolysis of peptide bonds at the t-proline carboxy terminal and, thus, plays an important role in the biological regulation of proline-containing neuropeptides and peptide hormones, which are recognized to be involved in learning and memory (Szeltner et al., 2000). The stilbene glycosides isolated from Boswellia papyrifera (Del.) Hochst (Burseraceae), trans-4′,5-dihydroxy-3-methoxystilbene-5-O-[α-l-rhamnopyranosyl-(1-2)-[α-l-rhamnopyranosyl-(1-6)]-β-d-glucopyranoside and trans-4′,5-dihydroxy-3-methoxystilbene-5-O-[α-l-rhamnopyranosyl-(1-6)]-β-d-glucopyranoside exhibited significant inhibition of phosphodiesterase I and xanthine oxidase (Atta-ur-Rahman et al., 2005). Triterpenes such as 3-α-acetoxy-27-hydroxylup-20(29)-en-24-oic acid, 11-keto-β-boswellic acid, β-elemionic
Table 5 | Plants used in Cameroon to treat diabetes, with evidence of their activities.

| Family          | Species*                                      | Traditional treatment                                                                 | Plant part used | Bioactive (or potentially active) compounds | Screened activitya                                                                 |
|-----------------|-----------------------------------------------|----------------------------------------------------------------------------------------|-----------------|---------------------------------------------|-------------------------------------------------------------------------------------|
| Anacardiaceae   | Anacardium occidentale L. (41935/HNC)         | Diabetes mellitus (Kamchtouing et al., 1998)                                             | Leaves          | Not identified                              | Leaves extract showed anti-diabetes activity through protective role against the diabetogenic action of STZ and hypoglycemic effects in rats (Kamchtouing et al., 1998; Sokeng et al., 2007) |
|                 | Sclerocarya birea [A. Rich.] Hochst (7770/HNC) | Diabetes, diarrhea, dysentery, gangrenous rectitis, fevers, stomach disorders, ulcers, sore eyes (Volt and Breyer-Brandwijk, 1962; Bryant, 1966; Gelfand et al., 1985; Dieye et al., 2008) | Leaves, bark, roots | Not identified                              | Bark extracts have been reported to exert hypoglycemic in rats following acute and chronic treatments (Ojewole, 2003; Dimo et al., 2007; Gondwe et al., 2008, acting directly on insulin-secreting cells (Ndifossap et al., 2010) |
| Asteraceae      | Ageratum conyzoides L. (19050/SFR/Cam)        | Cough, fever, skin disease, diabetes, bleeding due to external wounds, furuncle, eczema, carbuncle, headaches (Lavergne and Véria, 1989; Tsabang et al., 2001) | Whole plant     | Not identified                              | Leaves extract showed hypoglycemic and anti-hyperglycemic activities in STZ-induced diabetic rats (Nyunaï et al., 2009) |
| Bombacaceae     | Ceiba pentandra (L) Gaertner (43623/HNC)      | Diuretic, diabetes, hypertension, headache, dizziness, constipation, mental trouble, fever, peptic ulcer, rheumatism, leprosy (Nouni and Dibako, 2000; Nouni and Tchakonang, 2001; Ueda et al., 2002) | Bark, leaves, roots | Not identified                              | Roots extract reduced hyperglycemia in STZ-induced diabetic rats (Dzeufiet et al., 2006) |
| Crassulaceae    | Kalanchoe crenata (WEKC) (50103/YA/HNC)       | Inflammatory diseases, diabetes (Kamgang et al., 2008)                                    | Whole plant     | Not identified but terpenoids, tannins, polysaccharides, saponins, flavonoids and alkaloids were identified from the leaves (Kamgang et al., 2008) | Ethanol extract of the whole plant was found to possess significant hypoglycemic effect in normal rats by lowering blood glucose levels and anti-hyperglycemic effect by lowering and maintaining glycemia at normal levels in diabetic rats (Kamgang et al., 2008) |
| Euphorbiaceae   | Bridelia notellensii Beille (9676/HNC)         | Fever, rheumatism, diarrhea, and diabetes (Addae-Mensah and Achenbach, 1985; Onunkwo et al., 1996; Sokeng et al., 2005) | Not specified   | Not identified                              | Ethyl acetate and dichloromethane extracts and fractions of the bark significantly lowered blood glucose levels in type 2 diabetic rats (Sokeng et al., 2005) |
| Irvingiaceae    | Irvingia gabonensis (Aubry Lecomte ex O’Rorke) Baill. (28054/HNC) | Gonorrhea, gastrointestinal and hepatic disorders, wounds infection, diabetes, analgesia (Ngondi et al., 2005) | Bark, fruits, leaves, roots | Not identified                              | Seeds extract showed modulatory effect on diabetes induced dyslipidemia (Dzeufiet et al., 2009) in rats |
| Melianthaceae   | Bersama engleriuna Gurke (24725/HNC)          | Cancer, spasms, infectious diseases, male infertility, diabetes (Watcho et al., 2007) | Leaves, Stem bark, roots | Not identified but flavonoids, phenols, triterpenes, saponins, and anthraquinones were detected in all parts of the plan (Kuate et al., 2008) | Leaves extract showed hypoglycemic properties (Njike et al., 2005) |
| Rubiaceae       | Morinda lucida Benth.                         | Uncontrolled adult cases of diuresis not necessarily associated with diabetes but linked to general body weakness and rapid loss of weight (Kamanyi et al., 1994) | Not specified   | Not identified                              | Root extract showed potent hypoglycemic effects in both normoglycemic and alloxan-induced diabetic mice (Kamanyi et al., 1994) |

*aHNC or SRFK: Cameroon National herbarium code.

bScreened activity: streptozotocin (STZ).
Table 6 | Plants used in Cameroon with evidence of their as antioxidant activities.

| Family       | Species*                  | Traditional treatment                                      | Plant part used | Bioactive (or potentially active) compoundsb | Screened activityc |
|--------------|---------------------------|-----------------------------------------------------------|-----------------|---------------------------------------------|--------------------|
| Ebenaceae    | Diospyros sanza-minika A. Chevalier (9649/ SRF/Cam) | Epilepsy, paralysis, convulsions, spasm, pains (Burkill, 1985) | Leaves          | 11-O-p-hydroxybenzoylnorbergenin; 4-O-(30-methylgalloyl) norbergenin; 4-O-syringoylnorbergenin; norbergenin; 4-O-galloylnorbergenin; quercitol (Tangmouo et al., 2009) | DPPH scavenging activity: significant for 4-O-galloylnorbergenin, moderate for norbergenin, 11-O-p-Hydroxybenzoylnorbergenin, 4-O-(30-Methylgalloyl)norbergenin and 4-O-Syringoylnorbergenin (Tangmouo et al., 2009) |
|              | Guttiferae                | Dressing for wounds (Bouquet, 1969)                       | Sap             | Bangangxanthone A; bangangxanthone B; 2-hydroxy-1,7-dimethoxyxanthone; 1,5-dihydroxyxanthone (Lannang et al., 2005) | DPPH scavenging activity: bangangxanthone A isolated from the bark showed the best activity with an IC₅₀ = 870 μM while the standard value for BHA was IC₅₀ = 42.0 μM (Lannang et al., 2005) |
|              | Garcinia afzelii Engl.    | Bacterial infections, dental caries (Adu-Tutu et al., 1979; Waffo et al., 2006) | Leaves; flowers | Aafzelixanthones A; aafzelixanthones B (Waffo et al., 2006) | DPPH scavenging activity: Significant for the crude extract and moderate for Aafzelixanthones A and B (Waffo et al., 2006) |
|              | Hypericaceae              | Diarhea, dysentery, indigestion, poor pancreatic function (Berhaut, 1975; Prajapati et al., 2003) | Not specified   | Harunmadagascarins A and B, Harunmadagascarins B, harunganol B and harungin anthrone (Kouam et al., 2005) | DPPH scavenging activity: IC₅₀ of 60.97; 64.76 were recorded with harunmadagascarin and harunganol B respectively (Kouam et al., 2005) |
|              | Meliaceae                 | Arthritis, general fatigue, skin diseases and as febrifuge (Ayafor et al., 1994) | Seeds           | Quercetin (Omisore et al., 2005) | DPPH scavenging activity: low for quercetin (Omisore et al., 2005) |
|              | Entada rheddi Spreng (199666/ SRI/CAM) | Jaundice (Nzowa et al., 2010) | Seeds           | Rheediinoside A; rheediinoside B (Nzowa et al., 2010) | ABTS+ scavenging activity; moderate for rheediinoside B; low for rheediinoside A; DPPH scavenging activity: low activity for rheediinoside A and rheediinoside B (Nzowa et al., 2010) |
|              | Mimosaceae                | Malaria (Boyom et al., 2009) | Twigs           | Bartericins A; stigmasterol; isobavachalcone (Omisore et al., 2005) | DPPH scavenging activity: low bartericin A and isobavachalcone and stigmasterol (Omisore et al., 2005) |
|              | Dorstenia convexa De Wild (S3450 HNC) | Snakebite, rheumatic, infectious diseases, arthritis (Tsopmo et al., 1999) | Whole plant     | Bartericins A, B; stigmasterol; isobavachalcone; 4-hydroxylochnocarpin (Omisore et al., 2005) | DPPH scavenging activity: significant for twigs extract (Omisore et al., 2005) |
|              | Dorstenia barteri Bureau (44016/ HNC) | Rheumatism, stomach disorders (Bouquet, 1969) | Leaves          | Dorsmanin F; 6,8-diprenylerydicitol (Omisore et al., 2005) | DPPH scavenging activity: low for 6,8-diprenylerydicitol, and dorsmanin F (Omisore et al., 2005) |
|              | Dorstenia mannii Hook. f. (2135/ HNC) | Arthritis, rheumatism, malnutrition, debility, pain-killers, stomach disorders, wound infections, gastroenteritis, peptic ulcer, infectious diseases (Burkill, 1985; Noumi and Dibakto, 2002) | Bark            | Moracin R (46); moracin S (45); moracin T (43); moracin U (44) (Kapche et al., 2009) | DPPH scavenging activity: significant for bark crude extract, compounds 43–46 (Kapche et al., 2009) |
|              | Morus mesozygia Stapf. (4228/ SRFK) |                                                                         |                 |                                            |                    |

(Continued)
acid, 3 α-acetoxy-11-keto-β-boswellic acid, and β-boswellic acid also exhibited prolyl endopeptidase inhibitory activities (Atta-ur-Rahman et al., 2005).

**CONCLUSION**

The present review presents an overview of medicinal plants research in Cameroon and is intended to serve as scientific baseline information for the documented plants as well as a starting point for future studies. The paper draws attention on some active metabolites and plant extracts, with the potential for new drugs or improved plant medicines. The review inevitably shows the richness of the Cameroon flora as medicinal resource and demonstrates the effectiveness of numerous traditionally used plants. Presently, there is an urgent necessity for standardization of plant-derived drugs, as their use is still empirical. There is also an urgent requirement to standardize methods and cut-off points for describing their bioactivities. Other recommendations include parallel screenings by using cytotoxicity tests to preclude non-specific cytotoxicity from being interpreted as efficient following in vitro screening. The elucidation of the mechanisms of action of biologically active extracts and compounds should be strengthened and given priority in future investigations as already shown for natural products from other parts of the world (Kong et al., 2009; Youns et al., 2010; Konkimalla and Effert, 2010).

**ACKNOWLEDGMENTS**

Authors are grateful to Dr. H.M. Poumala (Faculty of Science, University of Yaoundé 1) for his support. Victor Kuete is also thankful to the Deutscher Akademische Austausch Dienst (DAAD) for the postdoctoral fellowship at the University of Mainz, Germany.

**REFERENCES**

Addae-Mensah, I., and Achenbach, H. (1985). Terpenoids and flavonoids of Bridelia ferruginea. Phytochemistry 24, 1817–1819.

Adjanohoun, I. E., Aboubakar, N., Dramane, K., Ebot, M. E., Ekpere, J. A., Eno-Orock, E. G., Focho, D., Gbile, Z. E., Kamanyi, A., Kamou, M., Keita, A., Mbenkum, T., Mbi, C. N., Mbile, A. L., Mbroume, I. L., Miburu, N. K., N’guyen, W., L. Nkongmeneck, B., Satabie, B., Sofowora, A., Tarrue, V., and Wirmum, C. K. (1996). *Traditional Medicine and Pharmacopoeia: Contribution to Ethnopharmacological and Floristic Studies in Cameroon*. Lagos-Nigeria: OAU/STRC.

Adu-Tutu, M., Afiful, Y., Asante-Appiah, K., Lieberman, D., Hall, J. B., and Elvin-Lewis, M. (1979). Chewing stick usage in southern Ghana. *Econ. Bot.* 33, 320–328.

Agbor, G. A., Kuate, A., and Oben, J. E. (2007). Medicinal plants can be good source of antioxidant: Case study in Cameroon. *Pak. J. Biol. Sci.* 10, 537–544.

Ames, B. N., Shigenaga, M. K., and Hagen, T. M. (1993). Oxidants, antioxidants and the degenerative diseases of aging. *Proc. Natl. Acad. Sci. U.S.A.* 90, 7915–7922.

Ammah, A., Nkou-Akenji, T., Ndip, R., and Deas, J.-E. (1999). An update on concurrent malaria and typhoid fever in Cameroon. *Trans. R. Soc. Trop. Med. Hyg.* 93, 127–129.

Anonymous. (2006). Plan stratégique national de développement et d’intégration de la médecine traditionnelle au Cameroun 2006-2010. http://www.irad-cameroun.org/Doc/ Documents/1138721368_new_year_speach_SG_d%C3%A9finitif.doc. (Accessed on May 04, 2010).

Asongalem, E. A., Foyet, H. S., Ekobo, S., Dimo, T., and Kamchoung, P. (2004). Antiinflammatory, lack of central analgesia and antipyretic properties of *Acanthus montanus* (Nees)T.Anderson. *J. Ethnopharmacol.* 95, 63–68.

Atta-ur-Rahman, Naz, H., Fadimatou, M., Asongalem, E. A., Foyet, H. S., Ekobo, S., Ngounou, F. N., Kimbu, S. F., Sondengam, B. L., and Iqbal Choudhary, M. I. (2005). Antioxidant constituents from *Boswellia papyrifera*: *J. Nat. Prod.* 68, 189–193.

Aubreville, A. (1950). *Flore Forestière Soudana-Guinéenne A.O.F. Cameroun* Paris: A.E.F, Société d’Édition Géographique Maritime et Coloniale.

Aylfor, J. F., Kimbu, S. F., and Ngadjui, B. T. (1994). Limonoids from Curupu *Carapa grandifolia* (Meliaceae). *Tetrahedron* 50, 9343–9354.

Babu, B. H., Shulesh, B. S., and Padikkala, J. (2001). Antioxidant and hepatoprotective effect of *Acanthus ilicifolius* (Acanthaceae). *Fitoterapia* 72, 272–277.

Bennett, P. (2007). New data, fresh perspectives: diabetes atlas, third edition. *Diabetes Voice* 52, 46–48.

Berhaut, J. (1975). *Flore Illustrée du Sénégal*, Tome IV Dakar: Préface de M. Leopold Sendar Senghor.

Bessong, P. O., Obi, C. L., Igumbor, E., Andreola, M.-L., and Livak, S. (2004). In vitro activity of three selected South African medicinal plants against human immunodeficiency virus type 1 reverse transcriptase. *Afr. J. Biotechnol.* 3, 555–559.

Bickii, J., Feuya Tchouya, G. R., Tchoouankeu, J. C., and Tsoamo, E. (2007a). The antiplasmodial agents of the stem bark of *Entandrophragma angolense* (Meliaceae). *Afr. J. Trad. CAM* 4, 135–139.

Bickii, J., Feuya Tchouya, G. R., Tchoouankeu, J. C., and Tsoamo, E. (2007b). Antimalarial activity in crude extracts of some Cameroonian medicinal plants. *Afr. J. Trad. CAM* 4, 107–111.

Bickii, J., Njitufe, N., Foyere, J. A., Basco, L. K., and Ringwald, P. (2000). In vitro...
Kuete and Effert

Cameroonian medicinal plants

antimalarial activity of limonoids from Khaya grandifoliola C.D.C. (Melaceae). J. Ethnopharmacol. 69, 27–33.
Boik, J. (2001). Natural Compounds in Cancer Therapy. Minnesota, USA: Oregon Medical Press.
Boym, F.F., Kemgne, E.M., Tepongning, R., Ngouana, V., Mbacham, W.F., Tsamo, E., Amvam Zollò, P.H., Guti, J., and Rosenthal, P.J. (2009). Antiplasmoidal activity of extracts from seven medicinal plants used in malaria treatment in Cameroon. J. Ethnopharmacol. 123, 483–488.
Bouquet, A. (1969). Fèticheurs et médicines traditionnelles du Congo (Brazzaville). Paris: ORSTOM.
Braithi, G., Kona, F.R., Fiasella, A., Buac, D., Soukoupov, J., Brancle, A., Burger, A.M., and Westwell, A.D. (2010). Exploring the structural requirements for inhibition of the ubiquitin E3-ubiquitin ligase breast cancer associated protein 2 (BCA2) as a treatment for breast cancer. J. Med. Chem. 53, 2757–2765.
Bray, D.H., Warhurst, D.C., Connelly, J.D., O’Neill, M.J., and Killipsson, J.D. (1990). Plants as sources of antimalarial drugs. Part 7. Activity of some species of Meliaceae and their constituent limonoids. Phytother. Res. 4, 39–45.
Bryant, A.T. (1966). Zulu Medicine and Medicine Men. Cape Town: Struik C.
Burkill, H.M. (1985). Useful Plants of Western Tropical Africa. Edinburgh: Royal Botanic Garden.
Calas, M., Cordina, G., Bompart, J., Bari, M.B., Le, T., Anelm, M.L., and Vial, H. (1997). Antimalarial activity of molecules interfering with plasmodium falciparum phospholipid metabolism. Structure–activity relationship analysis. J. Med. Chem. 40, 3557–3566.
Castro-Leal, J., Dayton, L., and Mehra, K. (2001). Public spending on health care in Africa: do the poor benefit? Bull. World Health Organ. 78, 66–74.
Cheek, M. (2004). Thecaearis annone-bae. IUCN 2009. IUCN Red List of Threatened Species. http://www.iucnredlist.org/apps/redlist/details/454570/0. (Accessed on April 13, 2008).
Chung, H.Y., Back, B.S., Song, S.H., Kim, M.S., Huh, J.I., Shin, K.H., Kim, K.W., and Lee, K.H. (1997). Xanthine dehydrogenase/xanthine oxidase and oxidative stress. Age (Omaha) 20, 127–140.
Cos, P., Vliephinck, A.J., Vanden Bergh, D., and Maes, L. (2006). Anti-infective potential of natural products: How to develop a stronger in vitro ‘proof-of-concept’. J. Ethnopharmacol. 106, 290–302.
Croft, S.L., Barrett, M.P., and Urbina, J.A. (2005). Chemotherapy of trypano- somiasis and leishmaniasis. Trends Parasitol. 21, 508–512.
Dahal, J.M. (1997). The Useful Plants of West Tropical Africa. London: The Crown Agents for the Colonies.
Dye, A.M., Sari, A., Diop, S.N., Ndaye, M., Sy-G.Y., Diarra, M., Rajafy Gaffary, L., Ndialy Sy, A., and Faye, B. (2008). Medicinal plants and the treatment of diabetes in Senegal: survey with patients. Fundam. Clin. Pharmacol. 22, 211–216.
Dimo, T., Focio, A.L., Nguelefack, T.B., Asongame, E.A., and Kamtchouing, P. (2006). Antifilariatic activity of leaf extract of Kalanchoe crenata Andr. Indian J. Pharmacol. 38, 115–119.
Dimo, T., Rakotorinina, S.V., Tan, P.V., Azay, J., Dongo, E., Kamtchouing, P., and Cros, G. (2007). Effect of Sclerocarya birrea (Anacardiaceae) stem bark methylene chloride/methanol extract on streptozotocin-diabetic rats. J. Ethnopharmacol. 110, 438–443.
Dongmo, A.B., Kamanyi, A., Chong-Arye Nyhe, B., Njamen, D., Nguelefack, T.B., Nole, T., and Wagner, H. (2001). Anti-inflammarory and analgesic properties of the stem bark extracts of Erythrophleum suaveolens (Caesalpiniaceae), Guillenim & Perrottet. J. Ethnopharmacol. 77, 137–141.
Dzeutfet, P.D.D., Ngouate, D.E., Dimo, T., Tédong, L., Ngueguim, T.E., Tchamadeu, M.C., Nkouambou, N.C., Sokeng, S.D., and Kamtchouing, P. (2009). Hypoglycemic and hypolipidemic effects of Irvingia gabonensis (Irvingiaceae) in diabetic rats. Pharmacognosyonline 2, 957–962.
Dzeutfet, P.D.D., Tédong, L., Asongame, E.A., Dimo, T., Sokeng, S.D., and Kamtchouing, P. (2006). Hypoglycaemic effect of methylene chloride/ methanol root extract of Ceiba pentandra in normal and diabetic rats. Indian J. Pharmacol. 38, 194–197.
EarthTrends. (2003). Biodiversity and Protected Areas–Cameroon. http://earthtrends.wri.org/pdf_library/country_profiles/bio_cou_120.pdf. (Accessed on May 04, 2010).
Edmondson, J. (2001). Malaria and Poverty: Opportunities to Address Malaria through Debt Relief and Poverty Reduction Strategies. www.ishitm.ac.uk/itd/dcbvu/malcon. (Accessed on November 08, 2009).
Ekwalla, N., and Tongo, E. (2003). Nos plantes qui soignent. Doula: Cameroon. Ed: Eo.
Eyang, K.O., Kumar, P.S., Kuete, V., Fofolle, G.N., Nkengfack, A.E., and Baskaran, S. (2008). Semisynthesis and antimutational activity of 2-acetyl-
Kamgang, R., Mboumi, R. Y., Fondjo, A. E., Tagne, M. A. F., Ndillé, G. P. R. M., and Yontek, J. N. (2008). Antiphytygical potential of the water–ethanol extract of Kalanche crenata (Crassulaceae). J. Nat. Med. 62, 34–40.

Kamtchouing, P., Sogbédé, M., Moundipa, P. F., Watcho, P., Jatsa, H. B., and Lontsi, D. (1998). Protective role of Anacardium occidentale extract against streptozotocin-induced diabetes in rats. J. Ethnopharmacol. 62, 95–99.

Kapche, G. D. W. F., Fozing, C. D., Donfack, J. H., Fotso, G. W., Amadou, D., Tcha, A. N., Bezabih, M., Moundipa, P. F., Ngadjui, B. T., and Abegaz, B. M. (2009). Prenylated arylbenzofuran derivatives from Morus mesozygia with antioxidant activity. Phytochemistry 70, 216–221.

Kermadoué, M., Prost, E., Harakat, D., Jaquey, M. J., Frédérick, M., Sondengam, L. B., Zèches, M., and Wafo-Téguo, P. (2006). Five lab dane diterpenoids from the seeds of Harungana madagascariensis. J. Nat. Prod. 69, 57–61.

Kapche, G. D. W. F., Fozing, C. D., Donfack, J. H., Fotso, G. W., Amadou, D., Tcha, A. N., Bezabih, M., Moundipa, P. F., Ngadjui, B. T., and Abegaz, B. M. (2009). Prenylated arylbenzofuran derivatives from Morus mesozygia with antioxidant activity. Phytochemistry 70, 216–221.

Kermadoué, M., Prost, E., Harakat, D., Jaquey, M. J., Frédérick, M., Sondengam, L. B., Zèches, M., and Wafo-Téguo, P. (2006). Five lab dane diterpenoids from the seeds of Harungana madagascariensis. J. Nat. Prod. 69, 57–61.

Kapche, G. D. W. F., Fozing, C. D., Donfack, J. H., Fotso, G. W., Amadou, D., Tcha, A. N., Bezabih, M., Moundipa, P. F., Ngadjui, B. T., and Abegaz, B. M. (2009). Prenylated arylbenzofuran derivatives from Morus mesozygia with antioxidant activity. Phytochemistry 70, 216–221.

Kermadoué, M., Prost, E., Harakat, D., Jaquey, M. J., Frédérick, M., Sondengam, L. B., Zèches, M., and Wafo-Téguo, P. (2006). Five lab dane diterpenoids from the seeds of Harungana madagascariensis. J. Nat. Prod. 69, 57–61.

Kapche, G. D. W. F., Fozing, C. D., Donfack, J. H., Fotso, G. W., Amadou, D., Tcha, A. N., Bezabih, M., Moundipa, P. F., Ngadjui, B. T., and Abegaz, B. M. (2009). Prenylated arylbenzofuran derivatives from Morus mesozygia with antioxidant activity. Phytochemistry 70, 216–221.

Kermadoué, M., Prost, E., Harakat, D., Jaquey, M. J., Frédérick, M., Sondengam, L. B., Zèches, M., and Wafo-Téguo, P. (2006). Five lab dane diterpenoids from the seeds of Harungana madagascariensis. J. Nat. Prod. 69, 57–61.
of West and Central Africa. *Forest Ecol. Manage.* 188, 173–183.

Ngond, J., Obay, A., and Debnik, S. (2005). The effects of Irvingia gabonensis seeds on body weight and blood lipids of obese subject in Cameroon. *Lipids Health Dis.* 4, 12.

Ngouela, S., Lenta, B. N., Tchamo Noungoue, D., Ngoupayo, J., Boyom, F., Tsamo, E., Gut, J., Rosenthal, P. J., and Connolly, J. D. (2006). Anti-plasmodial and antioxidant activities of constituents of the seed shells of *Symphonia globulifera* Linn f. *Phytochemistry* 67, 302–306.

Ngounou, E. N., Meli, A. L., and Lontsi, D. (2000). New isoflavone from Ceiba pendandura. *Phytochemistry* 54, 107–110.

Ngumbo, E. L., Dimo, V., Azbeze, A. G. B., Asongame, A. E., Alaoou, K., Dongo, A. B., Cherrierah, Y., and Kamtchouing, P. (2007). Anti-inflammatory and anti-oxidative activity of the stem bark of *Allanblackia monticola* Stander L.C. (Guttiferae). *J. Ethnopharmacol.* 114, 417–424.

Ngumbo, E. L., Dimo, V., Dongo, A. B., Azbeze, A. G. B., Alaoou, K., Asongame, A. E., Cherrierah, Y., and Kamtchouing, P. (2009). Anti-oxidative and anti-inflammatory activities of some isolated constituents from the stem bark of *Allanblackia monticola* Stander L.C. (Guttiferae). *Inflammopharmacology* 17, 37–41.

Nishimura, R., Tabata, K., Arakawa, M., Ito, Y., Kimura, Y., Akihisa, T., Nagai, H., Sakuma, A., Kohno, H., and Suzuki, T. (2007). Isovacabachalcone, a chalcone constituent of *Angelica keiskei*, induces apoptosis in neuroblastoma. *Biol. Pharm. Bull.* 30, 1878–1883.

Njamen, D., Mbafor, J. T., Fomum, Z. T., Kamanyi, A., Mbanya, J. C., Recio, L., and Ipeko, J. E. (2009). Anti-inflammatory activity of *Erythrina mildbraedii* leaves. *Phytother. Res.* 23, 330–339.

Njaman, D., Elbou, E., and Kamanyi, A. (2000). Medicinal plants of the Yaoundé area. *Phytother. Res.* 14, 99–102.

Njamen, D., Talla, E., Mbafor, J. T., Fomum, Z. T., Kamanyi, A., Mbanya, J. C., and Ipeko, J. E. (2009). *Aralia racemosa* leaves. *Fitoterapia* 80, 257–266.

Nowakowska, Z., Frantl, M., and Stoeck, K. (2007). Anti-inflammatory and antioxidant activity of the ethanolic extracts of *Euphorbia hirta* L. *J. Ethnopharmacol.* 114, 417–424.

Nkengfack, A., Azebeze, A. G. B., Waffo, A. K., Fomum, Z. T., Meyer, M., and Van Heerden, F. R. (2001). Cytotoxic isoflavones from *Erythrina indica*. *Phytochemistry* 58, 1113–1120.

Obih, P. O., Makinde, J. M., and Loeve, J. (1985). Investigation of various extracts of *Morinda lucida* for anti malarial actions on *Plasmodium berghei* in mice. *Afr. J. Med. Sci.* 14, 49–50.

Ojewole, J. A. (2004). Cytotoxic and anti-inflammatory activity of a crude extract of the leaf of *Erythrina crista-galli* on liver cancer cell line. *Phytother. Res.* 18, 801–808.

Ojewole, J. A. (2004). Hypoglycemic effect of *Scleroceara birrea* [A. Rich.] Hochst.] [Anacardiaceae] stem-bark aqueous extract in rats. *Phytochemistry* 67, 675–681.

Ojewole, J. A. (2004). Evaluation of the analgesic, anti-inflammatory and anti-diabetic properties of *Scleroceara birrea* (A. Rich.) Hochst. stem bark aqueous extract in mice and rats. *Phytother. Res.* 18, 801–808.

Olive-Bever, B. (1986). *Medicinal Plants in Tropical West Africa*. New York, NY: Praeger Publishers.

Omisore, N. O. A., Adewumi, C. S., Iweala, E. O., Ngadjui, B. T., Adenowo, T. K., Abegaz, B. M., Ojewole, J. A., and Watchueng, J. (2005). Anti-oxidant and anti-inflammatory activities of *Allanblackia monticola* Stander L.C. *Phytochemistry* 66, 1129–1131.

Okou, P., Mbeup, L. O., and Mompi, P. (2000). *African medicinal plants in the Dahomey area*. *Phytochemistry* 55, 103–107.

Ojewole, J. A., and Watchueng, J. (2005). Free radicals, antioxidants and anti-cancer triterpene saponins from *Euphorbia hirta*. *Phytochemistry* 71, 254–261.

Ojewole, J. A., and Watchueng, J. (2005). Free radicals, antioxidants and anti-cancer triterpene saponins from *Euphorbia hirta*. *Phytochemistry* 71, 254–261.

Osadebe, P. O., and Okoye, F. B. C. (2003). Anti-inflammatory effects of *Erythrina indica* extract on streptozotocin-induced diabetic rats. *Afr. J. Trad. CAM* 2, 94–102.

Ojewole, J. A., and Watchueng, J. (2005). Anti-inflammatory effects of *Erythrina indica* extract on streptozotocin-induced diabetic rats. *Afr. J. Trad. CAM* 2, 94–102.

Osadebe, P. O., and Okoye, F. B. C. (2003). Anti-inflammatory effects of *Erythrina indica* extract on streptozotocin-induced diabetic rats. *Afr. J. Trad. CAM* 2, 94–102.

Ojewole, J. A., and Watchueng, J. (2005). Free radicals, antioxidants and anti-cancer triterpene saponins from *Euphorbia hirta*. *Phytochemistry* 71, 254–261.

Osadebe, P. O., and Okoye, F. B. C. (2003). Anti-inflammatory effects of *Erythrina indica* extract on streptozotocin-induced diabetic rats. *Afr. J. Trad. CAM* 2, 94–102.

Ojewole, J. A., and Watchueng, J. (2005). Free radicals, antioxidants and anti-cancer triterpene saponins from *Euphorbia hirta*. *Phytochemistry* 71, 254–261.

Ojewole, J. A., and Watchueng, J. (2005). Free radicals, antioxidants and anti-cancer triterpene saponins from *Euphorbia hirta*. *Phytochemistry* 71, 254–261.

Ojewole, J. A., and Watchueng, J. (2005). Free radicals, antioxidants and anti-cancer triterpene saponins from *Euphorbia hirta*. *Phytochemistry* 71, 254–261.

Ojewole, J. A., and Watchueng, J. (2005). Free radicals, antioxidants and anti-cancer triterpene saponins from *Euphorbia hirta*. *Phytochemistry* 71, 254–261.
the isoflavonoid anti-inflammatory principle of Erythrina adstringens. Stem Bark. Nat. Prod. 66, P. F. Tchana, A. N., Dzickotze, C. T., and Mbiapo, F. T. (2006). Antinociceptive and anti-inflammatory activities of anthocyanins and other ethnomedicinal species as inhibitors of human tumour cell growth. Phytother. Res. 20, 111–116.

Whelan, L. C., and Ryan, M. F. (2003). Ethanolic extracts of Euphorbia and other ethnomedicinal species as inhibitors of human tumour cell growth. Phytother. Res. 17, 53–58.

WHO. (1980). WHO expert committee on diabetes mellitus: second report. Tech. Rep. Ser. 646, 1–80.

WHO. (1985). Diabetes mellitus: report of a WHO study group. Tech. Rep. Ser. 727, 1–113.

WHO. (2002). WHO traditional medicine strategy 2002–2005. Geneva.

World Health Organization. (1985). Diabetes mellitus: report of a WHO study group. Tech. Rep. Ser. 727, 1–113.

World Health Organization. (2007); http://www.who.int/whosis/whostat/EN_WHS09_Table2.pdf. 2002. Received: 30 June 2010; paper pending publication: 30 July 2010; accepted: 07 September 2010; published online: 25 October 2010. This article was submitted to Frontiers in Ethnopharmacology, a specialty of Frontiers in Pharmacology. Citation: Kuete V and Efferth T (2010) Cameroonian medicinal plants: pharmacology and derived natural products. Front. Pharmacol. 1:23. doi: 10.3389/ fpsph.2010.00123 Copyright © 2010 Kuete and Efferth. This is an open-access article subject to an exclusive license agreement between the authors and the Frontiers Research Foundation, which permits unrestricted use, distribution, and reproduction in any medium, provided the original authors and source are credited.

Conflict of Interest Statement: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Received: 30 June 2010; paper pending publication: 30 July 2010; accepted: 07 September 2010; published online: 25 October 2010. This article was submitted to Frontiers in Ethnopharmacology, a specialty of Frontiers in Pharmacology. Citation: Kuete V and Efferth T (2010) Cameroonian medicinal plants: pharmacology and derived natural products. Front. Pharmacol. 1:23. doi: 10.3389/fphar.2010.00123 Copyright © 2010 Kuete and Efferth. This is an open-access article subject to an exclusive license agreement between the authors and the Frontiers Research Foundation, which permits unrestricted use, distribution, and reproduction in any medium, provided the original authors and source are credited.

October 2010 | Volume 1 | Article 123 | 19

www.frontiersin.org