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Assessing Sub-saharian *Erythrina* for Efficacy: Traditional uses, Biological Activities and Phytochemistry

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Abstract: The genus *Erythrina* comprises more than 100 species, widely distributed in tropical and subtropical areas. In Africa, 31 wild species and 14 cultivated species have been described. In sub-Saharan Africa, *Erythrina* species are used to treat frequent parasitic and microbial diseases, inflammation, cancer, wounds. The rationale of these traditional uses in African traditional medicine was established by screening several species for biological activities. Promising activities were found against bacteria, parasites (Plasmodium), human and phytopathogenic fungi, some of which were multidrug resistant (MDR) microorganisms. Some species also exhibited antioxidant, anti-inflammatory activities and enzymes inhibitory properties. Most of the species chemically investigated were reported to contain flavanones, prenylated isoflavones, isoflavanones and pterocarpans. Some phytochemicals (vogelin B, vogelin C, isowighteone, abyssinin II, derrone) were the active principles as antibacterials, antifungals, antiplasmodials and inhibitors of enzyme borne diseases (PTP1B, HIV protease, DGAT). This review highlights the important role of *Erythrina* species as sources of lead compounds or new class of phytotherapeutic agents for fighting against major public health (MDR infections, cancer, diabetes, obesity) in Sub-Saharan Africa.

Key words: *Erythrina*, bioactive compounds, infectious diseases, metabolic diseases, Sub-saharian Africa

INTRODUCTION

Among the potential uses of African plants, those used in traditional medicine are in the forefront (Sofowora, 2002). Herbal medicines are an important part of the culture and traditions of African people (Fennell *et al*., 2004). Many patients from resource poor settings have strong beliefs in the use and efficacy of ethnomedicines (Chinsembu and Hedimbi, 2010) on which they are reliant for their health care needs. Nowadays industrial companies incorporated ingredients from plant origin in their medicines (El-Said and Al-Barak, 2011). Approximately, between 70-78% of commercial pharmaceuticals included plants (Lokhande *et al*., 2007; Ikpeme *et al*., 2011).

According to Gupta and Sharma (2010), renewed interest in traditional pharmacopoeias has meant that researchers are concerned both with biological activities and phytocompounds of medicinal plants. Plants form a great part of the biodiversity in tropical areas such as Africa. Among the species of Africa's flora, *Erythrina* species were considered.

The genus *Erythrina* (Leguminoseae) is widely distributed in tropical and subtropical areas of the world (Silva *et al*., 2011). As most of Leguminoseae, *Erythrina* species produce many secondary metabolites, some of which have a function of defense systems against pathogenic fungi and bacteria (Karthishwaran *et al*., 2010). Ethnobotanical discovery process of sub-Saharan *Erytrhina* have resulted in promising biological activities (Kone *et al*., 2004; Nguyen *et al*., 2010). Their related bioactive compounds also were reported (Atindehou *et al*., 2002a; Sato *et al*., 2003; Na *et al*., 2007; Innok *et al*., 2009). Many *Erythrina* species showed real potential for fighting against pathogenic agents incriminated in alarming public health problems in sub-Saharan Africa. For example, multidrug resistant pathogens are responsible for therapeutic failures (Kone and Kamanzi Atindehou, 2009). This situation is serious because microbial infections are the most frequent opportunistic diseases occurring during HIV/aids which affected many people in Africa. Moreover, during this infection, cancer and cardiovascular diseases, oxidative stress, generating free radicals, is recognized to cause damage in cells and immune system of patients. Scientists are searching for new molecules that can be alternative to conventional treatments (Coulidiati *et al*., 2011).

This present review aimed at assessing the ethnomedical, biological and phytochemical properties of several sub-Saharan *Erythrina* species studied in our

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laboratory and other laboratories from Africa, Asia, Europe and America. Studies are continuing on sub-Saharan *Erythrina* for identifying new biological activities or bioactive molecules. This review is limited to the only studies available from 1990 through to mid-2011.

Botanical data: *Erythrina* is pantropical, consisting of some 112 species, 70 neotropical, 31 African and 12 Asian. The genus is probably of South American origin but the ability of seeds to environments inhabited by the ancestral species has resulted in worldwide distribution (Kass, 1998). *Erythrina* species are trees, shrubs and perennial herbs with trifoliated leaves. Detailed botanical characteristics of these plants are described in many documents (Hutchinson and Dalziel, 1954-1972; Ake Assi, 2001).

Large cuttings and seeds can be used to reproduce *Erythrina*. This is an advantage whether a large scale use would be needed for development of medicines.

Ethnomedicine: uses in traditional medicine: Methods most often used to study tropical medicinal plant are random screening, taxonomic collecting or ethnobotanical collecting (Flaster, 1996). It has been shown that bioactive compounds from medicinal plants are of huge interest for drug development (Balick, 1990; Anago *et al*., 2011).

Although, species vary with region, *Erythrina* species are used as healing agents in traditional medicine in Africa. Of 31 African species, 11 (35%) have ethnomedical uses in sub-Saharan Africa. These are *E. abyssinica*, *E. addisoniae* Harms, *E. excelsa* Bak., *E. fusca* Lour., *E. latissima* E. Mey, *E. mildbraedii* Harms, *E. poeppigiana* (Walp.) O.F. Cook, *E. senegalensis* A. DC., *E. sigmoidea* Hua, *E. variegata* L. and *E. vogelii* Hook f. Other species may be used for health care; but no literature was available. Most of the consulted documents are articles obtained via Internet, Prelude Medicinal plants database (2008). This somewhat restricted the field of investigations, some documents such as thesis or reports not being accessible.

Erythrina species are widely prescribed in sub-Saharan traditional medicine against frequent diseases from microbial and parasitic origin. According to Prelude Medicinal Plants Database, *E. senegalensis* in West Africa and *E. abyssinica* in central Africa are the most used species. Thirty nine medicinal usages were found for *E. senegalensis* and 60 for *E. abyssinica*. *E. senegalensis* is used in West African countries for almost same therapeutic indications: Benin (Adjanohoun *et al*., 1989), Cameroon (Atsamo *et al*., 2011), Cote d'Ivoire (Tra Bi, 1997; Kamanzi Atindehou, 2002; Kone *et al*., 2004), Guinea (Magassouba *et al*., 2007), Guinea Bissau (Diniz *et al*., 1996), Mali (Togola *et al*., 2005, 2008) and Nigeria (Ainslie, 1937; MacDonald and Olorunfemi, 2000; Saidu *et al*., 2000; Igoli *et al*., 2005; Adamu *et al*., 2005). In Central Africa, *E. abyssinica* is used in Angola (Bossard, 1996), Burundi (Polygenis-Bigendako, 1990), Ethiopia (Bekalo *et al*., 2009), Kenya (Njoroge and Bussmann, 2006; Njoroge and Kibunga, 2007; Wagate *et al*., 2010), Democratic Republic of Congo (Ayobangira *et al*., 2000), Rwanda (Van Puyvelde *et al*., 1997) and Uganda (Tabuti *et al*., 2003; Lamorde *et al*., 2010). Also the use of this species in Nigeria was reported (Adamu *et al*., 2005). More information is available on Prelude and Pharmel databases.

The ailments treated are bacterial, fungal, parasitic and viral diseases, gastrointestinal disorders, liver disorders, sexual asthenia, nervous disorders, sterility, eyes diseases and kidney pain.

E. abyssinica and *E. senegalensis* also are prescribed in ethnoveterinary medicine practices against brucellosis, oedema, hygroma, dropsy, bacterial infections, skin diseases (Byavu *et al*., 2000; Ejobi *et al*., 2007).

Little information was found about the remaining species. *E. vogelii* is used in Cote d'Ivoire (Atindehou *et al*., 2002a) and Cameroon (Ali *et al*., 2010) against microbial infections. *E. sigmoidea* is prescribed against inflammations (Njamen *et al*., 2004; Kouam *et al*., 2007; Udem *et al*., 2010) and cancer (Watjen *et al*., 2007). *E. milbraedii* is used to prepare remedies against prostate (Tchokouaha *et al*., 2010).

No therapeutic uses were found in sub-Saharan Africa for the introduced species such as *E. poeppigiana* and *E. fusca*. In other countries, these plants are used against microbial infections (Sato *et al*., 2003), fever and inflammations (Innok *et al*., 2009).

All plant parts (leaves, stem barks, roots and flowers) are used for the preparation of remedies in the form of decoction, maceration, infusion, powders or calcinates to treat diseases. The treatments are administered by oral routes and baths.

Biological activities: rational uses of sub-Saharan *Erythrina* in traditional medicine: The sub-Saharan *Erythrina* species have been screened for their biological activities against various bacteria, fungi, parasites, enzymes borne diseases and free radicals.

Antibacterial activity: Sanitation and hygiene levels for the majority of people in Africa are not comparable to those of First World countries. Consequently African people are threatened by bacterial infections (Fennell *et al*., 2004) which are of public health concern.

Multidrug resistant-(MDR) bacteria have been reported in sub-Saharan Africa (Aka *et al*., 1987; Okesola *et al*., 1999; Benbachir *et al*., 2001; Kacou-N'Douba *et al*., 2001; Akoua-Koffi *et al*., 2004; Akinyemi *et al*., 2005). Beside this resistance, commercial antibacterial agents are incriminated for their numerous side effects (Nebedum *et al*., 2009). Medicinal plants such as *Erythrina* species are often used to treat bacterial infections.

Antibacterial tests were carried out using various screening methods such as agar diffusion, dilution and microdilution methods (Kone *et al*., 2004). The plant extracts were prepared from one solvent (ethanol, methanol, dichloromethane and acetone) or successively extracted with solvents from different polarity. The studied bacteria were positive gram and negative gram strains some of which were MDR-bacteria (MRSA). They were collection and clinical strains of *Bacillus cereus*, *Escherichia coli*, *Micrococcus lutea*, *Staphylococcus aureus*, *Staphylococcus epidermis*, *Proteus mirabilis*, *Enterococcus faecalis*, *Streptococcus* sp., *Pseudomonas aeruginosa* and *Lactobacillus* sp.

The results of all antibacterial screening showed high sensitivity of positive gram bacteria to *Erythrina* species extracts (Wagate *et al*., 2010). The susceptibility of gram-positive bacteria to extracts can be attributed to the fact that the cell wall of these bacteria is easier to penetrate than that of gram-negative bacteria (Rang and Dale, 1987).

E. senegalensis (Kone *et al*., 2004; Kone *et al*., 2007; Soro *et al*., 2010) and *E. vogelii* (Atindehou *et al*., 2002b) showed strong anti-MRSA activity (MICs = 12-3 μg mL^{-1}).

Against *Pseudomonas aeruginosa* and *Staphylococcus epidermidis*, a moderate antibacterial activity (375-94 μg mL^{-1}) was observed. *E. poeppigiana* exhibited antibacterial activity against bacteria such as MRSA (Sato *et al*., 2003, 2006). According to Fomum *et al*. (1983), *E. sigmoidea* possesses antibacterial activity. *E. variegata* showed activity against MRSA, *Streptococcus mutans* and *Lactobacillus* sp. (Tanaka *et al*., 2002; Sato *et al*., 2004).

None of sub-Saharan *Erythrina* species was reported to show activity against *Escherichia coli*.

The antibacterial activity gave evidence to the traditional uses of some African *Erythrina* species in traditional medicine against bacterial infections. Interestingly all sub-Saharan *Erythrina* have a high antibacterial activity, in particular against MDR-bacteria (MRSA, MLS_B). *Erythrina* species with anti-multidrug-resistance activity are promising and could be used for fighting against MDR-bacterial infections in sub-Saharan Africa.

Antifungal activity: Infections caused by *Candida albicans* (Sunday-Adeoye *et al*., 2009) are of importance because HIV/aids infection is devastating epidemic in Africa (Fennell *et al*., 2004). They are the earliest opportunistic affections during this disease. *Erythrina* species are used in sub-Saharan Africa for treating microbial diseases and some have been screened for antifungal activity. The potency of ethanol, methanol and dichloromethane extracts from these plants was evaluated against fungi and yeasts, using the bioautography (Homans and Fuchs, 1970) and agar overlay (Rahalison *et al*., 1991) methods on thin layer chromatograms. The most active extracts were non-polar ones (dichloromethane). This gives an indication on the lipophilic nature of the active compounds. *E. senegalensis* (Soro *et al*., 2010) and *E. poeppigiana* were active against *C. albicans*. *E. vogelii* exhibited activity against *Cladosporium cucumerinum*, a phytopathogenic filamentous fungus, while *E. variegata* was active against *Actinomyces* sp. (Sato *et al*., 2003).

Antiplasmodial activity: Malaria is part of the serious diseases and mortals in the tropical areas, in particular in Africa. In sub-Saharan Africa, this infectious disease, causing enormous deaths, is endemic due to warm climate (Dadji *et al*., 2011). It is recognized today that malaria is responsible for poverty and a major hurdle with economic development in many countries where this disease prevails. Treatments are available and still effective for the time being. However, there is an urgent need to search for new sources of drugs because the disease-borne agent, *Plasmodium* develops quickly resistance to the molecules in use (Peters, 1998; Wellems and Plowe, 2001; Djaman *et al*., 2004; Pradines *et al*., 2010).

The antiplasmodial activity was evaluated using ^{3}H-hypoxanthin and lactate dehydrogenase methods. Data on antiplasmodial activity were found only for *E. senegalensis* and *E. fusca*. The aqueous extract of *E. senegalensis* stem bark showed a weak activity against *Plasmodium berghei* (Saidu *et al*., 2000). The roots ethanolic extract exhibited strong activity against a multiresistant strain K1 of *Plasmodium falciparum*, with an IC_{50} of 1.82 μg mL^{-1} (Atindehou *et al*., 2004) while the methanol extract inhibited the growth of the same strain (IC_{50} = 99.7 μg mL^{-1}). *E. abyssinica* stem bark (ethyl acetate) exhibited activity against chloroquine-sensitive (D6) and -resistant (W2) *P. falciparum*, with IC_{50} values of 7.9±1.1 and 5.3±0.7 μg mL^{-1}, respectively (Yenesew *et al*., 2004). The stem bark ethyl acetate extract of *E. fusca* showed antiplasmodial activity against the multidrug resistant K1 strain of *P. falciparum* (Khaomek *et al*., 2008; Innok *et al*., 2009).

Anti-cancer, antioxidant and anti-inflammatory activities: High incidence of cancer, inflammations, cardiovascular diseases is attributed to the oxidative stress. Some sub-Saharan *Erythrina* species are used by traditional practitioners to treat cancer and inflammations. These plants were investigated for cancer chemopreventive agents and inhibitors of enzymes-borne diseases. The studies were carried out on enzymes such as phospholipase C gamma1, diacylglycerol acyltransferase (DGAT), protein tyrosin phosphatase 1 B (PTP1B), ERK kinase, 5-lipoxygenase and 15-lipoxygenase. Inhibitors of these enzymes are proposed in therapy of obesity, type 2 diabetes and cancer. The methods used are MTT method, Lewis lung cancer mice model, G-quadruplex system stability experiment.

Ethyl acetate extract of *E. milbraedii* stem bark inhibited PTP1B (Na *et al*., 2007; Jang *et al*., 2008). Dichloromethane extract of *E. senegalensis* stem barks gave inhibitory action against DGAT (Oh *et al*., 2009).

E. addisoniae acts by decreasing the ERK kinase activation (Watjen *et al*., 2007). The ethyl acetate extract inhibited PTP1B (Bae *et al*., 2006). *E. variegata* showed *in vitro* and *in vivo* antitumor activity against various tumor cells of the liver and lung (Zhang *et al*., 2009). A dose-response effect was observed. *E. milbraedii* was tested for effects on the growth of human breast and prostate (Tchokouaha *et al*., 2010).

Erytrhina species were tested for efficacy in reducing pain and inflammation using mouse paw oedema test, 5-lipoxygenase pathway. E. sigmoidea (Njamen *et al*., 2004), *E. senegalensis* (Udem *et al*., 2010) and *E. addisoniae* (Talla *et al*., 2003) showed anti-inflammatory activity.

E. mildbraedii ethyl acetate extract showed anti-inflammatory activity and radical scavenging activity in 1, 1-Diphenyl-2-Picrylhydrazyl (DPPH) assay (Njamen *et al*., 2003).

E. senegalensis (Soro *et al*., 2010) also exhibited the same potential. *E. variegata* extracts (aqueous, methanol) were DPPH and nitric oxide radical scavengers and inhibitors of lipid peroxidation (Sakat and Juvekar, 2010).

The antitumoral, antioxidant and anti-inflammatory activities confirm the traditional use of several species of *Erythrina* in the treatment of cancer, prostate and inflammation.

Anti-viral activity: The possible antiviral activity was evaluated vs viral enzymes such as proteases and neuraminidases. Protease is linked to HIV while neuraminidases are related to Influenza. Inhibitors of viral neuraminidase played an important role in the treatment of influenza. *E. senegalensis* showed inhibitory activity on HIV-1 protease (Lee *et al*., 2009), thus letting foresee a prospect in research for treatment against HIV/AIDS infection. The roots ethyl acetate extract of *E. addisoniae* exhibited an antiviral activity against H1N1 and H9N2 neuraminidases (Nguyen *et al*., 2010).

Other biological activities: *E. senegalensis* possesses analgesic and antipyretic action (Saidu *et al*., 2000) which supports its use in preparation of traditional remedies against malaria. *E. variegata* leaf showed anti-diabetic potential by reducing glycemy induced in rat (Kumar *et al*., 2011).

Bioactive compounds isolated from sub-Saharan *Erythrina*: The genus *Erythrina* is particularly known for its typical alkaloids some of which have an action similar to that of curare (Kamanzi Atindehou, 2002). A review of alkaloids from 1996 through to mid-2009 was recently carried out by (Parsons and Palframan, 2010). The flavonoids also are well represented within the genus; the great majority is flavanones, isoflavones, coumestans and pterocarpans (Dewick, 1993; Barron and Ibrahim, 1996). The present review on bioactive compounds of sub-Saharan *Erythrina* is devoted to non alkaloid secondary metabolites recently identified as antibacterial, antifungal, inhibitory, anti-inflammatory active principles.

Compounds isolated from sub-Saharan *Erythrina*: The conventional methods of chromatography were used to isolate molecules from sub-Saharan *Erythrina*. Their structures were elucidated one the basis of spectroscopic (UV, CD, MS, 1D and 2D NMR) and physicochemical analyses. Some of these structures are shown in Fig. 1. The majority of studied sub-Saharan *Erythrina* were carried out in laboratories from Europe, Asia and America due to lack of adapted equipment in many laboratories from sub-Saharan Africa. The African teams actively getting involved in research on sub-Saharan *Erythrina* phytochemistry, in collaboration with external teams, are those of Cameroun (Wandji *et al*., 1994; Nkengfack *et al*., 2001; Waffo *et al*., 2000; Waffo *et al*., 2006).

Common and known compounds (isowighteone, isolupalbigenine, 1-methoxyphaseollidine, ulexone, warangalone, lonchocarpols, wighteone, dolichines, sobavachalcone, erythrabissine, phaseollidine) have been isolated from sub-Saharan *Erytrhina* species (Taylor *et al*., 1986; Mitscher *et al*., 1998; Wandji *et al*., 1990; Telikepalli *et al*., 1990; Dagne *et al*., 1993; Dewick, 1993; Wandji *et al*., 1994; Barron and Ibrahim, 1996; Tanaka *et al*., 1996; Huang and Liou, 1997; Joubert, 1998; Oh *et al*., 1999; Yu *et al*., 2000; Wanjala and Majinda, 2000a, b; Tanaka *et al*., 2001;

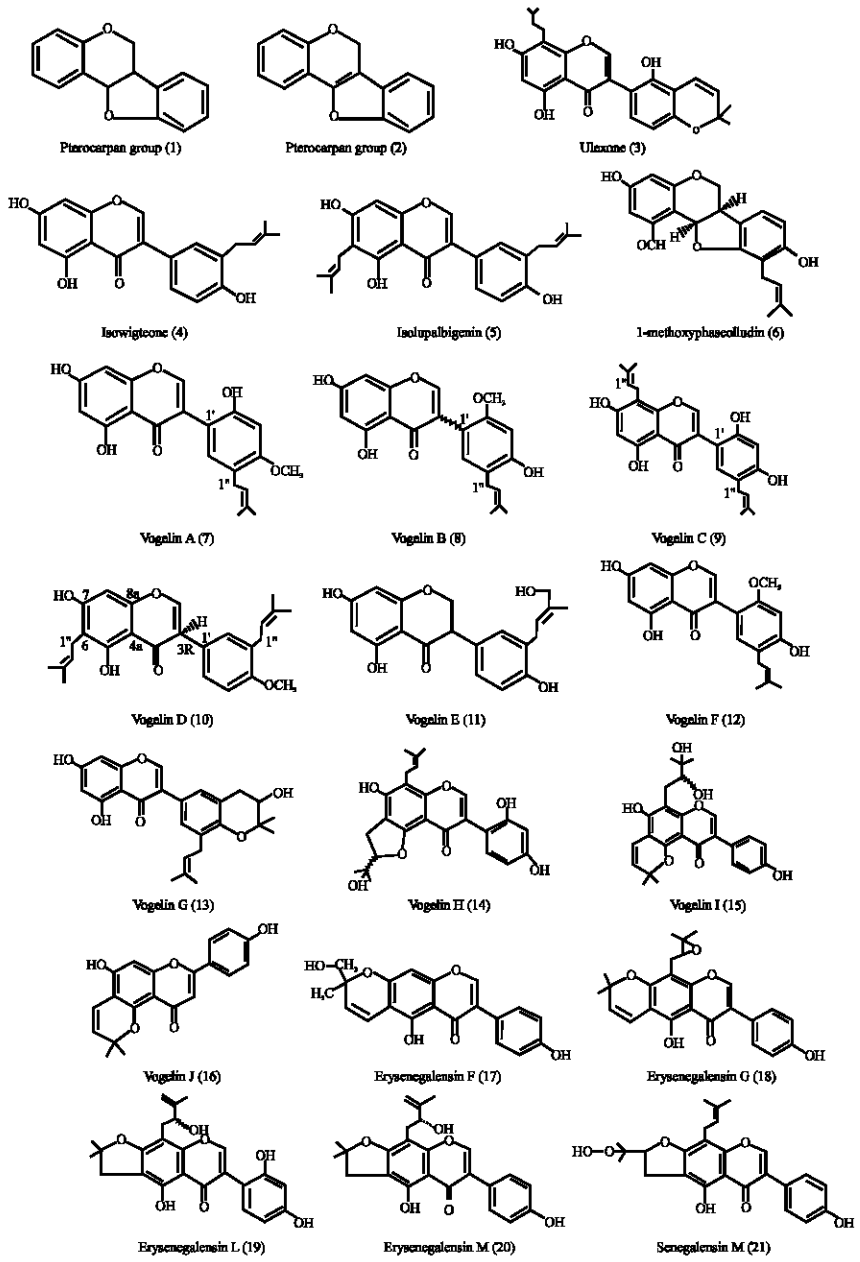

Fig. 1: Structures of molecules isolated from *Erytrhina* species

Wanjala and Majinda, 2001; Nkengfack *et al*., 2001; Tanaka *et al*., 2002; Atindehou *et al*., 2002a; Queiroz *et al*., 2002; Sato *et al*., 2003; Khaomek *et al*., 2008 ; Lee *et al*., 2009). In addition to these compounds, specific products to each studied species were described for the first at the time of their isolation. They are vogelins (Atindehou *et al*., 2002a; Queiroz *et al*., 2002; Waffo *et al*., 2006; Ali *et al*., 2010), senegalensis (Fomum *et al*., 1986; Wandji *et al*., 1990; Wandji *et al*., 1994; Tanaka *et al*., 2001), erysenegalenseins (Wandji *et al*., 1990, 1994; Wandji *et al*., 1995; Oh *et al*., 1999), fuscaflavanones (Innok *et al*., 2009), sigmoidins (Promsattha *et al*., 1988; Nkengfack *et al*., 1993, 1994a, b, 1997; Njamen *et al*., 2004; Ali *et al*., 2011), indicacins and indicacin (Waffo *et al*., 2000; Nkengfack *et al*., 2000).

Biologically active compounds: Some of the compounds (Table 1) isolated from sub-Saharan *Erythrina* species have been screened for biological activity against various pathogenic micro-organisms.

Table 1: Phytocompounds isolated from Subsaharian *Erythrina* species

Plant species	Organs used	Compounds	References
Erythrina addisoniae Harms		NI	
Erythrina fusca Lour.	Stem bark	Fuscaflavanones A1, A2, B, lupinifolin, lonchocarpol A, lonchocarpols C1, C2, D1 et D2, sandwicensin, phaseollidin, erythrabissin I, dolichin A et B, Isobavachalcone, wighteone	Iunok *et al.* (2009)
Erythrina excelsa Bak.		Isoflavones, indicacinin A, indicacinin B, indicacinin C	Fomum *et al.* (1986), Nkengfack *et al.* (2000, 2001) and Waffo *et al.* (2000)
Erythrina indica Lam.	Stem bark		
Erythrina mildbraedii Harms	Stem bark	Pterocarpans	Mistcher *et al.* (1988)
Erythrina poeppigiana (Walp.) O. F. Cook	Roots	Erypoegin A, demethylmedicarpin, sandwicensin, angolensin, erypostyrene	Sato *et al.* (2003)
Erythrina senegalensis DC.	Roots	NI	
	Stem bark	2,3-dihydroauriculatin, 6,8-diprenylgenistein, senegalensin, n-triacontyl4-ciunamate, erythrinasinate, erysenegalensein N, O, erysenegalenseine D, F, G, L et M, 8-prenylleutone, auriculatin, derrone, alpinumisoflavone	Taylor *et al.* (1986), Wandji *et al.* (1990), Oh *et al.* (1999), Fomum *et al.* (1986) and Wandji *et al.* (1990, 1994, 1995)
Erythrina sigmoidea Hua	Stem bark	Sigmoïdin A, sigmoïdin B, sigmoïdin E, sigmoïdin F, sigmoïdin G, sigmoïdin L, sigmoïdin K	Fomum *et al.* (1983), Njamen *et al.* (2004), Nkengfack *et al.* (1993, 1994a, b), Nkengfack *et al.* (1997) and Promsattha *et al.* (1988)
Erytrhina vogelii Hook f.	Roots	Vogelin A, vogelin B, vogelin C, vogelin D, vogelin E, vogelin F, voglin G, isowigteone, 1-methoxyphasollidin;	Kamanzi Atindehou (2002), Atindehou *et al.* (2002b) and Queiroz *et al.* (2002)
	Stem bark	Voglin H, vogelin I, vogelin J, 6-prenylapigenin, 6,8 -diprenylgenistein, 8-prenylluteone, warangalone (scandenone), limonianin, carpachromene	Waffo *et al.* (2006)

NI = Non indicated; bold type = Compounds with known biological activities

Against bacteria: Erypoegin A, demethylmedicarpin, sandwicensin, angolensin, erypostyrene (Sato *et al.*, 2003), Isolupalbigenin and erythrinin B (Sato *et al.*, 2006) isolated from *E. poeppigiana*, have strong activity against MDR-bacteria (MRSA) with MICs ranging between 1.56-3.13 μg mL^{-1}. Also, isowighteone, vogelin B, vogelin C and the 1-methoxyphaseollidin from *E. vogelii* showed high potential against MRSA, with MICs = 1.6-3.125 μg mL^{-1} (Kamanzi Atindehou, 2002). The sigmoïdins (*E. sigmoidea*) showed antibacterial activity (Fomum *et al.*, 1983). Erycristagallin and orientanol B (*E. variegata*) showed high anti-MRSA activity, with MICs of 3.13-6.25 μg mL^{-1} (Tanaka *et al.*, 2002).

Most of these antibacterial molecules have phenolic hydroxyls and prenylated groups. According to Barron and Ibrahim (1996), antibacterial and antifungal activities of flavonoids are mainly attributed to the presence of phenolic hydroxyls, since they act like inhibitors of enzymes. Also, the substitution of flavonic ring by prenylated groups, render these substances lipophilic and induces antimicrobial activity through membrane interactions of the involved cells.

Against fungi and yeasts: Erypostyrene (*E. poeppigiana*) was responsible for antifungal activity against *Candida albicans*, with MIC = 50 μg mL^{-1} (Sato *et al.*, 2003). Isowighteone and 1-methoxyphaseollidin showed high antifungal activity against *Cladosporium cucumerinum* (Kamanzi Atindehou, 2002).

Against *Plasmodium falciparum*: Phaseollidin (*E. fusca*) exhibited moderate antiplasmodial activity against *Plasmodium falciparum* (Innok *et al.*, 2009) while lonchocarpol A showed strong antimalarial activity, with IC_{50} value of 1.6 μg mL^{-1} (Khaomek *et al.*, 2008). From ethyl acetate extract of *E. abyssinica*, 5-prenylbutein and 5-deoxyabyssinin II have been isolated as antiplasmodial principles (Yenesew *et al.*, 2004).

Cytotoxicity activity: In addition to phaseollidin and lonchocarpol A, lupinifolin, sobavachalcone and fuscaflavanone showed weak to moderate cytotoxic activity against KB, BC and NCI-H187 cells (Innok *et al.*, 2009).

Anti-inflammatory et antioxidant activity: Sigmoïdins were responsible for anti-inflammatory and antioxidant activities of *E. sigmoidea* (Njamen *et al.*, 2004). Warangalone (*E. addisoniae*) showed marked effectiveness as an anti-inflammatory after systemic and local administration, respectively (Talla *et al.*, 2003). *In vitro*, erycristagallin (*E. milbraedii*) inhibited the arachidonic acid metabolism via 5-lipoxygenase pathway in rat polymorphonuclear leukocytes (IC_{50} = 23.4 μM) but had no effect on cyclooxygenase-1 metabolism in human platelets. This compound showed antioxidant activity in DPPH test (Njamen *et al.*, 2003).

Inhibitors of enzymes borne diseases: 8-prenylluteone, auriculatin, erysenegalenseins and alpinumisoflavone of

E. senegalensis showed dose-dependent inhibitory activity on HIV-1 protease (IC_{50} = 0,5 to 30 muM) (Lee *et al*., 2009). According to the same author, this inhibitory activity could be due to the presence of hydroxyl groups (noyau B) and prenylated groups (noyau A) in the structure of active molecules. Pterocarpans from *E. senegalensis* were strong inhibitors of 15-lipoxygenase (Togola *et al*., 2009).

For *Erythrina addisoniae*, it was observed that stilbenoids and chalcones were more active than isoflavones on neuraminidases. Stilbenoid gave high inhibitory effects on H1N1 (IC_{50} = 8.80±0.34 μg mL^{-1}) and H9N2 (IC_{50} = 7.19±0.40 μg mL^{-1}) neuraminidases (Nguyen *et al*., 2010).

Many molecules such as 2-arylbenzofurans, Orientanol E, 2,3-dihydroauriculatin, isolated from sub-Saharan *Erythrina* can be considered as new anticancer materials by PTP1B inhibition. Three structural conditions are important to inhibit the enzyme: B ring prenyl groups, hydroxylation (C-2'-and C-4') and cyclization between C-7 hydroxy group (B-ring) and C-6 or C-8 prenyl groups (A-ring) (Bae *et al*., 2006; Na *et al*., 2007). Orientanol E, 2,3-dihydroauriculatin, 2-arylbenzofurans (*E. addisoniae*) inhibited PTP1B (IC_{50} = 2.6±0.5 to 17.5±0.3 μM). Abyssinin II and parvisoflavone B (Jang *et al*., 2008), abyssinones, sigmoidin E and alpinumisoflavone (Na *et al*., 2007) from *E. milbraedii* also had effects (IC_{50} = 5.3 to 42.6 μM).

Flavanones with dihydrofuran moiety from the same plant inhibited PTP1B activity in an *in vitro* assay with IC_{50} values ranging from 15.2±1.2 to 19.6±2.3 μM (Cui *et al*., 2010).

E. senegalensis phytochemicals, namely 8-prenylleutone, auriculatin, erysenegalenseins alpinumisoflavone and 6,8-diprenylgenistein inhibited DGAT activity (IC_{50}= 1.1±0.3 to 15.1±1.1 μg mL^{-1}. On the basis of these data, isoflavonoids with isoprenyl groups could be considered as a novel class of DGAT inhibitors (Oh *et al*., 2009).

Cytotoxicity activity was reported for *E. milbraedii* phytochemicals. Scandenone, 5,4'-dihydroxy-2'-methoxy-8-(3,3-dimethylallyl)-2'',2''-dimethylpyrano[5,6:6,7] isoflavone and eryvarin B strongly inhibited the growth of cell lines. For this cytotoxic activity, non-oxidized isoprenyl group at C-8 is an important structural condition (Tchokouaha *et al*., 2010). Phaseollin and neorautenol (*E. addisoniae*) may be the active molecules (Watjen *et al*., 2007).

CONCLUSIONS

This review on sub-Saharan *Erythrina* clearly highlights their real potential for the treatment of infections from bacterial and fungal origin and malaria. Some among these plants and related phytochemicals (Isowighteone and 1-methoxyphaseollidin) showed a high promising activity on multidrug resistant pathogens such as MRSA, *Candida albicans* and *Plasmodium falciparum*. This activities show the interest of genus *Erythrina* for fighting against public health problems in West Africa. Its natural bioactive substances could be a prospect in the development for new therapeutic agents against the infections caused by the microbial MDR-agents. The genus *Erythrina* has further interest as sources of cancer chemopreventive agents and inhibitors of enzymes. Many bioactive substances isolated from this genus may lead to new pharmacons to be used in the therapy of cancer, obesity and diabetes type 2.

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