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African natural products with potential antioxidants and hepatoprotectives properties: a review

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Abstract

Free radicals are highly reactive molecules generated during oxidation reactions which in turn initiate chain reactions resulting to cellular damage. There is substantial evidence implicating free radicals especially reactive oxygen species (ROS) in the etiology of more than one hundred degenerative disorders in humans including, arthritis, atherosclerosis, ischemia and reperfusion injury of many tissues, gastritis, diabetics, central nervous system injury, acquired immunodeficiency syndrome (AIDS) and cancer. Scientific evidence postulates that bioactive compounds especially from natural products are capable of providing protection against free radicals. Consequently, few decades have witnessed a surfeit of research geared towards validating the antioxidant and hepatoprotective potential of the natural products. In this review, African natural products whose antioxidants activities were scientifically validated either in their crude extracts and/or derived products have been discussed. A total 1076 plants species representing 287 family, 132 isolated compounds and 7 insect/mollusk secreation were found. The plant species from the following families; Fababceae, Asteraceae, Lamiaceae, Moraceae, Euphorbiaceae, Combretaceae and Malvaceae have received more scientific attention than others. Analysis of the reports revealed that *Combretum apiculatum, Telfaria occidentalis, Acalypha racemosa, Garcinia lucida* were the most active plant extracts from African flora. The most active ROS-detoxifying phytochemicals were moracin T, U, S and R (**84–87**), oleanolic acid (**54**), 5,7,4′–trihydroxy–3,8,3′,5′–tetramethoxyflavone (**89**), 5,7,3′–trihydroxy-3,8,4′,5′–trimethoxyflavone (**88**), luteolin (3′,4′,5,7–tetrahydroxy flavone) (**117**) and genistein (4′,5,7–trihydroxyisoflavone) (**116**). The significant antioxidant potential demonstrated by some crude extracts and their constituent compounds render them good candidates for the development of new drugs. Although, the study of the mechanisms of actions as well as clinical validation of some of these isolated compounds is lacking. It is hoped that pertinent scientist and stakeholders will look further into some of these compounds for detailed authentification and subsequent commercialization.

Keywords: Antioxidants, DPPH, Hepatoprotective, Africa, Plants, Natural products

Introduction

Oxidation is a chemical reaction that transfers electrons or hydrogen from a substance to an oxidizing agent. Free radicals are generated during this oxidation reaction especially during oxidative respiration when there is a mitochondria leakage of activated oxygen [1], which in turn initiate a chain of reactions that results in cellular damage. Antioxidants terminate this chain of reactions by removing free radical intermediates, thus inhibiting further oxidation reactions [2]. They include reducing agents such as β-carotene, vitamin C, E and ascorbic acid, as well as enzymes like superoxide dismutase (SOD), catalase (CAT), glutathione and peroxidases [3], and therefore exert their protective role by being oxidized themselves. Furthermore, many antioxidants compounds have been characterized form plants including flavonoids. Flavonoids are phenolic compounds with importants roles in scavenging free radicals and thus play vital roles in preventing oxidative stress associated disorders [4]. Among the common ROS are superoxide ($O2^{•-}$), hydroxyl (OH), and peroxyl (OOH, ROO) radicals [5]. Enzymes capable of producing

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superoxide are xanthine oxidase, reduced nicotinamide adenine dinucleotide phosphate oxidases and cytochrome P_{450} [1]. The imbalance between the production of these free radicals and the detoxifying capacity of the antioxidants results in oxidative stress which is among the major implicative factors in etiology of certain degenerative and chronic diseases including diabetes, atherosclerosis, parkinson's disease [6], renal disorders [7], cardiovascular, inflammatory, cancer, autoimmune, neurodegenerative diseases [8], and several other human ailments [9].

The liver is the major regulatory organ responsible for the metabolism, storage, detoxification, secretions and excretions of various exogenous and endogenous molecules including xenobiotics [10]. It plays a vital role in maintaining cellular homeostasis and protects the body against deleterious effect of chemicals, drugs, toxin, organism and parasite [5]. Therefore, the healthy performance of the organ reflects the health status of human [11, 12]. However, during these protective roles this organ is susceptible to a numbers of diseases and disorders [13], from chemical drugs and other agents due to its distinctive metabolic roles and the proximal affiliation with the gastrointestinal tract (GIT) [14]. Hepatic injury may also results from excessive alcohol and paracetamol consumptions, exposure to infectious agents, xenobiotics and over the-counter drugs in western countries [15].

Hepatic diseases are a worldwide predicament often involving free radicals induced oxidative stress which if left untreated may advance from steatosis to chronic hepatitis, fibrosis and hepatocellular carcinoma [16]. The conventional drugs commonly used to combat the diseases and disorders associated with the liver are beset with different undesirable effects on biological systems [17]. As a result considerable attentions has been geared towards finding alternative, less toxic and effective antioxidants and hepatocurative agents from Africa natural product for the prevention, managements and treatment of diseases and disorders associated with the liver [18]. The natural products with medicinal reputation could serve as lead sources of natural antioxidants for development of novel drugs [12].

Africa is blessed with enormous biodiversity of natural product for healing practices [19]. From time immemorial Africa medicinal plants have been used by virtually all cultures to meet their health care needs. Evolutions have made plants to harbor a numbers of antioxidant chemicals (phytochemical or secondary metabolites) as natural means of surviving in hostile environments [20]. Consequently, few decades have witnessed a glut of research geared towards validating the quality, quantity, protective roles as well as therapeutic effectiveness of these antioxidant in African plants against oxidative stress induced diseases and disorders.

However, available reviews on the antioxidant potencies of African natural products; focused only on medicinal plants [21], published decade ago with emphasis only on 38 plants [22], others are limited to Cameroonian medicinal plants, [23], few African vegetables, fruits and mushrooms [24], and hepatoprotective activities of medicinal plants [25]. This review is intended to serve as scientific baseline information for the documented African natural products with antioxidants and hepatoprotectve reputation as well as a starting point for future studies.

Methodology (Search strategy)

To identify natural products from African flora and fauna with antioxidant and hepatoprotective potentials, a review was compiled based on scientific literature from various sources including; Google Scholar, Science Direct, PubMed, Medline, Science domain [19, 22, 26, 27]. The keywords used for identification of relevant data included the following terms; antioxidant, radical scavenging activities, anti-aging principles, reactive oxygen species, free radicals, African medicinal plants, natural product, 2,2-Diphenyl-1−picrylhydrazyl radical scavenging assay (DPPH), reducing properties and lipid peroxidations. All relevant data previously published in English were retrieved. However, data for natural products from sources other than African countries were completely excluded from this review paper. Using the specified procedure for acquisition of necessary data, 641 articles were retrieved, out of which 315, mainly in the form of journal articles, books and reviews; were used for compilation of the current review.

The information obtained from these research articles, captured in the current review paper includes; scientific names, that is the family, genus and specific names, parts of plants or mollusk used, solvent system used for the extraction procedure, the bioassay test carried out, whether in vitro or in vivo, as well as the antioxidant and hepatoprotective potencies of natural products originating from African flora and fauna (Tables 1, 2, 3, 4, 5 and 6). Information was also obtained from authenticated post graduate theses, conference proceedings with literature on antioxidant and hepatoprotective assay results of flora and fauna endemic or naturalized in Africa.

Results and discussion

A total 1076 plants species representing 287 family and 7 other natural products were identified. Previous phytochemical studies of ethnomedicinal plants of African origin used as antioxidants and for hepatoprotective properties led to characterization of approximately 132 compounds reviewed in this study. A map of Africa indicating the subregions of the continent as used in this review is presented in Fig. 1. From the reviewed plants with antioxidant and related data; 31.33% originate from

Table 1 Antioxidants activities of West African plants

Plants	Family	Part used	Solvents	Assay Methods	Inhibition/IC_{50}	Country of origin	References
Abrus precatorius L.	Leguminosae	Leaf	MeOH	DPPH	72.48% at 5 mg/mL	Nigeria	[136]
Abrus precatorius L.	Leguminosae	Seed/Shell	Oil	DPPH/ABTS/LP/NO	52.9.1.9,2.1/3,3,1.4,1.2 mg/mL	Nigeria	[137]
Artemisia absinthii L.	Asteraceae	Not stated	H_2O	FRAP	2228 μMol/L	Not stated	[30]
Acacia ataxacantha DC.	Fabaceae	Bark	CH_2Cl_2/EtOAc	DPPH	65/54% at 62.5 μg/mL	Benin	[138]
Acacia macrostachya Rchb. ex DC.	Verbenaceae	Root	MeOH	DPPH	4.30 μg/mL	Burkina Faso	[139]
Acalypha segetalis Mull.	Euphorbiaceae	Leaf	MeOH	DPPH	>200 μg/mL	Nigeria	[140]
Acalypha torta L.	Euphorbiaceae	Leaf	MeOH	DPPH	>200 μg/mL	Nigeria	[140]
Acanthospermum hispidium DC.	Asteraceae	Aerial parts	MeOH	DPPH	–	Benin	[141]
Adansonia digitata L.	Bombacaceae	Fruit	MeOH	DPPH	77.36%	Guinea	[142]
Adansonia digitata L.	Bombacaceae	Leaf	BtOH	FRAP	78%. at 500 μg/mL	Nigeria	[143]
Adansonia digitata L.	Bombacaceae	Fruit	MeOH	FRAP	24.50 mmol AEAC/100 g	Burkina Faso	[144]
Aframomum melegueta K.Schum.	Zingiberaceae	Fruit	MeOH	DPPH	111.12%	Guinea	[142]
Aframomum melegueta K.Schum.	Zingiberaceae	–	$(CH_3)_2CO$	DPPH/SAS	0.11/0.105 mg/mL	Nigeria	[145]
Albizia chevalieri Harms.	Fabaceae	Leaf	MeOH	DPPH	94.732% at 250 μg/mL	Nigeria	[146]
Alchornea laxiflora Pax & K. Hoffm.	Euphorbiaceae	Leaf	BtOH	FRAP		Nigeria	[143]
Alchornea ordifolia Mull. Arg.	Euphorbiaceae	Leaf	EtOAc/$(CH_3)_2CO$	DPPH	99.4/79% at 1.56 mg/mL	Nigeria	[147]
Allium sativum L.	Alliaceae	Spice	H_2O	DPPH/ABTS	1.4/0.66 mg/mL	Nigeria	[148]
Alstonia boonei De wild.	Apocynaceae	Cortex/Folium/Radix	MeOH	DPPH	++/++	Nigeria	[38]
Alstonia boonei De wild.	Apocynaceae	Stem	MeOH	DPPH/FRAP	68.5/1.40% at 400 μg/mL	Nigeria	[149]
Althaeae radix L.	Malvaceae	Not stated	H_2O	FRAP	59 μMol/L	Not stated	[30]
Amaranthus hybridus L.	Amaranthaceae	Leaf	MeOH	DPPH	9.0 ± 2.1 μg/mL	Nigeria	Adetutu et al., 2013 [150]
Amaranthus viridis L.	Amaranthaceae	Leaf	MeOH	DPPH	3.4 ± 0.25 μg/mL	Nigeria	Adetutu et al., 2015
Anarcadium occidentale L.	Anacardaceae	Bark	MeOH	DPPH/FRAP	43.5/0.70 at 400 μg/mL	Nigeria	[149]
Anisopus mannii N.E.Br.	Aslepiadaceae	Stem/Leaf/Root	H_2O	RSA	0.2/0.15/0.19 mM	Nigeria	[151]
Anogeissus leiocarpus (DC.) Guill. & Perr.	Combretaceae	Leaf	MeOH	DPPH	79.09 at 5 mg/mL	Nigeria	[136]
Anogeissus leiocarpus (DC.) Guill. & Perr.	Combretaceae	Root	H_2O	H_2O_2/Fe^{3+}	0.53/0.39%	Nigeria	[152]
Antidesma venosum E. Mey. ex Tul.	Euphorbiaceae	Fruit	MeOH	DPPH	9.53%	Guinea	[142]
Arctostasphylos uva-ursi L. (Spreng).	Ericaceae	Not stated	H_2O	FRAP	13207 μMol/L	Not stated	[30]
Argemone Mexicana L.	Papaveraceaea	Entire plant	MeOH	DPPH	1.73 μg/mL	Benin	[141]

Table 1 Antioxidants activities of West African plants *(Continued)*

Asperulae herba L.	Rubiaceae	Not stated	H_2O	FRAP	2557 μMol/L	Not stated	[30]
Balanites aegyptiaca (L.) Delile.	Balantiaceae	Leaf	MeOH	DPPH	52.53 μg/mL	Togo	[153]
Bardanae folium	Asteraceae	Not stated	H_2O	FRAP	2337 μMol/L	Not stated	[30]
Basilici herba L.	Lamiaceae	Not stated	H_2O	FRAP	5314 μMol/L	Not stated	[30]
Bauhinia rufescens Lam.	Caesalpiniaceae	Leaf	MeOH	DPPH	74.65% at 50 μg/mL	Nigeria	[154]
Besella alba L.	Basellaceae	Leaf/Stem	MeOH	DPPH	+/–	Nigeria	[39]
Betulae folium L.	Betulaceae	Not stated	H_2O	FRAP	3896 μMol/L	Not stated	[30]
Blepharis lineariifolia Pers.	Acanthaceae	Stem/Leaf	H_2O	DPPH	44 μg/mL	Burkina Faso	[155]
Blighia sapida K.D. Koenig	Sapindaceae	Fruit	MeOH	DPPH	38.54%	Guinea	[142]
Boerhavia diffusa L.	Nyctaginaceae	Leaf	MeOH	DPPH	++	Nigeria	[156]
Boswellia dalzielii Hutch.	Burceraceae	Stem back	EtOH	DPPH	83% at 10 μg/mL	Benin	[157]
Brachystegia eurycoma Harms.	Fabaceae	Seed	EtOH	DPPH	59.70 μg/mL	Nigeria	[158]
Brassica juncea (L.) Coss.	Brassicaceae	Seed	MeOH	DPPH/FRAP	68.9/1.30% at 400 μg/mL	Nigeria	[149]
Bridelia ferruginea Benth.	Euphorbiaceae	Fruit	MeOH	DPPH	13.30%	Guinea	[142]
Bridelia micrantha Baill.	Phyllanthaceae	Leaf	MeOH	DPPH/FRAP	97.70/1.39 at 400 μg/mL	Nigeria	[149]
Bursae pastoris herba	Brassicaceae	Not stated	H_2O	FRAP	654 μMol/L	Not stated	[30]
Byrsocarpus coccineus Schumach. & Thonn.	Connraceae	Folium/Radix	MeOH	DPPH	++/++	Nigeria	[38]
Byrsocarpus coccineus Schumach. & Thonn	Connaraceae	Root	MeOH	DPPH	–	Benin	[141]
Calendulae flos L.	Asteraceae	Not stated	H_2O	FRAP	1347 μMol/L	Not stated	[30]
Calliandria surinamensis Engl.	Fabaceae	Flower	MeOH	DPPH	<30% at 0.1 mg/mL	Nigeria	[159]
Canarium schweinfurthii Engl.	Burseraceae	Cortex	MeOH	DPPH	++++	Nigeria	[38]
Cantaurii herba Rafn.	Gentianaceae		H_2O	FRAP	1347 μMol/L	Not stated	[30]
Cantharelle cibarius Fr.	Cantherallaceae	Mushroom	–	LPO	49.74 nM	Nigeria	[160]
Cantharellus cibarius Fr.	Cantharellaceae	Fruit	MeOH/EtOH	DPPH	2.68/3.12 mg/mL	Nigeria	[161]
Canthium setosum Hiern.	Rubiaceae	Aerial parts	MeOH	DPPH	3.47 μg/mL	Benin	[141]
Capsicum frutescens L.	Solanaceae	Spice	H_2O	DPPH/ABTS	1.55/0.45 mg/mL	Nigeria	[148]
Carica papaya L.	Caricaceae	Leaf	EtOH	DPPH	0.58 mg/mL	Nigeria	[162]
Cassia sieberiana DC.	Fabaceae	Leaf	MeOH	DPPH	50 μg/mL	Nigeria	[163]
Cassia sieberiana DC.	Fabaceae	Stem	MeOH	DPPH/FRAP	40.1/0.83 at 400 μg/mL	Nigeria	[149]
Casstha filiformis mill.	Lauraceae	Stem	MeOH	DPPH/FRAP	75.8/1.61 at 400 μg/mL	Nigeria	[149]
Casuarina equisetifolia L.	Casuarinaceae	Fruit	MeOH	DPPH	88.97% at 100 μg/mL	Benin	[164]
Ceratotheca sesamoides Endl.	Pedaliaceae	Leaf	MeOH	DPPH	2.9 μg/mL	Ivory coast	[165]

Table 1 Antioxidants activities of West African plants *(Continued)*

Cetrariae lichen (L.) Ach.	Parmeliaceae	Not stated	H_2O	FRAP	125 μMol/L	Not stated	[30]
Chamomillae flos L.	Asteraceae	Not stated	H_2O	FRAP	2856 μMol/L	Not stated	[30]
Chellidonii herba L.	Papaveraceae	Not stated	H_2O	FRAP	3401 μMol/L	Not stated	[30]
Cichorii herba L.	Asteraceae	Not stated	H_2O	FRAP	1408 μMol/L	Not stated	[30]
Citrus sinensis Pers.	Rutaceae	Leaf	MeOH	DPPH/FRAP	69.7/1.22 at 400 μg/mL	Nigeria	[149]
Cleome gynandra L.	Capparidaceae	Leaf	CH_2Cl_2	DPPH	>38.4 μg/mL	Ivory coast	[165]
Clerodendrum formicarum Gurke.	Lamiacea	Leaf	MeOH	DPPH	>200 μg/mL	Cameroo	[140]
Clitocybe odora (Fr) P. Kumm.	Tricholometaceae	Mushroom	–	LPO	52.10 nM	Nigeria	[160]
Cnestis ferruginea DC.	Connaraceae	Leaf	H_2O	Fe^2/RP/DPPH	45.25/121.5/21.55 μg/mL	Ivory coast	[166]
Cnestis ferruginea DC.	Connaraceae	Cortex/Folium/ Radix	MeOH	DPPH	++++/++++/++++	Nigeria	[38]
Cnidoscolus acontifolius (Mill.) I.M. Johnst.	Euphorbiaceae	Leaf	BtOH	FRAP	76% at 500 μg/mL	Nigeria	[143]
Cola lepidota K. Schum.	Sterculiaceae	Leaf	$MeOH/CHCl_3$	DPPH	190/50 μg/mL	Nigeria	[167]
Combretum micranthum G. Don.	Combretaceae	Leaf	H_2O	ABTS	16.37 μMol Trolox/μg	Burkina Faso	[168]
Crataegi flos L.	Rosaceae	Not stated	H_2O	FRAP	3025 μMol/L	Not stated	[30]
Crateva adansonii Forst. F.	Capparaceae	Leaf	MeOH	DPPH	1562. 52 mg/mL	Nigeria	Tsado et al., 2016b [169]
Crinum jagus (J.Thomps.) Dandy.	Amarllidaceae	Bulb	MeOH	DPPH/FRAP	85.78/1.86 at 400 μg/mL	Nigeria	[149]
Crinum purpurascen Herbs.	Liliaceae	Folium/Radix	MeOH	DPPH	++/++	Nigeria	[38]
Croton lobatus L.	Euphorbiaceae	Aerial parts	MeOH	DPPH	1.96 μg/mL	Benin	[141]
Cymbopogon citrates Stapf.	Poaceae	Leaf	Oil	DPPH	7.48 at 0.1% oil	Burkina Faso	[170]
Cymbopogon giganteus Chiov.	Poaceae	Leaf	Oil	DPPH	18.76 at 0.1% oil	Burkina Faso	[170]
Detarium microcarpum Guill.	Caesalpiniaceae	Seed	EtOH	DPPH	89.00 μg/mL	Nigeria	[158]
Detarium microcarpum Guill.	Caesalpiniaceae	Fruit	MeOH	FRAP	48.45 mmol AEAC/100 g	Burkina Faso	[144]
Detarium senegalense J.F. Gmel.	Caesalpiniaceae	Fruit	MeOH	DPPH	94.26%	Guinea	[142]
Dialium dinklagei Harms.	Caesalpiniaceae	Leaf	H_2O	Fe^2/RP/DPPH	14.75/133.5/21.85 μg/mL	Ivory coast	[166]
Dialium guineense Willd	Caesalpiniaceae	Fruit	MeOH	DPPH	82.44%	Guinea	[142]
Dialium guineense Willd	Caesalpiniaceae	Fruit	MeOH	FRAP	<17.57 mmol AEAC/100 g	Burkina Faso	[144]
Dichapetalum guineense (DC.) Keay.	Dichapetalaceae	Leaf	MeOH	DPPH	–	Benin	[141]
Dicliptera verticillata C. Chr.	Acanthaceae	Stem/Leaf	H_2O	DPPH	785 μg/mL	Burkina Faso	[155]
Diospyros mespiliformis Hochst. ex A. DC.	Ebenaceae	Fruit	MeOH	DPPH	111.75%	Guinea	[142]
Diospyros mespiliformis Hochst. ex A. DC.	Ebenaceae	Fruit	MeOH	FRAP	<17.57 mmol AEAC/100 g	Burkina Faso	[144]
Diospyros monbuttensis Gurke.	Fabaceae	Leaf	H_2O	Fe^{2+}/RP/DPPH	9.41/> 200/22.25 μg/mL	Ivory coast	[166]

Table 1 Antioxidants activities of West African plants *(Continued)*

Duranta repens L.	Verbenaceae	Leaf	MeOH	DPPH/FRAP	72.61/1.71 at 400 μg/mL	Nigeria	[149]
Dyschoriste perrottetii (Nees) Kuntze.	Acanthaceae	Stem/Leaf	H_2O	DPPH	45 μg/mL	Burkina Faso	[155]
Ehinaceae purpurea L. (Monench)	Asteraceae	Not stated	H_2O	FRAP	4033 μMol/L	Not stated	[30]
Ekebergia senegalansis A. Juss.	Meliaceae	Leaf	MeOH	DPPH	13.33 μg/mL	Nigeria	Aladesanmi et al., 2007 [156]
Entada Africana Guill. & Per.	Fabaceae	Stem back	n-C_6H_{12}	DPPH/β-CLAMS/MLP	81.08/235.30/3.53 μg/mL	Nigeria	[83]
Entada africana Guill. & Per.	Fabaceae	Leaf	MeOH	DPPH	0.40 μg/mL	Togo	[153]
Entada Africana Guill. & Per.	Fabaceae	Leaf/Stem bark/ Leaf	H_2O	DPPH	3.36/1.36/1.4 μg/mL	Burkina Faso	[171]
Entandrophragma angolense C. DC.	Meliaceae	Stem	MeOH	DPPH	70.34 at 5 mg/mL	Nigeria	[136]
Epilobii herba	Rosaceae	Not stated	H_2O	FRAP	7899 μMol/L	Not stated	[30]
Equiseti herba	Equisetaceae	Not stated	H_2O	FRAP	2222 μMol/L	Not stated	[30]
Erythrina sigmoidea pobeg.	Fabaceae	Stem Bark	MeOH	DPPH	>200 μg/mL	Nigeria	[140]
Ethulia conyzoides L.F.	Asteraceae	Leaf	MeOH	DPPH	46.16 ± 1.52 μg/mL	Nigeria	[172]
Eucalyptus camaldulensis Dehnh.	Myrtaceae	Leaf	Oil	DPPH	3.68 at 0.1% oil	Burkina Faso	[170]
Euphrasiae herba	Orobandiaceae	Leaf	H_2O	FRAP	3107 μMol/L	Not stated	[30]
Farfarae folium	Asteraceae	Leaf	H_2O	FRAP	5350 μMol/L	Not stated	[30]
Felicia muricata Nees.	Asteraceae	Leaf	MeOH/$(CH_3)_2CO$	DPPH	70/410/120 μg/mL	Nigeria	[173]
Ficus asperifolia Miq.	Moraceae	Leaf	H_2O	DPPH/Fe^2/FRAP/NO/OH	78.65/59.27/44.05/47.03/29.25 at 5 mg/mL	Nigeria	[174]
Ficus capensis Thunb	Moraceae	Fruit	MeOH	DPPH	13.05%	Guinea	[142]
Ficus dicranostyla Mildbr.	Moraceae	Leaf	CH_2Cl_2	DPPH	>38.4 μg/mL	Côte	[165]
Ficus exasperate Roxb.	Moraceae	Leaf	EtOH	DPPH	23% at 10 μg/mL	Benin	[157]
Ficus platyphylla Delile.	Moraceae	Stem bark	MeOH	DPPH	1.93 μg/mL	Burkina Faso	[139]
Ficus sycomorus L.	Moraceae	Fruit	MeOH	FRAP	<17.57 mmol AEAC/100 g	Burkina Faso	[144]
Flacourtia flavescens Willd.	Flacourtiaceae	Leaf	EtOH	DPPH	>70% at 100 μg/mL	Benin	[157]
Foeniculi fructus B.P.	Apiaceae	Not stated	H_2O	FRAP	142 μMol/L	Not stated	[30]
Fragariae vesca L.	Rosaceae	Not stated	H_2O	FRAP	11022 μMol/L	Not stated	[30]
Fraxini excelsior L.	Lamiaceae	Not stated	H_2O	FRAP	7129 μMol/L	Not stated	[30]
Funtumia elastic (Preuss) Stapf.	Apocynaceae	Folium	MeOH	DPPH	+++	Nigeria	[38]
Garcina kola Heckel.	Clusiaceae	Seed	MeOH	DPPH/FRAP	69.65/1.33 at 400 μg/mL	Nigeria	[149]
Gardenia erubescens Stapf & Hutch.	Rubiaceae	Fruit	MeOH	FRAP	<17.57 mmol AEAC/100 g	Burkina Faso	[144]
Geranium robertianum L.	Geraniaceae	Not stated	H_2O	FRAP	10696 μMol/L	Not stated	[30]

Table 1 Antioxidants activities of West African plants *(Continued)*

Gnetum africanum Welw.	Gnetaceae	Leaf	MeOH			Nigeria	[175]
Gongronema latifolia Bush Buck (En).	Asclepiadaceae	Leaf/Stem	MeOH	DPPH	+++/+++	Nigeria	[39]
Gongronema latifolia Bush Buck (En).	Asclepiadaceae	Leaf	CH_2Cl_2	DPPH	90.70 μg/mL	Nigeria	[158]
Gongronema latifolia Bush Buck (En).	Asclepiadaceae	Leaf	BtOH/H_2O	DPPH	0.082/0.245 mg/mL	Nigeria	[176]
Gossypium arboretum L.	Malvaceae	Back	MeOH	DPPH	++	Nigeria	Aladesanmi et al., 2012
Guiera senegalensis Lam.	Combretaceae	Stem/Leaf/Root	H_2O	DPPH	15.4/20/17 μL/3 mL	Nigeria	[151]
Harungana madagascariensis Poir.	Hypericaceae	Root	MeOH	DPPH/FRAP	85/1.95 at 400 μg/mL	Nigeria	[149]
Hederae folium	Araliaceae		H_2O	FRAP	5100 μMol/L	Nigeria	[30]
Hedranthera barteri (Hook.f.).	Apocynaceae	Folium	MeOH	DPPH	++	Nigeria	[38]
Hericium erinaceus (Bull.) Persoon.	Hericiaceae	Mushroom	–	LPO	36.31 nM	Nigeria	[160]
Hibisci flos L.	Malvaceae	Not stated	H_2O	FRAP	3157 μMol/L	Not stated	[30]
Hibiscus sabdariffa L.	Malvaceae	Leaf	MeOH	DPPH	140.9	Nigeria	[177]
Hybanthus enneaspermus (L.) F. Muell.	Violaceae	Leaf	EtOH	DPPH	>70% at 100 μg/mL	Benin	[157]
Hygrophila auriculata (schumach.) Heine.	Acanthaceae	Stem/leaf	H_2O	DPPH	20 μg/mL	Burkina Faso	[155]
Hymenocadia acida Tul.	Phllanthacea	Leaf	MeOH	DPPH/FRAP	66.9/1.48 at 400 μg/mL	Nigeria	[149]
Hypericum perforatum L.	Hypericaceae		H_2O	FRAP	5127 μMol/L	Not stated	[30]
Icacina trichantha Oliv.	Icacinaceae	Cortex	MeOH	DPPH	++	Nigeria	[38]
Ipomoea asarifolia Roem.	Convolvulaceae	Stem/Leaf/Root	H_2O	DPPH	50/42/65 μL/mL	Nigeria	[151]
Irvingia gabonensis Baill. ex Lanen.	Irvingiaceae	Seed	EtOH	DPPH	15.30 μg/mL	Nigeria	[158]
Justicia galeopsis T. Anderson ex C.B. Clarke.	Acanthaceae	Leaf	CH_2Cl_2	DPPH	>38.4 μg/mL	Ivory Coast	[165]
Khaya grandifoliola C.DC.	Meliaceae	Stem back	n-C_6H_{12}	DPPH/β-CLAMS/MLP	50.00/13.86/2.99 μg/mL	Nigeria	[83]
Khaya senegalensis A. Juss.	Meliaceae	Stem bark	MeOH	DPPH	42.58 at 5 mg/mL	Nigeria	[136]
Khaya senegalensis A. Juss.	Meliaceae	Leaf	H_2O	ABTS	15.47/21.97 μMol Trolox/μg	Burkina Faso	[168]
Kigelia Africana (Lam.) Benth.	Bignoniaceae	Leaf/Stem bark	MeOH	DPPH	56.9 and 13.7 μg/mL	Ghana	[178]
Laccaria amethystine (Huds) Cook.	Hydnangiaceae	Mushroom	–	LPO	53.64 nM	Nigeria	[160]
Laccaria laccata (Scop) Cook.	Hydnangiaceae	Mushroom	–	LPO	34.77 nM	Nigeria	[160]
Lactarius deliciousus (L. ex Fr) S.F. Gray.	Russulaceae	Mushroom	–	LPO	34.46 nM	Nigeria	[160]
Lactuca taraxicofolia (Wild.) Schum.	Asteraceae	Leaf	MeOH	DPPH	2.0 ± 0.3 μg/mL	Nigeria	Adetutu et al., 2015
Landolfia owariensis P. Beauv.	Apocynaceae	Folium	MeOH	DPPH	+++	Nigeria	[38]

Table 1 Antioxidants activities of West African plants *(Continued)*

Landolphia heudelotii A. DC.	Apocynaceae	Fruit	MeOH	DPPH	8.34 s %	Guinea	[142]
Lannea acida A. Rich.	Anacardiaceae	Fruit	MeOH	DPPH	29.77%	Guinea	[142]
Lannea microcarpa Engl. & K. Krause.	Anacardiaceae	Fruit	MeOH	FRAP	<17.57 mmol AEAC/100 g	Burkina Faso	[144]
Lannea nigritana (scott Elliot) Keay.	Anacardiaceae	Fruit	MeOH	DPPH	7.53%	Guinea	[142]
Lantana ukambensis (Vatke) Verdc.	Verbenaceae	Stem	MeOH	DPPH	5.96 μg/mL	Burkina Faso	[139]
Lapaca spp	Lapacaceae	Leaf	MeOH	DPPH/FRAP	51.15/1.01 at 400 μg/mL	Nigeria	Chinaka et al., 2013
Laportea Aestuans (L.) Chew.	Urticaceae	Leaf	EtOH	DPPH/O_2/OH/NO/H_2O_2/ ABTS/LPO	15.0/247.0/84.3/67.3/230.7/81.0/ 82.7	Nigeria	[179]
Laurus nobilis L.	Lauraceae	Not stated	H_2O	FRAP	1260 μMol/L	Not stated	[30]
Lavandulae angustifolia Mill.	Lamiaceae	Not stated	H_2O	FRAP	7377 μMol/L	Not stated	[30]
Leea guinensis L.	Leeceae	Lignum	MeOH	DPPH	++	Nigeria	[38]
Lepidagathis anobrya Nees.	Acanthaceae	Stem/Leaf	H_2O	DPPH	16.33 μg/mL	Burkina Faso	[155]
Lepista nuda (Bull.) Cook.	Tricholometaceae	Mushroom	–	LPO	53.65 nM	Nigeria	[160]
Lepista saeva (Fr) Cook.	Tricholometaceae	Mushroom	–	LPO	34.46 nM	Nigeria	[160]
Lippia multiflora Moldeuke.	Verbanaceae	Leaf	Oil	DPPH	39.29 at 0.1% oil	Burkina Faso	[170]
Luglandis folium	Lamiaceae	Not stated	H_2O	FRAP	7432 μMol/L	Not stated	[30]
Macrolepiotata procera (Scp) Singer.	Lepiotaceae	Mushroom	–	LPO	38.75 nM	Nigeria	[160]
Majoranae folium Mull. Arg.	Lamiaceae	Not stated	H_2O	FRAP	4453 μMol/L	Not stated	[30]
Mallotus oppositifolius (Geiseler) Mull. Arg.	Euphorbiaceae	Leaf	MeOH	DPPH/FRAP	78.92/1.69 at 400 μg/mL	Nigeria	[149]
Malvae herba L.	Malvaceae	Not stated	H_2O	FRAP	927 μMol/L	Not stated	[30]
Mangifera indica Blume.	Anacardiacea	Leaf	EtOH	DPPH	0.313 mg/mL	Nigeria	[162]
Markhamia tomentosa K. schum. ex Engl	Bignoniaceae	Leaf	MeOH	DPPH	16.50 μg/mL	Nigeria	[156]
Marrubium vulgare L.	Lamiaceae	Not stated	H_2O	FRAP	1653 μMol/L	Not stated	[30]
Massularia acuminata (G.Don) Bullock.	Rubiaceae	Leaf	MeOH	DPPH	4.00 μg/mL	Nigeria	[156]
Melissa officinalis L.	Lamiaceae	Not stated	H_2O	FRAP	25234 μMol/L	Not stated	[30]
Mentha piperita L.	Lamiaceae	Not stated	H_2O	FRAP	8987 μMol/L	Not stated	[30]
Achille Millefolium L.	Asteraceae	Not stated	H_2O	FRAP	3228 μMol/L	Not stated	[30]
Monodora myristica Blanco.	Annonaceae	Seed	CH_2Cl_2	DPPH	54.50 μg/mL	Nigeria	[158]
Morinda lucida Benth.	Rubiacae	Leaf/Root	Oil	DPPH/ABTS/LP	7.82,6.20,0.08/7.82,8.82 and 0.02 mg/mL	Nigeria	[137]
Morus nigra L.	Moraceae	Not stated	H_2O	FRAP	2360 μMol/L	Not stated	[30]

Table 1 Antioxidants activities of West African plants *(Continued)*

Mucuna pruriens (L) DC.	Fabaceae	Leaf	H_2O/EtOH	DPPH	32.63/41.40 at 10 mg/mL	Nigeria	[180]
Mucuna pruriens (L) DC.	Fabaceae	Seed	EtOH	DPPH	7.30 μg/mL	Nigeria	[158]
Murraya koenigi (L.) Sprenge	Rutaceae	Leaf	MeOH	DPPH/FRAP	31.30/0.58 at 400 μg/mL	Nigeria	[149]
Myrianthus arboreus P. Beauv	Cecropiaceae	Leaf	CH_2Cl_2	DPPH	15.20 μg/mL	Ivory coast	[165]
Myristica fragrans Houtt.	Myristicaceae	–	$(CH_3)_2CO$	DPPH/SAS	0.10/0.135 mg/mL	Nigeria	[145]
Myrtilli fructus	Ericaceae	Not stated	H_2O	FRAP	7539 μMol/L	Not stated	[30]
Nauclea latifolia Blanco.	Rubiaceae	Fruit	MeOH	DPPH	79.61%	Guinea	[142]
Nauclea latifolia Blanco.	Rubiaceae	Root	MeOH	DPPH	1.56 μg/mL	Benin	[141]
Nelsonia canescens spreng.	Acanthaceae	Stem/Leaf	H_2O	DPPH	24.33 μg/mL	Burkina Faso	[155]
Newbouldia laevis (P.Beauv.)	Bignoniaceae	Leaf	H_2O	Fe^2/RP/DPPH	7.28/148/19.5 μg/mL	Ivory coast	[166]
Newbouldia laevis (P.Beauv.)	Bignoniaceae	Leaf	BtOH	FRAP	72% at 500 μg/mL	Nigeria	[143]
Newbouldia laevis (P.Beauv.)	Bignoniaceae	Leaf	H_2O	RP/DPPH	148.0/19.5	Ivory coast	[166]
Newbouldia laevis (P.Beauv.)	Bignoniaceae	Leaf	MeOH	DPPH	155.17 mg/mL	Nigeria	Tsado et al., 2016b [169]
Nymphaea lotus L.	Nympheaceae	Fruit	MeOH	DPPH	82.99%	Guinea	[142]
Ocimum basilicum L.	Lamiaceae	Leaf	Oil	DPPH	3.82 μg/mL	Burkina Faso	[170]
Ocimum canum L.	Lamiaceae	Leaf	Oil	DPPH	4.20 at 0.1% oil	Burkina Faso	[170]
Ocimum gratissimum L.	Lamiaceae	Leaf	CH_2Cl_2	DPPH	55.70 μg/mL	Nigeria	[158]
Olax varidis L	Olaceae	Leaf	MeOH	DPPH/FRAP	58.19/1.19 at 400 μg/mL	Nigeria	[149]
Oleae folium Hoffmans. & Link	Oleaceae	Not stated	H_2O	FRAP	3945 μMol/L	Not stated	[30]
Oncoba spinosa Forssk.	Flacourtiaceae	Fruit	MeOH	DPPH	13.52%	Guinea	[142]
Oxalis corniculata L.	Oxalidaceae	Leaf	MeOH	DPPH	95.68% at 100 μg/mL	Benin	[164]
Ozoroa insignis Delile.	Anacardiaceae	Stem	MeOH	DPPH	7.53 μg/mL	Burkina Faso	[139]
Parinari curatelifolia Planch. Ex Benth.	Chrysobalanaceae	Leaf	MeOH	DPPH	0.20 μg/mL	Togo	[153]
Parinari curatelifolia Planch. Ex Benth.	Chrysobalanaceae	Stem	MeOH	DPPH	10.5 μg/mL	Burkina Faso	[139]
Parinari excelsa Sabina.	Chrysobalanaceae	Fruit	MeOH	DPPH	77.52%	Guinea	[142]
Parkia biglobosa Benth.	Fabaceae	Fruit	MeOH	DPPH	92.25%	Guinea	[142]
Parkia biglobosa Benth.	Fabaceae	Stalk	MeOH	DPPH/FRAP	59.01/1.24 at 400 μg/mL	Nigeria	[149]
Parkia biglobosa Benth.	Fabaceae	Leaf	MeOH/EtOH	DPPH	56.83/58.17% at 0.1 mg/mL	Ghana.	[181]
Parkia biglobosa Benth.	Fabaceae	Fruit	MeOH	FRAP	<17.57 mmol AEAC/100 g	Burkina Faso	[144]
Pavetta corymbosa F.N. Williams.	Rubiaceae	Leaf	EtOH	DPPH	75.34 at 10 μg/mL	Benin	[157]
Pavetta crassipes K. schum.	Rubiaceae	Leaf	MeOH	DPPH	82.35 at 5 mg/mL	Nigeria	[136]
Petroselini crispum (Mill)	Apiaceae	Not stated	H_2O	FRAP	1318 μMol/L	Not stated	[30]

Table 1 Antioxidants activities of West African plants *(Continued)*

Phaseoli pericarpum	Fabaceae	Not stated	H_2O	FRAP	319 μMol/L	Not stated	[30]
Phaseolus lunatus Haberle.	Fabaceae	Seed coat	-	DPPH	0.37 mg/mL	Nigeria	[182]
Picralima nitida Th. & H. Dur.	Apocynaceae	Seed	MeOH	DPPH/FRAP	55.3/1.38 at 400 μg/mL	Nigeria	[149]
Piper guineense Thonn.	Piperaceae	Leaf	EtOH	DPPH	36.90 μg/mL	Nigeria	[158]
Plantago lancfolium	Plantaginaceae	Not stated	H_2O	FRAP	1727 μMol/L	Not stated	[30]
Plantago majorfolium	Plantaginaceae	Not stated	H_2O	FRAP	2733 μMol/L	Not stated	[30]
Pleioceras barteri Baill.	Apocynaceae	Leaf	MeOH	DPPH	-	Nigeria	Aladesanmi et al., 2012
Pleurotus ostreatus (Jacq. ex Fr) P. Kumm	Pleuntaceae	Mushroom	-	LPO	45.84 nM	Nigeria	[160]
Plumbago zeylanica L.	Plumbaginaceae	Root	MeOH	DPPH	-	Nigeria	Aladesanmi et al., 2012
Polygonum aviculare L.	Polygonaceae	Not stated	H_2O	FRAP	1210 μMol/L	Not stated	[30]
Primulae radix L.	Primulaceae	Not stated	H_2O	FRAP	2197 μMol/L	Not stated	[30]
Psidium guajava L. (GCL).	Myrtaceae	Leaf	EtOH	DPPH	0.04 mg/mL	Nigeria	[162]
Psidium guajava L. (GCL).	Myrtaceae	Bark	MeOH	DPPH	++	Nigeria	[156]
Psidium guayava L. (GCL).	Myrtaceae	Stem bark	EtOH	DPPH	>70% at 100 μg/mL	Benin	[157]
Psorospermum febrifugum Spach.	Hypericaceae	Leaf	MeOH	DPPH	2.3 μg/mL	Ivory Coast	[165]
Pterocarpus erinaceus Lam.	Papilionaceae	Aerial parts	MeOH	DPPH	3.37 μg/mL	Benin	[141]
Pterocarpus erinaceus Lam.	Fabaceae	Stem bark	H_2O	DPPH	0.80 μg/mL	Burkina Faso	[183]
Pterocarpus erinaceus Lam.	Fabaceae	Leaf/Stem bark	H_2O	ABTS	8.08/22.20 μMol Trolox/μg	Burkina Faso	[168]
Pterocarpus midbraedii Jacq.	Fabaceae	Leaf	MeOH			Nigeria	[175]
Pterocarpus milbraedii Jacq.	Fabaceae	Leaf	EtOH	DPPH	20.30 μg/mL	Nigeria	[158]
Pterocarpus santalinoides L'He'r. ex DC.	Fabaceae	Fruit	MeOH	DPPH	8.18%	Guinea	[142]
Raphia sudanica A. Chev.	Arecaceae	Fruit	MeOH	DPPH	93.98%	Guinea	[142]
Raphiostylis beninensis Planch. ex Benth.	Icacinaceae	Fruit	MeOH	DPPH	43.33%	Guinea	[142]
Rhynchosia buettneri Harms.	Fabaceae	Leaf	MeOH	DPPH	7.5 μg/mL	Ivory Coast	[165]
Ricinus communis L.	Euphorbiaceae	Root	MeOH	DPPH/FRAP	60.8/1.43 at 400 μg/mL	Nigeria	[149]
Rosmarini officinalis L.	Lamiaceae	Not stated	H_2O	FRAP	1277 μMol/L	Not stated	[30]
Puccinia rubi Schumach.	Phragmidiaceae	Not stated	H_2O	FRAP	12211 μMol/L	Not stated	[30]
Puccinia rubi-idaei (DC.) P. Karst.	Phragmidiaceae	Not stated	H_2O	FRAP	10025 μMol/L	Not stated	[30]
Saba senegalensis (A.D.C) Pichon.	Apocynaceae	Stem/Leaf	H_2O	DPPH	18.4 μg/mL	Burkina Faso	Yougbaré-Ziébrou et al., 2015 [184]
Saba senegalensis (A.D.C) Pichon.	Apocynaceae	Fruit	MeOH	FRAP	<17.57 mmol AEAC/100 g	Burkina Faso	[144]
Sacocephalus latifolius Afzel. Ex R. Br.	Rubiaceae	Leaf	MeOH	DPPH/FRAP	66.2/1.49 at 400 μg/mL	Nigeria	[149]

Table 1 Antioxidants activities of West African plants *(Continued)*

Salicis cortex Senna occidentalis	Saliaceae	Not stated	H_2O	FRAP	10892 μMol/L	Not stated	[30]
Salviae officinalis L.	Lamiaceae	Not stated	H_2O	FRAP	7603 μMol/L	Not stated	[30]
Sanbuci flos L.	Caprifoliaceae	Not stated	H_2O	FRAP	4055 μMol/L	Not stated	[30]
Satureja herba Mill.	Lamiaceae	Not stated	H_2O	FRAP	5339 μMol/L	Not stated	[30]
Schrankia leptocarpa DC.	Mimosaceae	Entire Plant	MeOH	DPPH	1.35 μg/mL	Benin	[141]
Sclerocarya birrea HO Chst.	Anacardiaceae	Fruit	MeOH	FRAP	<17.57 mmol AEAC/100 g	Burkina Faso	[144]
Secamone afzelii (Roem. & Schut.) K. Schum.	Asclepiadaceae	Aerial parts	MeOH	DPPH	1.74 μg/mL	Benin	[141]
Senae folium L.	Fabaceae	Not stated	H_2O	FRAP	1078 μMol/L	Not stated	[30]
Serpylli herba	Lamiaceae	Not stated	H_2O	FRAP	10868 μMol/L	Not stated	[30]
Sesanum indicum L.	Pedallaceae	Leaf	CH_2Cl_2	DPPH	43.10 μg/mL	Nigeria	[158]
Senna occidentalis (L.) Link.	Fabaceae	Leaf	MeOH	DPPH	263.53 μg/mL	Nigeria	[185]
Sida acuta Burm. F.	Malvaceae	Whole plant	H_2O	ABTS	6.12 μMol Trolox/μg	Burkina Faso	[168]
Solanium aethiopicum L.	Solanaceae	Leaf	MeOH	DPPH	5.2 μg/mL	Nigeria	Adetutu et al., 2015
Solanum melongena L.	Solanaceae	Leaf	MeOH			Nigeria	[175]
Solidaginis virgaurea L.	Asteraceae	Not stated	H_2O	FRAP	4256 μMol/L	Not stated	[30]
Sphenocentrum jollyanum Pierre.	Menispermaceae	Folium	MeOH	DPPH	+++	Nigeria	[38]
Sphenoceutrum jollyanum Pierre.	Menispermaceae	Root	MeOH	DPPH	++	Nigeria	[156]
Spiraea herba L.	Rosaceae	Not stated	H_2O	FRAP	15256 μMol/L	Not stated	[30]
Spondias mombin Jacq.	Anacardiaceae	Fruit	MeOH	DPPH	93.83%	Guinea	[142]
Stigmata maydis L.	Poaceae	Not stated	H_2O	FRAP	1009 μMol/L	Not stated	[30]
Strobilus lupuli L.	Cannabidaceae	Not stated	H_2O	FRAP	2204 μMol/L	Not stated	[30]
Strophanthus hispidus DC.	Apocynaceae	Leaf, root	MeOH	DPPH	49.8 and 45.1 μg/mL	Ghana	[178]
Strychnos spinosa Lam.	Loganiaceae	Fruit	MeOH	DPPH	111.71%	Guinea	[142]
Tamarindus indica L.	Caesalpiniaceae	Fruit	MeOH	DPPH	116.75%	Guinea	[142]
Tamarindus indica L.	Caesalpiniaceae	Fruit	MeOH	FRAP	12.42 mmol AEAC/100 g	Burkina Faso	[144]
Telfairia occidentalis Hook. F.	Cucurbitaceae	Leaf/Stem	MeOH	DPPH	+/–	Nigeria	[39]
Telfaria occidentalis Hook. F.	Cucurbitaceae	Leaf	MeOH	DPPH	1.8 ± 0.2 μg/mL	Nigeria	[150]
Teraxaci folium	Asteraceae	Not stated	H_2O	FRAP	4600 μMol/L	Not stated	[30]
Terminalia avicennioides Guill. & Perr.	Combretaceae	Root	H_2O	H_2O_2/Fe^{3+}	0.58/0.66	Nigeria	[152]
Terminalia catappa L.	Combretaceae	Leaf	Oil	DPPH	0.084 mg/mL	Nigeria	[186]
Terminalia catappa L.	Combretaceae	Leaf	MeOH	DPPH/FRAP	58.19/1.30 at 400 μg/mL	Nigeria	[149]
Tetrapleura tetraptera Taub.	Fabaceae	Fruit	EtOH	DPPH	12.70 μg/mL	Nigeria	[158]

Table 1 Antioxidants activities of West African plants *(Continued)*

Tetrapleura tetraptera Taub.	Fabaceaee	Leaf	MeOH/EtOH	DPPH	68.35/69.49% at 0.1 mg/mL	Ghana.	[181]
Thymi herba	Lamiaceae	Not stated	H_2O	FRAP	9069 μMol/L	Not stated	[30]
Tiliae flos Mill.	Malvaceae	Not stated	H_2O	FRAP	3807 μMol/L	Not stated	[30]
Trema orientalis (L.) Blume.	Cannabaceae	Leaf	H_2O	Fe^2/RP/DPPH	24.55/24.3/22.75 μg/mL	Ivory Coast	[166]
Trichilia heudeloti. Planch.	Meliaceae	Leaf	MeOH	DPPH	6.50 μg/mL	Nigeria	Aladesanmi et al., 2012
Urticae folium L.	Urticaceae	Not stated	H_2O	FRAP	3168 mol/L	Not stated	[30]
Uvaria chamae P. Beauv.	Annonaceae	Fruit	MeOH	DPPH	13.52%	Guinea	[142]
Uvaria chanae P. Beauv.	Annonaceae	Root	MeOH	DPPH/FRAP	95.08/1.9 at 400 μg/mL	Nigeria	[149]
Verbasi flos L.	Scrophulariaceae	Not stated	H_2O	FRAP	603 μMol/L	Not stated	[30]
Verbenae herba	Verbinaceaae	Not stated	H_2O	FRAP	2089 μMol/L	Not stated	[30]
Vernonia amygdalina Delile.	Asteracea	Leaf	EtOH	DPPH	19.33 μg/mL	Nigeria	[158]
Vernonia Amygdalina Delile.	Astereacea	Leaf	MeOH	DPPH	85.8 at 20 μg/mL	Nigeria	[187]
Vernonia amygdalina Delile.	Asteracea	Leaf	EtOH	DPPH	2.30 mg/mL	Nigeria	[162]
Veronicae officinalis L.	Plantaginaceae	Not stated	H_2O	FRAP	6514 μMol/L	Not stated	[30]
Violae tricolor L.	Violaceae	Not stated	H_2O	FRAP	846 μMol/L	Not stated	[30]
Visci albi L.	Santalaceae	Not stated	H_2O	FRAP	727 μMol/L	Not stated	[30]
Vitellaria paradoxa C.FGaertn	Sapotaceae	Fruit	MeOH	FRAP	<17.57 mmol AEAC/100 g	Burkina Faso	[144]
Vitex doniana Sweet.	Verbenaceae	Fruit	MeOH	DPPH	82.99%	Guinea	[142]
Vitex doniana Sweet.	Verbenaceae	Leaf	H_2O/EtOH	DPPH	87.52/3.30 at 10 mg/mL	Nigeria	[180]
Voacanga Africana Stapf ex Scott Elliot.	Liliaceae	Folium	MeOH	DPPH	++++	Nigeria	[38]
Xeoderris sthulmannii L.	Fabaceae	Stem bark	MeOH	DPPH	2.36 μg/mL	Burkina Faso	[139]
Ximenia Americana L.	Olacaceae	Fruit	MeOH	FRAP	17.57 mmol AEAC/100 g	Burkina Faso	[144]
Xylopia aethiopica A. Rich.	Annonaceae	Fruit	MeOH	DPPH	13.70%	Guinea	[142]
Xylopia aethiopica A. Rich.	Annonaceae	Seed	EtOH	DPPH	10.70 μg/mL	Nigeria	[158]
Zingiber officinale Roscoe.	Zingebracea	Spice	H_2O	DPPH/ABTS	1.21,/0.04 mg/mL	Nigeria	[148]
Zingiber officinale Roscoe.	Zingiberaceae	-	$(CH_3)\ _2CO$	DPPH/SAS	0.075/0070 mg/mL	Nigeria	[145]
Ziziphus mauritiana Lam.	Rhamnaceae	Fruit	MeOH	FRAP	18.28 mmol AEAC/100 g	Burkina Faso	[144]

Key: +++ Strong intensity of yellow colouration, ++ Intermediate intensity of yellow colouration, + Weak intensity of yellow colouration, – No yellow colouration, + + – Antioxidant in low quantity, + ++ – Antioxidant in moderate quantity, ++++ – Antioxidant in large quantity, *RSA* radical scavenging activity, *RC* reducing power capacity, *OH* hydroxyl ion, *NO* nitric oxide radical inhibition, H_2O_2 hydrogen peroxide inhibition activity, *LPO* lipid peroxidation inhibition activity, $ABTS^+$ 2,2′-azinobis-3–ethylbenzothiozolin-6–sulfonic acid cation decolourization test, ß-*CLAMS* ß-carotene-linoleic acid model system, *MLP* microsomal lipid peroxydation, *FRAP* fe^{2+} chelating ability and ferric reducing antioxidant properties, *DPPH* 1,1–dipheyl-2–picry-hydrazyl, *ORAC* oxygen radical absorbance capacity, *TEAC* trolox equivalent antioxidant capacity, *MeOH* methanol, CH_2Cl_2 dichloromethane, *EtOH* ethanol, *EtOAc* ethyl acetate, $n\text{-}C_6H_{12}$ hexane, $(CH_3)\ _2CO$ acetone, H_2O aqueous, *BtOH* butanol

Table 2 Antioxidants activities of Northern Africa African plants

Plants	Family	Part used	Solvents	Assay Methods	Inhibition/EC_{50}	Country of origin	References
Acacia arabica (Lam) Wild.	Fabaceae	Leaf	MeOH	DPPH	61.20% at 50 μg/mL	Sudan	[188]
Acacia nilotica Delile.	Mimosaceae	Bark	EtOH	SORSA	75% at 1 μg/mL	Sudan	[45]
Acacia nilotica Delile.	Mimosaceae	Pod	MeOH	DPPH	37.57 μM	Sudan	[189]
Acalypha marginata Spreng.	Euphorbiaceae	Leaf	$CHCl_3$/MeOH	DPPH	29/89 at 50 μg/mL	Egypt	[42]
Achillea millefolium L.	Asteraceae	Leaf	EtOH	DPPH/TBA	58.11/51.2 at 100 μg/mL	Egypt	[190]
Adansonia digitata L.	Malvaceae	Leaf	EtOH	DPPH	13%	Sudan	[191]
Adhatoda vasica Nees.	Acauthaceae	Leaf	$CHCl_3$/MeOH	DPPH	3/13 at 50 μg/mL	Egypt	[42]
Adhatoda vasica Nees.	Acanthaceae	Aerial parts	MeOH	DPPH	>100 μg/mL	Egypt	[192]
Ajuga iva (L.) Schreb.	Lamiaceae	Aerial parts	MeOH	DPPH	486.60 μg/mL	Algeria	[193]
Albezzia anthelmintica Benth.	Loganiaceae	Leaf	$CHCl_3$/MeOH	DPPH	20/49 at 50 μg/mL	Egypt	[42]
Albezzia stipulate (DC.) Bovin.	Mimosaceae	Leaf	$CHCl_3$/MeOH	DPPH	1/18 at 50 μg/mL	Egypt	[42]
Albizzia anthelmintica Benth.	Mimosaceae	-	EtOH	SOCA	<50 at 1 μg/mL	Sudan	[45]
Alhagi maurorum Medik.	Leguminosae	Leaf	H_2O	DPPH	0.47 mmol TEAC/g	Libya	[194]
Aloe vera L.	Xanthorrhoeaceae	Juice	MeOH	DPPH	>100 μg/mL	Egypt	[192]
Alternanthera versicolor Forssk.	Amaranthaceae	Leaf	$CHCl_3$/MeOH	DPPH	0.5/71 at 50 μg/mL	Egypt	[42]
Althaea rosea Hohen.	Malvaceae	Leaf	$CHCl_3$/MeOH	DPPH	19/58 at 50 μg/mL	Egypt	[42]
Amaranthus tricolor L.	Amaranthaceae	Leaf	$CHCl_3$/MeOH	DPPH	1/0 at 50 μg/mL	Egypt	[42]
Anabasis articulata L.	Chenopodiaceae	Whole plant	EtOH/H_2O	DPPH	40/42% at 100 μg/mL	Egypt	[41]
Anacyclus clavatus Pers.	Asteraceae	Aerial parts	MeOH	DPPH	27.20 μg/mL	Algeria	[193]
Anacyclus pyrethrum L (DC).	Asteraceae	Root	MeOH	DPPH	26.3 μg/mL	Egypt	[192]
Anastatica hierochuntica L.	Brassicaceae	Leaf	EtOH	DPPH	150.85 μg/mL	Egypt	[195]
Anogeisus leiocarpus (DC.) Guill. & Perr.	Combretaceae	Leaf	MeOH	FRAP	92%	Sudan	[196]
Anthorium scherzerianum Schott.	Araceae	Leaf	$CHCl_3$/MeOH	DPPH	14/37 at 50 μg/mL	Egypt	[42]
Antigonon leptopus Hook & Arm.	Polygonaceae	Leaf	EtOH	DPPH	89%	Sudan	[197]
Arbutus Pavarii Pamp.	Ericaceae	Leaf	MeOH	DPPH	4.55 μg/mL	Algeria	[198]
Arbutus unedo L.	Ericaceae	Aerial parts	MeOH	DPPH/ABTS	3.8/4.2 μg/mL	Algeria	[199]
Argemone mexicana L.	Papaveraceae	Not stated	EtOH	SORSA	<50 at 1 μg/mL	Sudan	[45]
Aristolochia bracteolata L.	Aristolochiaceae	Not stated	EtOH	SORSA	<50 at 1 μg/mL	Sudan	[45]
Artemisia absinthium L.	Compositae	Leaf	H_2O	DPPH	0.89 mmol TEAC/g	Libya	[194]
Artemisia annua L.	Asteraceae	Leaf	EtOH	DPPH/TBA	37.97/49.6 at 100 μg/mL	Egypt	[190]
Arum palaestinum Boiss.	Araceae	Leaf	EtOH/H_2O	DPPH	12/43% at 100 μg/mL	Egypt	[41]
Asparagus plumosus Baker.	Liliaceae	Leaf	$CHCl_3$/MeOH	DPPH	0/16 at 50 μg/mL	Egypt	[42]
Asparagus setaceus Jessop.	Liliaceae	Leaf	$CHCl_3$/MeOH	DPPH	5/15 at 50 μg/mL	Egypt	[42]
Asparagus stipularis Rch. D.	Liliaceae	Whole plant	EtOH/H_2O	DPPH	72/70% at 100 μg/mL	Egypt	[41]
Asphodelus microcarpus Rch. D.	Liliaceae	Whole plant	EtOH/H_2O	DPPH	60/49% at 100 μg/mL	Egypt	[41]
Aspidistra lurida Ker Gawl.	Convallariaceae	Leaf	$CHCl_3$/MeOH	DPPH	0/39 at 50 μg/mL	Egypt	[42]
Astragalus pinosus L.	Leguminosae	Whole plant	EtOH/H_2O	DPPH	28/19% at 100 μg/mL	Egypt	[41]
Atriplex halimus L.	Chenopodiaceae	Whole plant	EtOH/H_2O	DPPH	70/50% at 100 μg/mL	Egypt	[41]

Table 2 Antioxidants activities of Northern Africa African plants *(Continued)*

Balanites aegyptiaca Delile.	Balanitaceae	Bark	EtOH	SORSA	72% at 1 μg/mL	Sudan	[45]
Balanites aegyptiaca Delile.	Balanitaceae	Seed	Oil		17%	Sudan	[200]
Bauhenia variegata	Leguminosae	Leaf	$CHCl_3$/MeOH	DPPH	18/94 at 50 μg/mL	Egypt	[42]
Bauhinia alba Buch.	Caesalpiniaceae	Leaf	MeOH	DPPH/ABTS	74.32/25.29 μg/mL	Egypt	[201]
Beta vulgaris L.	Amaranthaceae	Leaf	Cold H_2O/hot H_2O/MeOH	DPPH	0.5/22/0.48 mg/mL	Egypt	[202]
Beta vulgaris L.	Amaranthaceae	Whole plant	EtOH/H_2O	DPPH	41/30% at 100 μg/mL	Egypt	[41]
Bombax malabaricum DC.	Bombacaceae	Leaf	$CHCl_3$/MeOH	DPPH	2/96 at 50 μg/mL	Egypt	[42]
Boswellia sacra Flueck.	Burseraceae	Gum	MeOH	DPPH	>100 μg/mL	Egypt	[192]
Bougainvillea glabra Choisy.	Nyctaginaceae	Leaf	$CHCl_3$/MeOH	DPPH	20/50 at 50 μg/mL	Egypt	[42]
Bougainvillea pixie-pink	Nyctaginaceae	Leaf	$CHCl_3$/MeOH	DPPH	22/39 at 50 μg/mL	Egypt	[42]
Bougainvillea spectabilis Wild.	Nyctaginaceae	Leaf	$CHCl_3$/MeOH	DPPH	12/38 at 50 μg/mL	Egypt	[42]
Brachichton acerifolium	Sterculiaceae	Leaf	$CHCl_3$/MeOH	DPPH	16/22 at 50 μg/mL	Egypt	[42]
Brassica nigra W.D.J. Koch.	Brassicaceae	Seed	MeOH	DPPH	32.82 μML	Sudan	[189]
Brassica nigra W.D.J. Koch.	Brassicaceae	Seed	MeOH	DPPH	>100 μg/mL	Egypt	[192]
Brassica rapa L.	Brassicaceae	Root	MeOH	DPPH	>100 μg/mL	Egypt	[192]
Buddleia davidii Franch	Loganiaceae	Leaf	$CHCl_3$/MeOH	DPPH	10/50 at 50 μg/mL	Egypt	[42]
Buddleja rufescens	Caesalpiniodeae	Leaf	MeOH	DPPH	81% at 500 μg/mL	Sudan	[203]
*Caesalpinia pulcherrima (*L.) Sw.	Loganiaceae	Leaf	$CHCl_3$/MeOH	DPPH	25/27 at 50 μg/mL	Egypt	[42]
Cakile maritime Scop.	Cruciferae	Whole plant	EtOH/H_2O	DPPH	58/55% at 100 μg/mL	Egypt	[41]
Calendula officinalis L.	Asteraceae	Leaf	EtOH	DPPH/TBA	22.08/2.60 at 100 μg/mL	Egypt	[190]
Calendula officinalis L.	Asteraceae	Leaf	H_2O	DPPH	0.67 mmol TEAC/g	Libya	[194]
Calicotome spinosa L.	Fabaceae	Leaf	MeOH	DPPH	29.20 μg/mL	Algeria	[193]
Calicotome villosa Poir.	Fabaceae	Leaf	MeOH	ß-CLAMS	29.8 μg/mL	Tunisia.	[204]
Caliistemon lanceolatus (Curtis) Dum.Cours.	Myrtaceae	Leaf	$CHCl_3$/MeOH	DPPH	23/78 at 50 μg/mL	Egypt	[42]
Calliandra haematocephala Hassk.	Mimosaceae	Leaf	$CHCl_3$/MeOH	DPPH	10/23 at 50 μg/mL	Egypt	[42]
Camellia sinensis (L). Kuntze.	Theaceae	Leaf	H_2O	DPPH	17.044 mmol TEAC/g	Libya	[194]
Camellia sinensis (L). Kuntze.	Theaceae	Leaf	EtOH/H_2O	DPPH	85/70% at 100 μg/mL	Egypt	[41]
Camellia sinensis (L). Kuntze.	Theaceae	Leaf	Tea	DPPH	3.0 μg/mL	Algeria	[205]
Capparis Spinosa L.	Capparidaceae	Leaf	MeOH	DPPH	57.75 μg/mL	Algeria	[198]
Capsicum annuum L.	Solanaceae	Fruit	EtOH/H_2O	DPPH	57/25% at 100 μg/mL	Egypt	[41]
Capsicum annuum L.	Solanaceae	Whole plant	EtOH/H_2O	DPPH	90/81% at 100 μg/mL	Egypt	[41]
Capsicum frutescens L.	Solanaceae	Leaf	Cold H_2O/hot H_2O/MeOH	DPPH	0.69/22.2/0.57 mg/mL	Egypt	[202]
Carissa grandiflora A.DC.	Apocynaceae	Leaf	$CHCl_3$/MeOH	DPPH	2/0 at 50 μg/mL	Egypt	[42]
Cassia acutifolia L.	Fabaceae	Leaf	Cold H_2O/hot H_2O/MeOH	DPPH	0.58/39/0.59 mg/mL	Egypt	[202]
Cassia didymobotrya Delile.	Fabaceae	Leaf	$CHCl_3$/MeOH	DPPH	19.5/12 at 50 μg/mL	Egypt	[42]
Cassia fistula L.	Fabaceae	Leaf	$CHCl_3$/MeOH	DPPH	21.6/45 at 50 μg/mL	Egypt	[42]
Cassia fistula L.	Fabaceae	Fruit	MeOH	DPPH	75 μg/mL	Egypt	[192]

Table 2 Antioxidants activities of Northern Africa African plants *(Continued)*

Cassia nigricans Vahl.	Caesalpinaceae	Not stated	EtOH	SORSA	<50 at 1 μg/mL	Sudan	[45]
Cassia senna L.	Ceasalpiniaceae	leaf	MeOH	DPPH	33.56 μM	Sudan	[189]
Centaurea calcitrapa L.	Asteraceae	Aerial parts	MeOH	DPPH	231.70 μg/mL	Algeria	[193]
Ceratonia siliqua L.	Fabaceae	Pod	H_2O	DPPH/ABTS	7.7/9.7%	Morocco	[206]
Cestrum diurnum ex Dunal.	Solonaceae	Leaf	$CHCl_3$/MeOH	DPPH	30/20 at 50 μg/mL	Egypt	[42]
Chrysanthemum frutesence (L.) Sch. Bip.	Compositae	Leaf	$CHCl_3$/MeOH	DPPH	0/87 at 50 μg/mL	Egypt	[42]
Chrysanthemum red L.	Asteraceae	Leaf	$CHCl_3$/MeOH	DPPH	15.53 at 50 μg/mL	Egypt	[42]
Cistanche phelypaea L.	Orobanchaceae	Whole plant	EtOH/H_2O	DPPH	50/85% at 100 μg/mL	Egypt	[41]
Cistus incanus L.	Cistaceae	Leaf	MeOH	DPPH	17.75 μg/mL	Algeria	[198]
Cistus Parviflorus Gaterau.	Cistaceae	Leaf	MeOH	DPPH	4.75 μg/mL	Algeria	[198]
Citrullus colocynthis (L) Schrad.	Cucurbitaceae	Not stated	EtOH	SORSA	<50 at 1 μg/mL	Sudan	[45]
Citrus limon (L) Osbeck	Rutaceae	Fruit	EtOH/H_2O	DPPH	91/70% at 100 μg/mL	Egypt	[41]
Cochlospermum planchonii Hook. F. ex Planach.	Cochlospermaceae	Root	MeOH	DPPH/FRAP	01.83/06.50 mg/mL	Egypt	[207]
Colocasia antiquorum Schott.	Araceae	Leaf	Cold H_2O/hot H_2O/MeOH	DPPH	0.49/49.7/0.27 mg/mL	Egypt	[202]
Combretum aculeatum Vent.	Combretaceae	Leaf	MeOH	FRAP	98%	Sudan	[196]
Combretum hartmannianum Schweinf.	Combretaceae	Leaf	EtOH/MeOH/H_2O	DPPH	146/14/967 μg/mL	Sudan	[208]
Combretum hartmannianum Schweinf.	Combretaceae	Leaf	MeOH	RSA/FRAP	86/11%	Sudan	[208]
Combretum hartmannianum Schweinf.	Combretaceae	Leaf	MeOH	FRAP	99%	Sudan	[196]
Conocarpus erectus L.	Combretaceae	Leaf	$CHCl_3$/MeOH	DPPH	15/45 at 50 μg/mL	Egypt	[42]
Coratonia siliqua L.	Loganiaceae	Leaf	$CHCl_3$/MeOH	DPPH	1.5/40 at 50 μg/mL	Egypt	[42]
Cordia africana Lam.	Boraginaceae	Leaf/Stem bark/Fruit	MeOH	DPPH	80/88/74/37%	Sudan	[209]
Cordia sebestena Andrew.	Boraginaceae	Leaf	$CHCl_3$/MeOH	DPPH	15/42 at 50 μg/mL	Egypt	[42]
Cordyline fruticosa Gopp.	Laxmamiaceae	Leaf	$CHCl_3$/MeOH	DPPH	18/21 at 50 μg/mL	Egypt	[42]
Crinum longifolium L.	Amaryllidaceae	Leaf	$CHCl_3$/MeOH	DPPH	6/21 at 50 μg/mL	Egypt	[42]
Cryptostegia grandiflora R. Br.	Asclpiadaceae	Leaf	$CHCl_3$/MeOH	DPPH	0/35 at 50 μg/mL	Egypt	[42]
Cucurbita maxima Duchesne.	Cucurbitaceae	Seed	EtOH	DPPH	38%	Sudan	[191]
Cucurbita pepo Vell.	Cucurbitaceae	Leaf	MeOH/H_2O	DPPH	>0.19 mg/mL	Algeria	[210]
Cupressus sempervirens L.	Cupressaceae	Leaf	$CHCl_3$/MeOH	DPPH	6/65 at 50 μg/mL	Egypt	[42]
Cupressus sempervirens L.	Cupressacea	Leaf	MeOH	DPPH	29.20 μg/mL	Algeria	[193]
Cymbopogon citratus Stapf.	Poaceae	Leaf	EtOH	DPPH/TBA	24.79/2.7 at 100 μg/mL	Egypt	[190]
Cymbopogon citratus Stapf.	Poaceae	Leaf	MeOH	DPPH	30.64 μM	Sudan	[189]
Cymbopogon schoenanthus Spreng.	Poaceae	Leaf	MeOH	DPPH	34.28 μML	Sudan	[189]
Cynara scolymus L.	Asteraceae	Rizhome	MeOH/flavonoid	DPPH	17.7/13.3 μg/mL	Libya	[211]
Cyperus alternifolius Stend.	Cyperaceae	Leaf	$CHCl_3$/MeOH	DPPH	2/31 at 50 μg/mL	Egypt	[42]
Cypressus macrocarpa	Cupressaceae	Leaf	$CHCl_3$/MeOH	DPPH	3/49 at 50 μg/mL	Egypt	[42]
Datura arborea L.	Solonaceae	Leaf	$CHCl_3$/MeOH	DPPH	17/56 at 50 μg/mL	Egypt	[42]
Daucus carota L.	Umbelliferae	Whole plant	EtOH/H_2O	DPPH	85/81% at 100 μg/mL	Egypt	[41]
Derris rubosta (Roxb. ex DC.) Benth.	Fabaceae	Leaf	MeOH	DPPH/ABTS	138/294 μg/mL	Egypt	[201]

Table 2 Antioxidants activities of Northern Africa African plants *(Continued)*

Didonia viscose Jacq.	Sapindaceae	Leaf	$CHCl_3$/MeOH	DPPH	0/90 at 50 μg/mL	Egypt	[42]
Dracaena fragrans Ker Gawl.	Moraceae	Leaf	$CHCl_3$/MeOH	DPPH	15/33 at 50 μg/mL	Egypt	[42]
Dracaena marginata L.	Agavaceae	Leaf	$CHCl_3$/MeOH	DPPH	15/13 at 50 μg/mL	Egypt	[42]
Duranta repens L.	Verbenaceae	Leaf	$CHCl_3$/MeOH	DPPH	16/44 at 50 μg/mL	Egypt	[42]
Eichhornia azurea K	Pontederiaceae	Fruit	EtOH/H_2O	DPPH	54/50% at 100 μg/mL	Egypt	[41]
Elaeagnus macrophylla Thunb.	Elaeagnaceae	Leaf	$CHCl_3$/MeOH	DPPH	45/8 at 50 μg/mL	Egypt	[42]
Emblica officinalis Gaetn.	Euphorbiaceae	Fruit	MeOH	DPPH	63 μg/mL	Egypt	[192]
Erica arborea L.	Ericaceae	Aerial parts	MeOH	DPPH/ABTS	5.7/6.8 μg/mL	Algeria	[199]
Erica multiflora L.	Ericaceae	Aerial parts	MeOH	DPPH/ABTS	10.2/9.0 μg/mL	Algeria	[199]
Eucalyptus globules Labill.	Myrtaceae	Leaf	MeOH	DPPH/H_2O_2	–	Algeria	[212]
Eucalyptus rostrata Cav.	Myrtaceae	Leaf	$CHCl_3$/MeOH	DPPH	9/90 at 50 μg/mL	Egypt	[42]
Eugenia uniflora L.	Myrtaceae	Leaf	$CHCl_3$/MeOH	DPPH	13/16 at 50 μg/mL	Egypt	[42]
Euonymus japonicus Thunb.	Celastraceae	Leaf	$CHCl_3$/MeOH	DPPH	3/66 at 50 μg/mL	Egypt	[42]
Euphorbia paralias L.	Euphorbiaceae	Whole plant	EtOH/H_2O	DPPH	81/51% at 100 μg/mL	Egypt	[41]
Euphorbia serrata L.	Euphorbiaceae	Leaf	MeOH	DPPH	40 μg/mL	Libya	[213]
Euphorbia splendens Bojer ex Hook.	Euphorbiaceae	Leaf	$CHCl_3$/MeOH	DPPH	5.5/31 at 50 μg/mL	Egypt	[42]
Ferula assafoetida L.	Apiaceae	Gum	MeOH	DPPH	>100 μg/mL	Egypt	[192]
Ficus alii L.	Moraceae	Leaf	$CHCl_3$/MeOH	DPPH	1/3 at 50 μg/mL	Egypt	[42]
Ficus benjamina L.	Moraceae	Leaf	$CHCl_3$/MeOH	DPPH	2/3 at 50 μg/mL	Egypt	[42]
Ficus carica L.	Moracea	Whole plant	EtOH/H_2O	DPPH	84/80% at 100 μg/mL	Egypt	[41]
Ficus carica L.	Moraceae	Leaf	MeOH	DPPH	113.30 μg/mL	Algeria	[193]
Ficus elastica Roxb.	Moraceae	Leaf	$CHCl_3$/MeOH	DPPH	11.5/41 at 50 μg/mL	Egypt	[42]
Ficus enfictoria L.	Moraceae	Leaf	$CHCl_3$/MeOH	DPPH	3.5/31 at 50 μg/mL	Egypt	[42]
Ficus hawaii L.	Moraceae	Leaf	$CHCl_3$/MeOH	DPPH	3/25 at 50 μg/mL	Egypt	[42]
Ficus natalensis Hochst.	Moraceae	Leaf	$CHCl_3$/MeOH	DPPH	5/16 at 50 μg/mL	Egypt	[42]
Ficus nitida Miq.	Moraceae	Leaf	$CHCl_3$/MeOH	DPPH	5/25 at 50 μg/mL	Egypt	[42]
Ficus religiosa L.	Moraceae	Leaf	$CHCl_3$/MeOH	DPPH	3/24 at 50 μg/mL	Egypt	[42]
Ficus vasta Forss K.	Moraceae	Leaf	MeOH	RSA/Iron chelating	88/03%	Sudan	[208]
Foeniculum vulgare Mill.	Apiaceae	Leaf	$CHCl_3$/MeOH	DPPH	46/16 at 50 μg/mL	Egypt	[42]
Fraxinus latifolia Benth.	Oleaceae	Leaf	EtOH	OH	79.76 μg/mL	Algeria	[214]
Gazania splendens Hort. Angl	Compositae	Leaf	$CHCl_3$/MeOH	DPPH	0/89 at 50 μg/mL	Egypt	[42]
Geigeria alata Benth & Hook. F.	Asteraceae	-	EtOH	SORSA	<50 at 1 μg/mL	Sudan	[45]
Globularia alypum L.	Globulariaceae	Leaf	MeOH	DPPH	39.30 μg/mL	Algeria	[193]
Globularia alypum L.	Globulariaceae	Leaf	MeOH/H_2O/EtOAc	DPPH	33.32/36.12/38.29 μg/mL	Algeria	[215]
Globularia Arabica Jaub & Spach.	Globulariaceae	Leaf	MeOH	DPPH	7.65 μg/mL	Algeria	[198]
Glycyrrhiza glabra L.	Galegeae	Seed	EtOH/H_2O	DPPH	47/84% at 100 μg/mL	Egypt	[41]
Grass L.	Poaceae	Leaf	$CHCl_3$/MeOH	DPPH	5/30 at 50 μg/mL	Egypt	[42]
Guiera senegalensis Lam.	Combretaceae	Leaf	MeOH	RSA/Iron chelating	90/05%	Sudan	[208]
Hammada scoparia (Pomel) Iljin.	Chenopodiaceae	Leaf	MeOH	DPPH	8 μg/mL	Libya	[211]

Table 2 Antioxidants activities of Northern Africa African plants *(Continued)*

Helianthemum lippii Mill.	Cistaceae	Leaf	MeOH	DPPH/OH	58.98/324.84 μg/mL	Algeria	[216]
Helianthemum lippii Mill.	Cistaceae	Leaf	MeOH	DPPH	45.2 μg/mL	Algeria	[198]
Helianthus annuus L.	Asteraceae	Seed	Oil	DPPH	52%	Sudan	[200]
Helychrysum stoechas L.	Asteraceae	Aerial parts	MeOH	DPPH	46.30 μg/mL	Algeria	[193]
Herniaria glabra Mill.	Caropllaceae	Aerial parts	MeOH	DPPH	332.5 μg/mL	Algeria	[193]
Hibiscus mutabilic L.	Malvaceae	Leaf	$CHCl_3$/MeOH	DPPH	0/40 at 50 μg/mL	Egypt	[42]
Hibiscus sabdariffa L.	Malvaceae	Leaf	H_2O	DPPH	5.62 mmol TEAC/g	Libya	[194]
Hibiscus sabdariffa L.	Malvaceae	Calyces	MeOH	DPPH	33.24 μM	Sudan	[189]
Hydnora abyssinica A. Braun.	Hydnoraceae	Leaf	EtOH	SORSA	59% at 1 μg/mL	Sudan	[45]
Hydnora abyssinica A. Braun.	Hydnoraceae	Rhizome	MeOH	RSA/Iron chelating	77/02%	Sudan	[208]
Hydrangea red L.	Saxifragaceae	Leaf	$CHCl_3$/MeOH	DPPH	4/29 at 50 μg/mL	Egypt	[42]
Hyoscyamus albus L.	Rhamnacea	Leaf	MeOH	DPPH	60 μg/mL	Libya	[213]
Hyphaene thebaica Mark.	Arecacea	Not stated	EtOH	SORSA	<50 at 1 μg/mL	Sudan	[45]
Inula viscosa L.	Asteraceae	Leaf	Oil	DPPH, ABTS/H_2O_2	-	Algeria	[217]
Jacarandas acutifolia L.	Bignoniaceae	Leaf	$CHCl_3$/MeOH	DPPH	18/55 at 50 μg/mL	Egypt	[42]
Jasminum grandiflorum L.	Oleaceae	Flower	H_2O	DPPH/ABTS	14.35/10.2%	Morocco	[206]
Jasminum grandiflorum L.	Oleaceae	Leaf	$CHCl_3$/MeOH	DPPH	39/52 at 50 μg/mL	Egypt	[42]
Jasminum primulinum ex Baker.	Oleaceae	Leaf	$CHCl_3$/MeOH	DPPH	6/30 at 50 μg/mL	Egypt	[42]
Jatropha curcas L.	Euphorbiaceae	Root/Leaf	EtOH	DPPH	0.048/0.063	Egypt	[218]
Jatropha integerrima Jacq.	Euphorbiaceae	Leaf	$CHCl_3$/MeOH	DPPH	13/10 at 50 μg/mL	Egypt	[42]
Jatropha multifidal L.	Euphorbiaceae	Leaf	$CHCl_3$/MeOH	DPPH	47/17 at 50 μg/mL	Egypt	[42]
Khaya senegalensis A. Juss.	Meliaceae	Leaf	$CHCl_3$/MeOH	DPPH	13/86 at 50 μg/mL	Egypt	[42]
Khaya senegalensis A. Juss.	Meliaceae	Leaf	EtOH	SORSA	71% at 1 μg/mL	Sudan	[45]
Kigelia pinnata DC.	Bignoniaceae	Leaf	$CHCl_3$/MeOH	DPPH	3/0 at 50 μg/mL	Egypt	[42]
Kochia indica Wight.	Chenopodiaceae	Whole plant	EtOH/H_2O	DPPH	50/72% at 100 μg/mL	Egypt	[41]
Lagerstroemia indica L.	Lythraceae	Leaf	$CHCl_3$/MeOH	DPPH	28/89 at 50 μg/mL	Egypt	[42]
Lantana camara L.	Verbenaceae	Leaf	$CHCl_3$/MeOH	DPPH	12/32 at 50 μg/mL	Egypt	[42]
Lantana montevidensis Briq.	Verbenaceae	Leaf	$CHCl_3$/MeOH	DPPH	11/30 at 50 μg/mL	Egypt	[42]
Laurus nobilis L.	Lauraceae	Leaf	H_2O	DPPH/ABTS	18.93/18.61%	Morocco	[206]
Laurus nobilis L.	Lauraceae	Leaf	$CHCl_3$/MeOH	DPPH	49/89 at 50 μg/mL	Egypt	[42]
Laurus nobilis L.	Lauraceae	Leaf	Oil	DPPH, ABTS/H_2O_2	-	Algeria	[217]
Lavandula angustifolia Mill.	Lamiaceae	Leaf	$CHCl_3$/MeOH	DPPH	2.6/36 at 50 μg/mL	Egypt	[42]
Lepidium sativum	Brassicaceae	Seed	MeOH	DPPH	33.61 μM	Sudan	[189]
Leucophyllum frutescens	Scrophulariaceae	Leaf	$CHCl_3$/MeOH	DPPH	16.4/31 at 50 μg/mL	Egypt	[42]
Ligustrum ovalifolium Hassk.	Oleaceae	Leaf	$CHCl_3$/MeOH	DPPH	9/11 at 50 μg/mL	Egypt	[42]
Limoniastrum monopetalum Boiss.	Plumaginaceae	Whole plant	EtOH/H_2O	DPPH	85/82% at 100 μg/mL	Egypt	[41]
Lonicera japonica Thunb.	Caprifoliaceae	Leaf	$CHCl_3$/MeOH	DPPH	5/16 at 50 μg/mL	Egypt	[42]
Lotas polyphyllus E.D. Clarke	Leguminosae	Whole plant	EtOH/H_2O	DPPH	27/27% at 100 μg/mL	Egypt	[41]
Luffa aegyptiaca Mill.	Curcubitaceae	Leaf	Cold H_2O/hot H_2O/MeOH	DPPH	1.19/17.9/0.75 mg/mL	Egypt	[202]
Majorana hortensis Moench.	Lamiaceae	Leaf	EtOH	DPPH/TBA	69.73/63.6 at 100 μg/mL	Egypt	[190]

Table 2 Antioxidants activities of Northern Africa African plants *(Continued)*

Marrubium vulgare L.	Lamiaceae	Leaf	H_2O	DPPH	0.43 mmol TEAC/g	Libya	[194]
Marrubium vulgare L.	Lamiaceae	Aerial parts	MeOH	DPPH	84.20 μg/mL	Algeria	[193]
Matricaria chamomilla L.	Compositae	Leaf	H_2O	DPPH	2.15 mmol TEAC/g	Libya	[194]
Matricaria chmomilla L.	Asteraceae	Flower	MeOH	DPPH	91.69% at 50 μg/mL	Sudan	[188]
Matricaria recutita L.	Asteraceae	Flower	H_2O	DPPH/ABTS	0.67/5.97%	Morocco	[206]
Melia azedarach L.	Meliaceae	Leaf	$CHCl_3$/MeOH	DPPH	2/32 at 50 μg/mL	Egypt	[42]
Melilotus officinalis Pall.	Fabaceae	Aerial parts	MeOH	DPPH	>100 μg/mL	Egypt	[192]
Mentha pulegium L.	Lamiaceae	Leaf	EtOH	DPPH/ABTS	42.7/30.2	Algeria	[219]
Mentha pulegium L.	Lamiaceae	Leaf	EtOAc	DPPH	1.7 μg/mL	Algeria	[220]
Mentha rotundifolia Sole.	Lamiaceae	Leaf	EtOH	DPPH/ABTS	71.3/40.4 μg/mL	Algeria	[219]
Mentha spicata Crantz.	Lamiaceae	Leaf	EtOH	DPPH/ABTS	16. 2/10.3 μg/mL	Algeria	[219]
Moricandia nitens L.	Cruciferae	Whole plant	EtOH/H_2O	DPPH	89/85% at 100 μg/mL	Egypt	[41]
Moringa pterygosperma Gaertn.	Moringaceae	Leaf	$CHCl_3$/MeOH	DPPH	15/30 at 50 μg/mL	Egypt	[42]
Morus alba L.	Moraceae	Leaf	$CHCl_3$/MeOH	DPPH	14/40 at 50 μg/mL	Egypt	[42]
Myoporum pictum Banks & Sol. Ex G. Forst.	Myoporaceae	Leaf	$CHCl_3$/MeOH	DPPH	42.7/26 at 50 μg/mL	Egypt	[42]
Myrtus communis Blanco.	Myrtaceae	Leaf	H_2O	DPPH	19.04 mmol TEAC/g	Libya	[194]
Myrtus Communis Blanco.	Myrtaceae	Leaf	$CHCl_3$/MeOH	DPPH	26.6/90 at 50 μg/mL	Egypt	[42]
Myrtus communis L.	Myrtaceae	Aerial parts	Oil	DPPH	6018 μg/mL	Algeria	[221]
Narcissus tazetta L.	Oleaceae	Leaf	$CHCl_3$/MeOH	DPPH	22/40 at 50 μg/mL	Egypt	[42]
Nephrlepis bostoniensis L.	Polypodiaceae	Leaf	$CHCl_3$/MeOH	DPPH	16/43 at 50 μg/mL	Egypt	[42]
Nerium oleander L.	Apocyanaceae	Leaf	H_2O	DPPH	3.15 mmol TEAC/g	Libya	[194]
Nerium oleander L.	Apocynaceae	Leaf	$CHCl_3$/MeOH	DPPH	19/31 at 50 μg/mL	Egypt	[42]
Nerium oleander L.	Apocynaceae	Leaf	MeOH	DPPH	64.5 μg/mL	Egypt	[192]
Nicotiana glauca L.	Solanaceae	Leaf	EtOH/MeOH/H_2O	DPPH	54/13/30 μg/mL	Sudan	[193]
Nigella sativa L.	Ranunculaceae	Not stated	EtOH	SORSA	<50 at 1 μg/mL	Sudan	[45]
Nigella sativa L.	Ranunculaceae	Seed	EtOH	DPPH	60%	Sudan	[222]
Nigella sativa L.	Ranunculaceae	Seed	MeOH	DPPH	>100 μg/mL	Egypt	[192]
Nigella sativa L.	Ranunculaceae	Seed	Oil	DPPH	85%	Sudan	[200]
Ocimum basilicum L.	Lamiaceae	Bark	EtOH	SORSA	66% at 1 μg/mL	Sudan	[45]
Ocimum basilicum L.	Lamiaceae	Seed	EtOH/H_2O	DPPH	72/9.8% at 100 μg/mL	Egypt	[41]
Ocimum basillcum L.	Lamiaceae	Leaf	Cold H_2O/hot H_2O/MeOH	DPPH	0.21/53.0/0.19 mg/mL	Egypt	[202]
Olea europaea (Wall. Ex G. Don) Cif.	Oleaceae	Whole plant	EtOH/H_2O	DPPH	50/81% at 100 μg/mL	Egypt	[41]
Olen europaea (Wall. Ex G. Don) Cif.	Oleaceae	Leaf	H_2O	DPPH	8.08 mmol TEAC/g	Libya	[194]
Origanum glandulosum Salzm.	Lamiaceae	Aerial parts	MeOH	DPPH	12.80 μg/mL	Algeria	[193]
Origanum majorana L.	Lamiaceae	Leaf	H_2O	DPPH	0.859 mmol TEAC/g	Libya	[194]
Origanum syriacum L.	Lamiaceae	Leaf	EtOH	DPPH/TBA	55.7/25.39	Egypt	[190]
Panax quinquefolius L.	Araliaceae	Seed	EtOH/H_2O	DPPH	11/56% at 100 μg/mL	Egypt	[41]
Parkinsonia aculeata L.	Loganiaceae	Leaf	$CHCl_3$/MeOH	DPPH	17/9 at 50 μg/mL	Egypt	[42]

Table 2 Antioxidants activities of Northern Africa African plants *(Continued)*

Peganum harmala L.	Zygophyllaceae	Not stated	EtOH	SORSA	<50 at 1 μg/mL	Sudan	[45]
Peganum harmala L.	Zygophyllaceae	Seed	MeOH	DPPH	>100 μg/mL	Egypt	[192]
Peganum harmala L.	Zygophyllaceae	Seed	MeOH	H_2O_2	3.33 mg/mL	Algeria	[223]
Peganum harmala L.	Zygophyllaceae	Seed	MeOH/H_2O	DPPH	0.194/1.345 mg/mL	Algeria	[224]
Pelargonium oderatissimum L.	Geraniaceae	Leaf	$CHCl_3$/MeOH	DPPH	9/89 at 50 μg/mL	Egypt	[42]
Pelargonium zonale L Her.	Geraniaceae	Leaf	$CHCl_3$/MeOH	DPPH	12/32 at 50 μg/mL	Egypt	[42]
Phagnalon rupestre Dc.	Compositae	Leaf	H_2O	DPPH	3.88 mmol TEAC/g	Libya	[194]
Phalangium variegate L.	Liliaceae	Leaf	$CHCl_3$/MeOH	DPPH	3/17 at 50 μg/mL	Egypt	[42]
Phoenix dactylifera L.	Palmaceae	Whole plant	EtOH/H_2O	DPPH	83/77% at 100 μg/mL	Egypt	[41]
Pinus halipensis Miller.	Pinaceae	Leaf	MeOH	DPPH	115.50 μg/mL	Algeria	[193]
Piper nigrum Wall.	Piperaceae	Seed	MeOH	DPPH	>100 μg/mL	Egypt	[192]
Pistacia atlantica Desf.	Anacardiaceae	Gall	Oil	DPPH/ABTS/FRAP	417.61/495.6/0.115 μg/mL	Algeria	[225]
Pistacia lentiscus L.	Anacardiaceae	Leaf	EtOAc	DPPH/OH	6.8/8.2 μg/mL.	Algeria	[226]
Pistacia lentiscus L.	Anacardiaceae	Leaf	MeOH	DPPH	4.30 μg/mL	Algeria	[193]
Pithecellobium dulce Benth.	Fabaceae	Leaf	$CHCl_3$/MeOH	DPPH	11/23 at 50 μg/mL	Egypt	[42]
Pittosporum tobira (Thunb.) W.T. Alton.	Pittosporaceae	Leaf	$CHCl_3$/MeOH	DPPH	11/9 at 50 μg/mL	Egypt	[42]
Pituranthos tortousus (Coss.) Maire.	Apiaceae	Leaf	H_2O	DPPH	0.46 mmol TEAC/g	Libya	[194]
Pituranthos tortusous (Coss.) Maire.	Umbelliferae	Whole plant	EtOH/H_2O	DPPH	58/81% at 100 μg/mL	Egypt	[41]
Plantago major Elliot.	Plantaginaceae	Aerial parts	MeOH	DPPH	48.00 μg/mL	Algeria	[193]
Plumeria alba L.	Apocynaceae	Leaf	$CHCl_3$/MeOH	DPPH	28/15 at 50 μg/mL	Egypt	[42]
Poinciana regia Bojer.	Caesalpiniaceae	Leaf	$CHCl_3$/MeOH	DPPH	15/15 at 50 μg/mL	Egypt	[42]
Polianthes tuberose L.	Agavaceae	Leaf	$CHCl_3$/MeOH	DPPH	8/12 at 50 μg/mL	Egypt	[42]
Populus tremula L.	Salicaceae	Leaf	MeOH	DPPH	88.70 μg/mL	Algeria	[193]
Psidium guajava L.	Myrtaceae	Leaf	EtOH/H_2O	DPPH	97/88% at 100 μg/mL	Egypt	[41]
Punica granatum L.	Punicaceae	Leaf	$CHCl_3$/MeOH	DPPH	9/96 at 50 μg/mL	Egypt	[42]
Punica granatum L.	Punicaceaea	Fruit	EtOH/H_2O	DPPH	85/75% at 100 μg/mL	Egypt	[41]
Quercus Coccifera L.	Fagaceae	Leaf	MeOH	DPPH	18.65 μg/mL	Algeria	[198]
Quercus robur L.	Fagaceae	Leaf	H_2O	DPPH	20.63 mmol TEAC/g	Libya	[194]
Raphanus raphanistrum L.	Cruciferae	Leaf	H_2O	DPPH	0.47 mmol TEAC/g	Libya	[194]
Retama raetam Webb & Berthel.	Leguminosae	Whole plant	EtOH/H_2O	DPPH	80/78% at 100 μg/mL	Egypt	[41]
Retama raetem Webb & Berthel.	Fabaceae	Leaf	MeOH	DPPH	40 μg/mL	Libya	Alghazeer et al., 2012
Rhamnus alaternus L.	Rhamnaceae	Leaf	MeOH	DPPH	54.16 μg/mL	Algeria	[193]
Rhamnus alaternus L.	Rhamnaceae	Leaf	MeOH	DPPH	40.7 μg/mL	Algeria	[198]
Rheum palmaum	Polygonaceae	Stem	MeOH	DPPH	14.2 μg/mL	Egypt	[192]
Ricinus communis L.	Euphorbiaceae	Leaf	MeOH	DPPH	90.57% at 50 μg/mL	Sudan	[188]
Ricinus communis L.	Euphorbiaceae	Seed	Oil	DPPH	51%	Sudan	[200]
Rosa banksiae R. Br.	Rosaceae	Leaf	$CHCl_3$/MeOH	DPPH	25/42 at 50 μg/mL	Egypt	[42]
Rosmarinus officinalis L.	Lamiaceae	Leaf	EtOH	DPPH	+	Algeria	[227]
Rosmarinus officinalis L.	Lamiaceae	Leaf	H_2O	DPPH	0.51 mmol TEAC/g	Libya	[194]

Table 2 Antioxidants activities of Northern Africa African plants *(Continued)*

Rosmarinus officinalis L.	Lamiaceae	Leaf	$CHCl_3$/MeOH	DPPH	28.6/31 at 50 μg/mL	Egypt	[42]
Rosmarinus officinalis L.	Lamiaceae	Leaf	EtOH	DPPH/TBA	69.73/70.6 at 100 μg/mL	Egypt	[190]
Rosmarinus officinalis L.	Lamiaceae	Whole plant	EtOH/H_2O	DPPH	38/65% at 100 μg/mL	Egypt	[41]
Rosmarinus officinalis L.	Lamiaceae	Aerial parts	MeOH	DPPH	19.4 μg/mL	Egypt	[192]
Rubus idaeus Thunb.	Rosaceae	Leaf	EtOAc	DPPH	4.80 μg/mL	Algeria	[228]
Ruscus hyphoglossum L.	Liliaceae	Leaf	$CHCl_3$/MeOH	DPPH	0/42 at 50 μg/mL	Egypt	[42]
Russelia juncea Zucc.	Scrophulariaceae	Leaf	$CHCl_3$/MeOH	DPPH	17/30 at 50 μg/mL	Egypt	[42]
Ruta graveolens L.	Rutaceae	Leaf	H_2O	DPPH	0.60 mmol TEAC/g	Libya	[194]
Ruta graveolens L.	Rutaceae	Leaf	MeOH	DPPH	61 μg/mL	Egypt	[192]
Salix alba Thunb.	Salicaceae	Cortex	MeOH	DPPH	15.50 μg/mL	Algeria	[193]
Salvia officinalis L.	Lamiaceae	Leaf	H_2O	DPPH	0.81 mmol TEAC/g	Libya	[194]
Salvia officinalis L.	Lamiaceae	Leaf	$CHCl_3$/MeOH	DPPH	45/49 at 50 μg/mL	Egypt	[42]
Salvia officinalis L.	Lamiaceae	Leaf	Oil	DPPH, ABTS/H_2O_2	-	Algeria	[217]
Salvia triloba L.	Lamiaceae	Aerial Parts	MeOH	DPPH	20.7 μg/mL	Egypt	[192]
Sanseviera guineenses Thunb.	Liliaceae	Leaf	$CHCl_3$/MeOH	DPPH	23.5/18 at 50 μg/mL	Egypt	[42]
Santolina chamaecyparissus L.	Asteraceae	Leaf	H_2O/MeOH	β-CLAM	64%/61% at 50 μg/mL	Algeria	[229]
Santolina chamaecyparissus L.	Asteraceae	Leaf	$CHCl_3$/MeOH	DPPH	11/46 at 50 μg/mL	Egypt	[42]
Satureja thymbra L.	Lamiaceae	Leaf	Oil	DPPH	0.0967 mg/mL	Libya	[230]
Schefflera actinophylla Harms.	Araliaceae	Leaf	$CHCl_3$/MeOH	DPPH	3/94 at 50 μg/mL	Egypt	[42]
Schefflera arboricola Hayata.	Araliaceae	Leaf	$CHCl_3$/MeOH	DPPH	2/0 at 50 μg/mL	Egypt	[42]
Schinus terebentifolius Raddi.	Anacardiaceae	Leaf	$CHCl_3$/MeOH	DPPH	15/12 at 50 μg/mL	Egypt	[42]
Sciadophyllum pulchrima L.	Araliaceae	Leaf	$CHCl_3$/MeOH	DPPH	1.5/18 at 50 μg/mL	Egypt	[42]
Sesamum indicum L.	Pedaliaceae	Seed	Oil	DPPH	34%	Sudan	[200]
Sesbania aegyptiaca Pers.	Fabaceae	Leaf	$CHCl_3$/MeOH	DPPH	17/43 at 50 μg/mL	Egypt	[42]
Solanum lycopersicum L.	Solanaceae	Bark	EtOH/H_2O	DPPH	82/82% at 100 μg/mL	Egypt	[41]
Solanum nigrum L.	Solanaceae	Whole plant	EtOH/H_2O	DPPH	85/55% at 100 μg/mL	Egypt	[41]
Solanum rantonnetii Carriere.	Solanaceae	Leaf	MeOH	DPPH/ABTS	162/239 μg/mL	Egypt	[201]
Solenostemma argel Hayne.	Apocyanaceae	Leaf	Cold H_2O/hot H_2O/MeOH	DPPH	0.61/33.3/0.43 mg/mL	Egypt	[202]
Sonchus oleraceus L.	Asteraceae	Leaf	EtOH	SORSA	56 at 1 μg/mL	Sudan	[45]
Spathodea tilotica P.Beauv.	Bignoniaceae	Leaf	$CHCl_3$/MeOH	DPPH	19/85 at 50 μg/mL	Egypt	[42]
Sterculia diversifolia L.	Sterculiaceae	Leaf	$CHCl_3$/MeOH	DPPH	14/88 at 50 μg/mL	Egypt	[42]
Strelitzia reginae Banks.	Streliziaceae	Leaf	$CHCl_3$/MeOH	DPPH	32/45 at 50 μg/mL	Egypt	[42]
Striga hermonthica Delile.	Orobanchaceae	Whole plant	MeOH	RSA/Iron chelating	29/23%	Sudan	[208]
Sysimbrium officinalis (L.) Scop.	Brassicaceae	Flower	MeOH	DPPH	145.0 μg/mL	Algeria	[193]
Syzgium aromaticum (L.) Merrill & Perry.	Myrtaceae	Leaf	H_2O	DPPH	20.49 mmol TEAC/g	Libya	[194]
Syzygium aromaticum (L.) Merrill & Perry.	Myrtaceae	Pud	MeOH	DPPH	15.9 μg/mL	Egypt	[192]
Tabernaemontana divaricata G. Don.	Apocynaceae	Leaf	$CHCl_3$/MeOH	DPPH	40/44 at 50 μg/mL	Egypt	[42]
Tecoma capensis Lindl.	Bignoniaceae	Leaf	$CHCl_3$/MeOH	DPPH	0/55 at 50 μg/mL	Egypt	[42]

Table 2 Antioxidants activities of Northern Africa African plants *(Continued)*

Tecomaria capensis Thunb.	Bignoniaceae	Leaf	$CHCl_3$/MeOH	DPPH	9/90 at 50 μg/mL	Egypt	[42]
Tephrosia apollinea Klotzsch.	Papilionaceae	-	EtOH	SORSA	<50 at 1 μg/mL	Sudan	[45]
Tephrosia apollinea Klotzsch.	Leguminosae	Aerial parts	n-C_6H_{12}/EtOH/ MeOH/H_2O	DPPH	>1000/120/48/ 2835 μg/mL	Sudan	[45]
Terminalia arjuna Roxb.ex DC.	Combretaceae	Leaf	$CHCl_3$/MeOH	DPPH	27/42 at 50 μg/mL	Egypt	[42]
Terminalia arjuna Roxb.ex DC.	Combretaceae	Fruit	MeOH	DPPH	3.1 μg/mL	Egypt	[192]
Terminalia chebula Retz.	Combretaceae	Fruit	MeOH	DPPH	2.2 μg/mL	Egypt	[192]
Teucrium polium Decne. ex C. Presl.	Lamiaceae	Aerial parts	MeOH	DPPH	30.20 μg/mL	Algeria	[193]
Teucrium polium Decne. ex C. Presl.	Lamiaceae	Aerial parts	MeOH	DPPH	96.4 μg/mL	Egypt	[192]
Teucrium polium Decne.ex C. Presl.	Lamiaceae	Leaf	H_2O	DPPH	0.22 mmol TEAC/g	Libya	[194]
Thapsia garganica L.	Apiaceae	Root/Leaf/ Flower	MeOH	DPPH	9.98/10.08/ 19.32 mg/100 mL	Algeria	Yasmine et al., 2012
Thapsia garganica L.	Apiaceae	Leaf	MeOH	DPPH	50 μg/mL	Libya	Alghazeer et al., 2012
Thapsia garganica L.	Apiaceae	Leaf	MeOH/EtOH	DPPH	91.92% 79.60%	Algeria.	[231]
Thevetia narifolia L.	Apocynaceae	Leaf	$CHCl_3$/MeOH	DPPH	26/29 at 50 μg/mL	Egypt	[42]
Thuja orientalis L.	Cupressaceae	Leaf	$CHCl_3$/MeOH	DPPH	0/71 at 50 μg/mL	Egypt	[42]
Thymelaea hirsute Mill.	Thymelaeaceae	Whole plant	EtOH/H_2O	DPPH	76/35% at 100 μg/ mL	Egypt	[41]
Thymelaea microphylla Coss & Durieu.	Thymelaceae	Leaf	EtOH	DPPH	77.86%	Algeria	[224]
Thymus vulgaris M. Bieb.	Lamiaceae	Leaf	H_2O	DPPH	0.949 mmol TEAC/ g	Libya	[194]
Thymus vulgaris M. Bieb.	Lamiaceae	Leaf	EtOH	DPPH/TBA	96.85/70.8 at 100 μg/mL	Egypt	[190]
Tinospora bakis Miers.	Menispermaceae	Leaf	EtOH	SORSA	54% at 1 μg/mL	Sudan	[45]
Tradescantea spp	Commelinaceae	Leaf	$CHCl_3$/MeOH	DPPH	44/0 at 50 μg/mL	Egypt	[42]
Tradescantea zebrine (Schinz) D.R. Hunt.	Commelinaceae	Leaf	$CHCl_3$/MeOH	DPPH	1/16 at 50 μg/mL	Egypt	[42]
Trigonella foenum-graecum Suter.	Fabaceae	Seed	H_2O	DPPH/ABTS	9.23/13.27%	Morocco	[206]
Trigonella foenum-graecum Suter.	Fabaceae	Seed	MeOH	DPPH	90.94% at 50 μg/ mL	Sudan	[188]
Trigonella foenum-graecum Suter.	Fabaceae	Seed	MeOH	DPPH	37.32 μML	Sudan	[189]
Ulmus campestris L.	Ulmaceae	Leaf	MeOH	DPPH	61.50 μg/mL	Algeria	[193]
Urginea maritima (L.) Stearn.	Liliaceae	Leaf	H_2O	DPPH	0.72 mmol TEAC/g	Libya	[194]
Urtica urens L.	Urticaceae	Leaf	H_2O	DPPH	0.36 mmol TEAC/g	Libya	[194]
Vernonia amygdalina Delile.	Asteraceae	-	EtOH	SORSA	<50 at 1 μg/mL	Sudan	[45]
Vinca rossea (L.) G. Don.	Apocynaceae	Leaf	$CHCl_3$/MeOH	DPPH	9/48 at 50 μg/mL	Egypt	[42]
Vitex trifolia L.	Verbenaceae	Leaf	$CHCl_3$/MeOH	DPPH	22/89 at 50 μg/mL	Egypt	[42]
Vitis vinifera L.	Vitaceae	Whole plant	EtOH/H_2O	DPPH	90/85% at 100 μg/ mL	Egypt	[41]
Xanthium brasilicum Vell.	Asteraceae	-	EtOH	SORSA	<50 at 1 μg/mL	Sudan	[45]
Ximenia Americana L.	Olacaceae	-	EtOH	SORSA	<50 at 1 μg/mL	Sudan	[45]
Yucca desmetiana Baker.	Agavaceae	Leaf	$CHCl_3$/MeOH	DPPH	3/6 at 50 μg/mL	Egypt	[42]
Zingiber officinale Roscoe.	Zingiberceae	Leaf	H_2O	DPPH	1.08 mmol TEAC/g	Libya	[194]

Table 2 Antioxidants activities of Northern Africa African plants *(Continued)*

Zingiber officinale Roscoe.	Zingiberaceae	Rhizome	MeOH	DPPH	>100 μg/mL	Egypt	[192]
Ziziphus spina-christi Georgi.	Rhamnaceae	Leaf	MeOH	DPPH	91.13% at 50 μg/mL	Sudan	[188]
Zygophulum simplex L.	Zygophyllaceae	Whole plant	EtOH/H_2O	DPPH	85/44% at 100 μg/mL	Egypt	[41]
Zygophyllum album L.	Zygophyllaceae	Aerial parts	Oil	DPPH	615 μg/mL	Algeria	[221]
Zygophyllum album L.	Zygophyllaceae	Whole plant	EtOH/H_2O	DPPH	80/64% at 100 μg/mL	Egypt	[41]
Zygophyllum coccineum L	Zygophyllaceae	Leaf	n-C_6H_{12}	DPPH	10.80 ± 0.3%	Egypt	[232]

Key: RSA: Radical scavenging activity; RC: Reducing power capacity; OH: Hydroxyl ion; NO: Nitric oxide radical inhibition; H_2O_2: Hydrogen peroxide inhibition activity; LPO: Lipid peroxidation inhibition activity; $ABTS^+$: 2,2′-azinobis-3–ethylbenzothiozolin-6–sulfonic acid cation decolourization test; ß-CLAMS: ß-Carotene-linoleic acid model system; SORSA: Superoxide anion radical scavenging activity (SORSA);MLP: Microsomal lipid peroxydation; FRAP: Fe^{2+} chelating ability and ferric reducing antioxidant properties; DPPH: 1,1–dipheyl-2–picry-hydrazyl; ORAC: Oxygen radical absorbance capacity; TEAC: Trolox equivalent antioxidant capacity;MeOH: Methanol; CH_2Cl_2: Dichloromethane; EtOH: Ethanol; EtOAc: Ethyl acetate; n-C_6H_{12}: Hexane; $(CH_3)_2CO$: Acetone; H_2O: Aqueous; BtOH: Butanol

Northern Africa, 30.97% from Western Africa, 17.98% from Central Africa, 13.98% from Southern Africa, and 5.72% from Eastern Africa (Fig 2). Tables 1, 2, 3, 4, 5 and 6 gives a summary of the plant species that were tested, the family these plants belong to, the parts of the plants that were used to prepare the test samples, the solvent used for the extraction procedure and their potencies in different units depending on the protocol used. The plants that have been extensively studied with regard to these activities belonged to the following families; Fababceae (6.34%), Asteraceae (6.34%), Lamiaceae (5.13%), Moraceae (4.30%), Euphorbiaceae (2.41%), Combretaceae (2.19%), and Malvaceae (1.81%) (Fig. 3). The structures of the compounds isolated from some of the plants with antioxidant activities are presented in (Fig. 4, Additional file 1). The plant parts that were tested for activities included the leaves, stems and stem bark, roots and root bark, pods, flowers and other aerial parts.

A number of procedures have been developed for assessment of in vitro antioxidant potencies of natural products. These protocols are based on two major chemical reactions including; hydrogen atom and electron transfer reactions. To determine the antioxidant potencies of the extracts and compounds using the hydrogen atom transfer mechanisms, one of the following parameters are measured; oxygen radical absorbance capacity (ORAC), total radical antioxidant power (TRAP) and beta carotene bleaching potential. The second category involves electron transfer reactions that measures the following parameters; ferric reducing antioxidant power (FRAP), diphenyl-2–picryl-hydrazyl radical scavenging assay (DPPH), trolox equivalent antioxidant capacity (TEAC), hydroxyl radical scavenging assay, superoxide anion radical scavenging assay, nitric oxide radical scavenging assay and total phenol assay [28]. Despite the recent popularity in antioxidant research, lack of standardized assays to compare research results from different research groups has been a major challenge [29].

The antioxidant potencies of natural products reviewed in this study were categorized based on the degree of inhibitions of free radicals when tested using one or more of the procedures discussed above. In order to increase the reliability of the antioxidant results more than one protocols were used. However, in accordance with the criteria for evaluation of in vitro antioxidant activities of natural products [23, 30, 31], in this report we propose the following cutoff points;

(1) Extracts and compounds are considered to have high or significant capacity ($IC_{50} < 10$ μg/mL for extract and $IC_{50} < 1$ μg/mL for compounds), promising activity (IC_{50} = 10–50 μg/mL for extract and IC_{50} = 5–10 μg/mL for compounds), moderate activity (IC_{50} = 50–100 μg/mL for extract and IC_{50} = 5–10 μg/mL for compounds), while sample with $IC_{50} > 100$ μg/mL for extract and > 10 μg/mL for compounds were considered to have low antioxidant capacity.
(2) Antioxidants activities of plant extracts are considered to be very high when FRAP was > 20 mM/L, high when FRAP was 10–20 mM/L, good when FRAP was 5–10 mM/L, low when FRAP was 1–5 mM/L and very low when FRAP was below 1 mM/L.
(3) When dealing with radical scavenging activity at a constant concentrat ion. Plant extracts were considered to exhibit low, medium, high and significant activities when their % RSA at 50 mg/mL were observed to be < 25%, 25–50%, 50–80% and > 80%, respectively.
(4) When dealing with DPPH radical scavenging activities on the basis of degree of color changes extracts are considered to have high or significant capacity when showed strong intensity of yellow coloration, moderate when showed moderate intensity of yellow colouration, and low capacity when showed moderate intensity of yellow colouration

Table 3 Antioxidants activities of Southern AfricaAfrican plants

Plants	Family	Part used	Solvents	Assay Methods	Inhibition/EC_{50}	Country of origine	References
Acacia galpinii Butt Davy.	Fabaceae	Bark	EtOH	DPPH	16.05 μg/mL	South Africa	[46]
Acokanthera oppositifolia Lan.	Apocynaceae	Stem	MeOH	ABTS/DPPH	99.0% at 0.08 mg/mL and 70% at 1 mg/mL	South Africa	[233]
Adenia gummifera Harms.	Passifloraceae	Root	EtOAc	AChE	0.0189 mg/mL	South Africa	[234]
Adenia gummifera Harms.	Passifloraceae	Stem	MeOH	ABTS/DPPH	94.2 at 0.08 mg/mL and 60% at 1 mg/mL	South Africa	[233]
Aloe arborescens Mill.	Xanthorrhoeaceae	Leaf	EtOH	DPPH	-	South Africa	[46]
Aloe barbadensis Mill.	Xanthorrhoeaceae	Leaf	EtOH	DPPH	-	South Africa	[46]
Aloe ferox Mill.	Xanthorrhoeaceae	Leaf	EtOH	DPPH	-	South Africa	[46]
Aloe ferox Mill.	Asphodelaceae	Leaf	EtOH/ $(CH_3)_2CO$/ MeOH/H_2O	DPPH	0.086/0.288/0.288/ 0.517 mg/mL.	South Africa	[235]
Bauhinia bowkeri Harv.	Fabaceae	Leaf	n-C_6H_{12}/CH_2Cl_2	DPPH.	11.147/5.21 μg/mL	South Africa	[236]
Bauhinia galpinii N. E. Br.	Fabaceae	Leaf	n-C_6H_{12}/CH_2Cl_2	DPPH	79.58/9.92 μg/mL	South Africa	[236]
Bauhinia petersiana Bolle.	Fabaceae	Leaf	n-C_6H_{12}/CH_2Cl_2	DPPH	47.45/8.18 μg/mL	South Africa	[236]
Bauhinia variegata Linn.	Fabaceae	Leaf	n-C_6H_{12}/CH_2Cl_2	DPPH	97.02/8.40 μg/mL	South Africa	[236]
Heteromorpha trifoliate (Spreng.) Cham & Schltdl.	Apiaceae	Leaf	$CO(CH_3)_2$	DPPH	4.35 mg/mL	South Africa	[237]
Indigofera frutescens L.	Papilionaceae	Leaf	$CO(CH_3)_2$	DPPH	0 mg/mL	South Africa	[237]
Zanthoxylum capense (Thunb) Harv.	Rutaceae	Leaf	$CO(CH_3)_2$	DPPH	4.0 mg/mL	South Africa	[237]
Milletia grandis (E.Mey.) Skeels.	Papilionaceae	Leaf	CO $(CH_3)_2$	DPPH	4.6 mg/mL	South Africa	[237]
Brachylaena discolor DC.	Asteraceae	Leaf	CO $(CH_3)_2$	DPPH	2.6 mg/mL	South Africa	[237]
Clerodendrum glabrum E. Mey.	Lamiaceae	Leaf	CO $(CH_3)_2$	DPPH	3.5 mg/mL	South Africa	[237]
Strychnos mitis S. Moore.	Strychnaceae	Leaf	CO $(CH_3)_2$	DPPH	3.5 mg/mL	South Africa	[237]
Cyathea dregei Kunze.	Cyatheaceae	Leaf	CO $(CH_3)_2$	DPPH	3.0 mg/mL	South Africa	[237]
Apodytes dimidiate E. Mey. ex Arn.	Icacinaceae	Leaf	CO $(CH_3)_2$	DPPH	3.5 mg/mL	South Africa	[237]
Melia azedarach L.	Meliaceae	Leaf	CO $(CH_3)_2$	DPPH	3.3 mg/mL	South Africa	[237]
Clausena anisata (Wild.) Hook.f. ex Benth.	Rutaceae	Leaf	CO $(CH_3)_2$	DPPH	2.5 mg/mL	South Africa	[237]
Maesa lanceolata Forssk.	Maesaceae	Leaf	CO $(CH_3)_2$	DPPH	1.4 mg/mL	South Africa	[237]
Leucosidea sericea Eckl. & Zeyh.	Rosaceae	Leaf	CO $(CH_3)_2$	DPPH	0.0 mg/mL	South Africa	[237]
Viscum album L.	Viscaceae	Leaf	MeOH	$Fe2^+$	10 mg/mL	Nigeria	[238]
Ficus capreifolia Delile.	Moraceae	Leaf	CO $(CH_3)_2$	ABTS	0.34 TEAC	South Africa	[239]

Table 3 Antioxidants activities of Southern AfricaAfrican plants *(Continued)*

Ficus cordata Thunb.	Moraceae	Leaf	CO $(CH_3)_2$	ABTS	0.27 TEAC	South Africa	[239]
Ficus craterostoma Mildbr. & Burret.	Moraceae	Leaf	CO $(CH_3)_2$	ABTS	0.66 TEAC	South Africa	[239]
Ficus glumosa Delile	Moraceae	Leaf	CO $(CH_3)_2$	ABTS	1.29 TEAC	South Africa	[239]
Ficus lutea Vahl.	Moraceae	Leaf	CO $(CH_3)_2$	ABTS	4.80 TEAC	South Africa	[239]
Ficus natalensis Hochst.	Moraceae	Leaf	CO $(CH_3)_2$	ABTS	0.69 TEAC	South Africa	[239]
Ficus polita Vahl.	Moraceae	Leaf	CO $(CH_3)_2$	ABTS	0.31 TEAC	South Africa	[239]
Ficus religiosa L.	Moraceae	Leaf	CO $(CH_3)_2$	ABTS	0.59 TEAC	South Africa	[239]
Ficus sycomorus L.	Moraceae	Leaf	CO $(CH_3)_2$	ABTS	1.91 TEAC	South Africa	[239]
Ficus thonningii Blume	Moraceae	Leaf	CO $(CH_3)_2$	ABTS	0.77 TEAC	South Africa	[239]
Peltophorum africanum Sond.	Fabaceae	Leaf	CO $(CH_3)_2$	DPPH	4.67 μg/mL	South Africa	[240]
Zanthoxylum capense (Thunb.) Harv.	Rutaceae	Leaf	CO $(CH_3)_2$	DPPH	138.78 μg/mL	South Africa	[240]
Clausena anisata (Wild.) Hook.f. ex Benth.	Rutaceae	Leaf	CO $(CH_3)_2$	DPPH	119.36 μg/mL	South Africa	[240]
Sutherlandia frutescens (L.) R. Br.	Fabaceae	Leaf	EtOH	DPPH	+++	South Africa	[241]
Senna italic Mill.	Fabaceae	Root	MeOH	DPPH	++	South Africa	[242]
Combretum vendee	Combretecacea	Leaf	MeOH	DPPH	+	South Africa	[243]
Rhoicissus tridentate Wild & Drum	Vitaceae	Leaf	CO $(CH_3)_2$	DPPH	2.5 TEAC	South Africa	[244]
Baphia racemosa (Hochst) Baker.	Fabaceae	Leaf	CO $(CH_3)_2$	DPPH/ABTS	210.69/195.10 μg/mL	South Africa	[245]
Crotalaria capensis Jacq.	Fabaceae	Leaf	CO $(CH_3)_2$	DPPH/ABTS	195.26/207.09 μg/mL	South Africa	[245]
Erythrina caffra Thunb.	Fabaceae	Leaf	CO $(CH_3)_2$	DPPH/ABTS	268.6/173.28 μg/mL	South Africa	[245]
Lonchocarpus nelsii (Schinz) Heering & Grimme.	Fabaceae	Leaf	CO $(CH_3)_2$	DPPH/ABTS	247.70/134.64 μg/mL	South Africa	[245]
Virgilia divaricata Adamson.	Fabaceae	Leaf	CO $(CH_3)_2$	DPPH/ABTS	271.58/150.57 μg/mL	South Africa	[245]
Indigofera cylindrical L.	Fabaceae	Leaf	CO $(CH_3)_2$	DPPH/ABTS	22.31/41.39 μg/mL	South Africa	[245]
Xylia torreana Brenan.	Fabaceae	Leaf	CO $(CH_3)_2$	DPPH/ABTS	16.90/14.56 μg/mL	South Africa	[245]
Podalyria calyptrata (Retz.) Willd.	Fabaceae	Leaf	CO $(CH_3)_2$	DPPH/ABTS	35.21/36.66 μg/mL	South Africa	[245]
Dalbergia nitidula Baker.	Fabaceae	Leaf	CO $(CH_3)_2$	DPPH/ABTS	9.31/21.30 μg/mL	South Africa	[245]
Maytenus peduncularis (Sond) Loes.	Celastraceae	Leaf	CO $(CH_3)_2$; n-C_6H_{12}	DPPH/ ABTS/OH	1.88/8.65/23.92 μg/mL	South Africa	[246]
Maytenus procumbens (L.f.) Loes.	Celastraceae	Leaf	CO $(CH_3)_2$; n-C_6H_{12}	DPPH/ ABTS/OH	3.56/4.03/107.69 μg/mL	South Africa	[246]

Table 3 Antioxidants activities of Southern AfricaAfrican plants *(Continued)*

Maytenus senegalensis (Lam.) Exell.	Celastraceae	Leaf	CO $(CH_3)_2$; n-C_6H_{12}	DPPH/ ABTS/OH	6.71/5.34/146.30 μg/mL	South Africa	[246]
Maytenus undata (Thunb)	Celastraceae	Leaf	CO $(CH_3)_2$; n-C_6H_{12}	DPPH/ ABTS/OH	3.89/7.89/80.68 μg/mL	South Africa	[246]
Eriosema robustum Baker.	Fabaceae	Twig	EtOH	DPPH	1.84 mg/mL	South Africa	[247]
Mormodica balsamina L.	Cucurbitaleae	Aerial parts	CO $(CH_3)_2$	DPPH	200 μg/mL	South Africa	[248]
Senna italica Mill.	Fabaceae	Aerial parts	CO $(CH_3)_2$	DPPH	120 μg/mL	South Africa	[248]
Cassia abbreviata Oliv.	Fabaceae	Stem bark	CO $(CH_3)_2$	DPPH	<7.8 μg/mL	South Africa	[248]
Waltheria indica L.	Malvaceae	Aerial parts	CO $(CH_3)_2$	DPPH	80 μg/mL	South Africa	[248]
Tinospora fragosa (I. Verd.) I. Verd & Troupin	Menispermaceae	Aerial parts	CO $(CH_3)_2$	DPPH	430 μg/mL	South Africa	[248]
Gymnospora buxifolia (Eckl. & Zeyl.) Loes.	Celastraceae	Aerial parts	CO $(CH_3)_2$	DPPH	40 μg/mL	South Africa	[248]
Combretum apiculatum Sond.	Combretaceae	Leaf	EtOAc/BtOH	DPPH	3.91/2.44 μg/mL	South Africa	[249]
Aloe sessiliflora Pole-Evams.	Xanthorrhoeaceae	Leaf	EtOH	DPPH	-	South Africa	[46]
Amaranthus asper	Amaranthaceae	Leaf	$(CH_3)_2CO$/ MeOH/H_2O	DPPH/ABTS	72.5, 53.5 and 46.0%/96.5, 61.8 and 79.1% at 0.05 mg/mL	South Africa	[250]
Amaranthus dubius Mart. ex Thell.	Amaranthaceae	Leaf	MeOH	DPPH/ABTS	App 50/75%	South Africa	[48]
Amaranthus spinosus L.	Amaranthaceae	Leaf	MeOH	DPPH/ABTS	0.16 mmol TEAC/g	South Africa	[47]
Anchusa capensis Thunb.	Boraginacee	Leaf	EtOH	DPPH	-	South Africa	[46]
Annona senegalensis Pers.	Annonaceae	Bark	EtOH	DPPH	-	South Africa	[46]
Apodytes dimidiate E. Mey. Exarn	Icacinaceae	Leaf	$(CH_3)_2CO$	DPPH	3.5 μg/mL	South Africa	[237]
Arbutus unedo L.	Ericaceae	Leaf	EtOH	DPPH	-	South Africa	[46]
Aspalathus linearis (N.L.Burm.) R. Dahlgr.	Leguminosae	Leaf	EtOH	DPPH	3.5 ± 0.5 μg/mL	South Africa	[46]
Barleria albostellata C.B. Clarke.	Acanthaceae	Leaf	EtOH	DPPH	-	South Africa	[46]
Barleria repens Nees.	Acanthaceae	Leaf	EtOH	DPPH	-	South Africa	[46]
Berkheya setifera DC.	Asteraceae	Corn	MeOH	DPPH/H_2O_2	2 335/55 μg/mL	Lesotho	[251]
Bidens Pilosa L.	Asteraceae	Leaf	$(CH_3)_2CO$/ MeOH/H_2O	DPPH	95.7, 94.2, 91.7%, at 1 mg/mL	South Africa	[252]
Bidens pilosa L.	Asteraceae	Leaf	MeOH	DPPH/ABTS	12.10/0.057 mmol TEAC/g	South Africa	[47]
Brachylaena discolor DC.	Asteraceae	Leaf	$(CH_3)_2CO$	DPPH	2.6 μg/mL	South Africa	[237]
Broussonetia papyrifera L.	Moraceae	Leaf	EtOH	DPPH	-	South Africa	[46]
Buxus macowanii Oliv.	Buxaceae	Leaf	EtOH	DPPH	-	South Africa	[46]
Camellia sinensis (L.) Kuntze	Theaceae	Tea	MeOH	DPPH/H_2O_2	1 440/75 μg/mL	Lesotho	[251]

Table 3 Antioxidants activities of Southern AfricaAfrican plants *(Continued)*

Carpobrotus edulis L.	Mesembryanthemaceae	Leaf	H_2O/EtOH	DPPH/ ABTS/NO	0.018 and 0.016/0.020 and 0.022/0.05 and 0.023 mg/mL,	South Africa	[253]
Carpobrotus edulis L.	Azioaceae	Leaf	EtOH	DPPH	-	South Africa	[46]
Cassia abbreviate Oliv.	Caesalpinioidaeae	Bark/ Leaf/ Root	MeOH	DPPH.	86/85/85%	Zimbabwe	[51]
Celtis Africana Burm. F.	Ulmaceae	Leaf/ Stem	MeOH	DPPH	64.95/89.69% at 0.1 mg/mL	South Africa	[254]
Ceratonia siliqua L.	Leguminosae	Leaf	EtOH	DPPH	-	South Africa	[46]
Chenopodium album L.	Amaranthaceae	Leaf	$(CH_3)_2CO$/ MeOH/H_2O	DPPH	62.4, 87.2 and 81.7% at 1 mg/mL	South Africa	[252]
Chenopodium album L.	Chenopodiaceae	Leaf	MeOH	DPPH/ABTS	App 60/70%	South Africa	[48]
Clausena anisaa (Wild.) Hook. F. ex Benth.	Rutaceae	Leaf	$(CH_3)_2CO$	DPPH	2.5 μg/mL	South Africa	[237]
Clerodendrum glabrum E. May.	Lamiaceae	Leaf	$(CH_3)_2CO$	DPPH	3.5 μg/mL	South Africa	[237]
Combretum apiculatum Sond.	Combretaceae	Leaf	EtOH	DPPH	1.6 ± 0.02 μg/mL	South Africa	[46]
Combretum molle R. Br. ex G. Don.	Combretaceae	Leaf	EtOH	DPPH	9.83 ± 0.8 μg/mL	South Africa	[46]
Corchorus olitarius Engl & Diels.	Tiliaceae	Leaf	MeOH	DPPH/ABTS	17.11/0.04 mmol TEAC/g	South Africa	[47]
Cotyledon orbiculata L.	Crassulaceae	Leaf	EtOH	DPPH	-	South Africa	[46]
Crinum bulbispermum (Burm.f) MilneRedhead & Schweick.	Amaryllidaceae	Root	EtOAc	AChE	0.0393 mg/mL	South Africa	[234]
Cryptocarya woodii Engl.	Lauraceae	Leaf	EtOH	DPPH	-	South Africa	[46]
Cyathea dregei Kuntze.	Cyatheaceae	Leaf	$(CH_3)_2CO$	DPPH	3.0 μg/mL	South Africa	[237]
Dahlia imperialis Roezl.	Asteraceae	Leaf	EtOH	DPPH	-	South Africa	[46]
Datura stramonium Wall.	Solanaceae	Leaf	EtOH	DPPH	-	South Africa	[46]
Dichrostachys cinerea Wight & Arn.	Leguminosae	Leaf	EtOH	DPPH	-	South Africa	[46]
Dichrostachys cinerea Wight & Arn.	Mimosaceae	Leaf/ Root	MeOH	DPPH.	88/27%	Zimbabwe	[51]
Diospyros lycioides Desf.	Ebenaceae	Twig	EtOH	DPPH	-	South Africa	[46]
Dodonaea viscose Mart.	Sapindaceae	Leaf	EtOH	DPPH	-	South Africa	[46]
Elaedendron matabelicum	Celastraceae	Root	MeOH	DPPH.	87%	Zimbabwe	[51]
Elephantorrhiza goetzei Harns.	Leguminosae	Root	MeOH	DPPH.	85%	Zimbabwe	[51]
Erythrophleum lasianthum Corbishley.	Leguminosae	Leaf	EtOH	DPPH	-	South Africa	[46]
Euclea divinorum Hiern.	Ebenaceae	Leaf	EtOH	DPPH	-	South Africa	[46]
Euclea natalensis A.Dc	Ebenaceae	Root	EtOH	DPPH	-	South Africa	[46]

Table 3 Antioxidants activities of Southern AfricaAfrican plants *(Continued)*

Felicia muricata Nees.	Asteraceae	Leaf	MeOH/$(CH_3)_2CO$/EtOH	DPPH	70/410/120 μg/mL	South Africa	[173]
Flacourtia indica Merr.	Flacourticaceae	Leaf/ Root	MeOH	DPPH.	94/82%	Zimbabwe	[51]
Galenia africana L.	Aizoaceae	Leaf	EtOH	DPPH	90.92 ± 1.2 μg/mL	South Africa	[46]
	Asclepiadacae	Leaf	EtOH	DPPH	-	South Africa	[46]
Gomphocarpus fruticosus R. Br.	Greyiaceae	Leaf	EtOH	DPPH	-	South Africa	[46]
Greyia flanaganii Bolus.	Greyiaceae	Leaf	EtOH	DPPH	7.9 ± 0.23 μg/mL	South Africa	[46]
Greyia sutherlandii Hook & Harv.	Celastraceae	Leaf/ Root/ Twig	MeOH	DPPH.	90/96/87%	Zimbabwe	[51]
Gymnosporia senegalensis Loes.	Anacardiaceae	Leaf	EtOH	DPPH	2.6 ± 0.21 μg/mL	South Africa	[46]
Harpephyllum caffrum Bernh. Ex C. Krauss.	Apiaceae	Leaf	$(CH_3)_2CO$	DPPH	4.36 μg/mL	South Africa	[237]
Heteromorpha trifoliate Eckl & Zeyh.	Myrtaceae	Leaf	EtOH	DPPH	-	South Africa	[46]
Heteropyxis natalensis	Euphorbiaceae	Leaf	EtOH	DPPH	-	South Africa	[46]
Hyaenanche globosa Lamb.	Hydnoraceae	Leaf	MeOH	NO/DPPH/ ABTS	60%/80%/95% at 0.05 mg/mL	South Africa	[255]
Hydnora Africana Thunb.	Hypoxidaceae	Tuber	MeOH	DPPH.	86%	Zimbabwe	[51]
Hypoxis hemerocallidea Fisch.	Papilionaceae	Leaf	$(CH_3)_2CO$	DPPH	0 μg/mL	South Africa	[237]
Indigofera frutescens L.F.	Meliaceae	Bark/ Root	MeOH	DPPH.	96/87%	Zimbabwe	[51]
Khaya anthotheca C. DC.	Bignoniaceae	Bark/ Fruit/ Root	MeOH	DPPH.	81/85/45%	Zimbabwe	[51]
Kigelia africana (Lam.) Benth.	Ranunculaceae	Root	EtOH	DPPH	-	South Africa	[46]
Knowltonia vesicatoria Sims.	Anacardiaceae	Root	MeOH	ABTS/DPPH	0.0036/0.0151 mg/mL	South Africa	[234]
Lannea schweinfurthii Engl.	Rosaceae	Leaf	$(CH_3)_2CO$	DPPH	0.0 μg/mL	South Africa	[237]
Leucosidea sericea Eckl. & Zeyh.	Rosaceae	Leaf	MeOH	DPPH/H_2O_2	850/68 μg/mL	Lesotho	[251]
Leucosidea sericea Eckl. & Zeyh.	Verbenaceae	Leaf	MeOH	DPPH/ABTS	14.62/0.015 mmol TEAC/g	South Africa	[47]
Lippia javanica Spreng.	Maesaceae	Leaf	$(CH_3)_2CO$	DPPH	1.4 μg/mL	South Africa	[237]
Maesa lanceolata G. Don.	Magnoliaceae	Leaf	EtOH	DPPH	–	South Africa	[46]
Magnolia grandiflora ex Dc.	Meliaceae	Leaf	$(CH_3)_2CO$	DPPH	3.3 μg/mL	South Africa	[237]
Melia azedarach Blanco.	Papilionaceae	Leaf	$(CH_3)_2CO$	DPPH	4.6 μg/mL	South Africa	[237]
Millettia grandis Jkeel.	Myrsinaceae	Stalk	EtOH	DPPH	–	South Africa	[46]
Myrsine Africana L.	Chrysobalanaceae	Bark	EtOH	DPPH	–	South Africa	[46]

Table 3 Antioxidants activities of Southern AfricaAfrican plants *(Continued)*

Parinari curatellifolia Planch. ex Benth.	Geraniaceae	Leaf/ Root	MeOH	ABTS/DPPH	100%/90% at 0.5 mg/mL	South Africa	[256]
Pelargonium reniforme Spreng.	Geraniaceae	Leaf/ Root	MeOH	ABTS	100% at 0.025 mg/mL	South Africa	[256]
Pelargonium reniforme Spreng.	Fabaceae	Leaf	MeOH	DPPH	19.8% at 2.5 mg/mL	South Africa	[257]
Philenoptera violacea Klotz sch.	Piperaceae	Root	MeOH	ABTS/DPPH	0.040/0.044 mg/mL	South Africa	[234]
Piper capense L.F.	Polygalaceae	Leaf/ Stem	MeOH	DPPH	20% at 2500 μg/mL	Lesotho	[251]
Polygala virgate Vell.	Ranunculaceae	Leaf	EtOH	DPPH	24.7 ± 2.05 μg/mL	South Africa	[46]
Ranunculus repens Watson.	Anacardiaceae	Leaf/ Root	MeOH	DPPH.	96/96%	Zimbabwe	[51]
Rhus chirindensis Baker.	Anacardiacae	Leaf	EtOH	DPPH	–	South Africa	[46]
Rhus lancea L.f.	Euphorbiaceae	Leaf	MeOH/n-C_6H_{12}/CH_2Cl_2/ $(CH_3)_2CO$	ABTS	784/629.3/573.6 and 544.6 *μ*g/mL	South Africa	[258]
Ricinus communis L.	Polygonaceae	Leaf	$(CH_3)_2CO$/ MeOH/H_2O	DPPH	72.1, 97.7,85.3%	South Africa	[259]
Rumex ecklonianus Meisn.	Amaryllidaceae	Bulb	EtOAc	AChE	0.0003 mg/mL	South Africa	[234]
*Scadoxus puniceus*L.	Fabaceae	Stem bark	MeOH	DPPH/ ABTS/H_2O_2/ LO/NO	87.5%,89.47%,77.15%, 86.48% and 77.75% at 0.5 mg/mL	South Africa	[260]
Schotia latifolia Jacq.	Anacardiaceae	Bark	EtOH	DPPH	2.06 ± 0.03 μg/mL	South Africa	[46]
Sclerocarya birrea Hochst.	Anacardiaceae	Bark	MeOH	DPPH.	89%	Zimbabwe	[51]
Sclerocarya birrea	Polygalaceae	Root	MeOH	DPPH.	93%	Zimbabwe	[51]
Securidaca longepedunculata Fresen.	Sapotaceae	Bark	EtOH	DPPH	–	South Africa	[46]
Sideroxylon inerme L.	Solanaceae	Leaf	MeOH	DPPH/ABTS	App 35/60%	South Africa	[48]
Solanum nigrum L.	Asteraceae	Leaf	$(CH_3)_2CO$	ABTS/DPPH	97.8%/85.6 at 1 mg/mL	South Africa	[261]
Sonchus asper Hill.	Asteraceae	Leaf	$(CH_3)_2CO$	ABTS/DPPH	99.4%/56.1% at 1 mg/mL	South Africa	[261]
Sonchus oleraceus L.	Menispermaceae	Stem bark	MeOH	SOD/H_2O_2	13.11/30.04 μg/mL	South Africa	[80]
Sphenocentrum jollyanum Pierre.	Loganiaceae	Bark	H_2O	DPPH/ H_2O_2/ABTS/ NO	0.739/0.023/0.089/ 0.49 mg/mL	South Africa	[262]
Strychnos henningsiib Gilg.	Strychnaceae	Leaf	$(CH_3)_2CO$	DPPH	3.5 μg/mL	South Africa	[237]
Strychnos mitis S. Moore.	Boraginaceae	Leaf	EtOH	DPPH	-	South Africa	[46]
Symphytum officinale	Asteraceae	Leaf	MeOH	DPPH/ABTS	13.99./0.012 mmol TEAC/g	South Africa	[47]
Tagetes minuta L.	Cucurbitaceae	Leaf	MeOH	DPPH/ABTS	2.93/0.03 mmol TEAC/g	South Africa	[47]
Telfairia occidentalis Hook. F.	Combretaceae	Leaf/ Root	MeOH	DPPH.	89/89%	Zimbabwe	[51]
Terminalia sericea Carnbess.	Combretaceae	Root	MeOH	ABTS/DPPH	0.0031/0.0147 mg/mL	South Africa	[234]

Table 3 Antioxidants activities of Southern AfricaAfrican plants *(Continued)*

Terminalia sericea Carnbess.	Fabaceae	Leaf/ Stem	MeOH	DPPH	14% at 2500 μg/mL	Lesotho	[251]
Trifolium burchellianum Serr.	Alliaceae	Root	EtOAc	AChE/ ABTS/DPPH	0.0319 mg/mL	South Africa	[234]
Tulbaghia violacea Har v.	Alliacea	Rhizome	MeOH	DPPH/H_2O_2	35,19.3/17.9 μg/mL	South Africa	Olorunnisola et al., 2011 b
Tulbaghia violacea Har v.	Alliaceae	Rhizome	Oil	DPPH	83.0 μg/mL	South Africa	[263]
Tulbaghia violacea Har v.	Urticaceae	Leaf	MeOH	DPPH/ABTS	App 45/75%	South Africa	[48]
Urtica lobulata E. Mey.	Fabaceae	Leaf	MeOH	ABTS	0.95 mmol TEAC/g	South Africa	[47]
Vigna unguiculata L.	Cancellaceae	Leaf	EtOH	DPPH	111 ± 2.5 μg/mL	South Africa	[46]
Warburgia salutaris Chiou.	Canellaceae	Bark/Leaf/ Root/ Twig	MeOH	DPPH.	73/87/94/89%	Zimbabwe	[51]
Warburgia salutaris Chiou.	Fabaceae	Leaf	MeOH	DPPH	2.5 mg/mL	South Africa	[257]
Xanthocercis zambesiaca	Apocynaceae	Root	EtOAc	DPPH	0.0005 mg/mL	South Africa	[234]
Xysmalobium undulatum R. Br.	Rutaceae	Leaf	$(CH_3)_2CO$	DPPH	4.0 μg/mL	South Africa	[237]
Zanthoxylum capense Har v.	Rutaceae	Leaf	EtOH	DPPH		South Africa	[46]
Zanthoxylum capense Har v.	Rutaceae	Root	MeOH	AChE/ABTS	0.01/0.075 mg/mL	South Africa	[234]
Zanthoxylum davyi P.G. Waterman.	Rhamnaceae	Root	MeOH	ABTS/DPPH	0.0187/0.0291 mg/mL	South Africa	[234]

Key: *RSA* radical scavenging activity, *RC* reducing power capacity, *OH* hydroxyl ion, *NO* nitric oxide radical inhibition, H_2O_2 hydrogen peroxide inhibition activity, *LPO* lipid peroxidation inhibition activity, $ABTS^+$ 2,2′-azinobis-3–ethylbenzothiozolin-6–sulfonic acid cation decolourization test, ß-*CLAMS* ß-carotene-linoleic acid model system, *SORSA* superoxide anion radical scavenging activity (SORSA), *MLP* microsomal lipid peroxydation, *FRAP* fe^{2+} chelating ability and ferric reducing antioxidant properties, *DPPH* 1,1–dipheyl-2–picry-hydrazyl, *ORAC* oxygen radical absorbance capacity, *TEAC* trolox equivalent antioxidant capacity, *MeOH* methanol, CH_2Cl_2 dichloromethane, *EtOH* ethanol, *EtOAc* ethyl acetate, *n*-C_6H_{12} hexane, $(CH_3)_2CO$ acetone, H_2O aqueous, *BtOH* butanol

(5) When dealing with Trolox equivalents (TEAC), antioxidants activities of plants extracts are considered to be very high when activities was < 0.05 and < 0.5 mmol Trolox/g in ABTS and DPPH assay, moderate at 0.05–0.20 and 0.5–1.0 mmol Trolox/g in ABTS and DPPH assay, low at 0.21–0.5 and 1.1–5.0 mmol Trolox/g in ABTS and DPPH assay, while extract with trolox equivalents > 0.5 and > 5 mmol/g in ABTS and DPPH assay respectively are considered inactive.
(6) When dealing with in vitro hepatoprotective, plant extracts were considered to exhibit significant, medium and low hepatoprotective activities when inhibiting oxidation phenomena of > 80%, 50% and < 50% at concentration ≤ 200 μg/mL respectively

Many antioxidant compounds have been characterized form plants including flavonoids. Flavonoids are phenolic compounds with importants roles in scavenging free radicals and thus play vital roles in preventing oxidative stress associated disorders [4]. The antioxidant effects of flavonoids in biological systems are accredited to its capacity to transport electrons to free radicals, chelate metals, activate antioxidant enzymes, and reduce radicals of alpha-tocopherol or to inhibit oxidases while phenolic compounds exert it antioxidant activities by inactivating free radicals or preventing decomposition of hydroperoxide into free radicals [32]. In this review the antioxidant potential of flavonoids and other phenolic compounds have been highlighted in Table 7.

Evaluations of biochemical parameters including aspartate transaminase (AST), alanine transaminase (ALT), alkaline phosphatase (ALP), total proteins, albumins, bilirubins, super oxide dismutase (SOD), catalase, malondialdehyde (MDA), glutathione peroxidase have been widely used in assessing the integrity of the liver [33–37]. Therefore, the hepatoprotective capacities of natural products reviewed in this study were assessed based on the levels of ameliorative effect on hepatotoxicants

Table 4 Antioxidants activities of Central African plants

Plants	Family	Part used	Solvents	Assay Methods	Inhibition/IC_{50}	Country of origin	References
Abrus precatorius L	Papiliomoidae	Leaf	MeOH	DPPH	6.88%	Cameroon	[53]
Acalypha manniana Mull. Arg.	Euphobiaceae	Leaf	MeOH/n-C_6H_{12}	DPPH	4.51 and 4.80%	Cameroon	[264]
Acalypha racemosa B. Heyne.	Euphorbiaceae	Leaf/Stem	MeOH	DPPH/NO′HO	2.11,1.92,2.12/ 2.28.1.49,10.04 μg/mL	Cameroon	[52]
Acanthus montanus T. Anderson	Acanthaceae	Leaf	MeOH	DPPH	9.88%	Cameroon	[53]
Adenocarpus mannii Hook. f	Fabaceae	Leaf	EtOH	DPPH	361.30 μg/mL	Cameroon	[265]
Ageratum conizoides L.	Asteraceae	Leaf	MeOH	DPPH	9.05%	Cameroon	[53]
Ageratum conyzoides L.	Asteraceae	Bark/Leaf/ Rhizome	MeOH;CH_2Cl_2	Fe (II)-Ascorbate induced LP	−9.31% at 200 μg/mL	Cameroon	[117]
Alchornea cordifolia Pax & K. Hoffm.	Euphorbiaceae	Leaf	MeOH	DPPH	39.70%	Cameroon	[53]
Alchornea laxiflora Pax & K. Hoffm.	Euphorbiaceae	Bark/Leaf/ Rhizome	MeOH;CH_2Cl_2	Fe (II)-Ascorbate induced LP	95.90% at 200 μg/mL	Cameroon	[117]
Allanblackia floribunda L.	Guttiferae	Root Bark	MeOH	DPPH	76.3 μg/mL	Cameroon	[266]
Amaranthus spinosa L.	Amaranthaceae	Leaf	MeOH	DPPH	3.78%	Cameroon	[53]
Annona muricata L.	Annonaceae	Leaf	MeOH	DPPH	9.88%	Cameroon	[53]
Annona senegalensis Pers.	Anonaceae	Bark/Leaf/ Rhizome	MeOH;CH_2Cl_2	Fe (II)-Ascorbate induced LP	16.17% at 200 μg/mL	Cameroon	[117]
Anthocleista schweinfurthii Gilg.	Gentianaceae	Leaf	MeOH	DPPH	1.20 μg/mL	Congo	[267]
Anthocleista schweinfurthii Gilg.	Loganiaceae	Bark/Leaf/ Rhizome	MeOH;CH_2Cl_2	Fe (II)-Ascorbate induced LP	−0.05% at 200 μg/mL	Cameroon	[117]
Aspilia africana Pers.	Asteraceae	Bark/Leaf/ Rhizome	MeOH;CH_2Cl_2	Fe (II)-Ascorbate induced LP	52.91% at 200 μg/mL	Cameroon	[117]
Asystasia gangetica A. Juss.	Acanthaceae	Leaf	MeOH	DPPH	3.08%	Cameroon	[53]
Azadirachta indica A. Juss.	Meliaceae	Bark/Leaf	MeOH	DPPH	59.80/2.88%	Cameroon	[53]
Barteria fistulosa Mast.	Passifloraceae	Leaf	EtOH	DPPH	100.16 μg/mL	Cameroon	[265]
Bersama engleriana Gunke.	Melianthaceae	Leaf	MeOH	DPPH	93.71% at 1000 μg/mL	Cameroon	[268]
Bidens pilosa L.	Asteraceae	Leaf	MeOH	DPPH	7.57%	Cameroon	[53]
Bidens pilosa L.	Asteraceae	Bark/leaf/ Rhizome	MeOH;CH_2Cl_2	Fe (II)-Ascorbate induced LP	50.92% at 200 μg/mL	Cameroon	[117]
Bracica dera L.	Bracicaceae	Leaf	MeOH	DPPH	5.11%	Cameroon	[53]
Carica papaya L.	Caricaceae	Leaf	MeOH	DPPH	7.72%	Cameroon	[53]
Carica papaya L.	Caricaceae	Bark/leaf/ Rhizome	MeOH;CH_2Cl_2	Fe (II)-Ascorbate induced LP	−2.68% at 200 μg/mL	Cameroon	[117]
Cassia alata L.	Legceasalpoidee	Leaf	MeOH	DPPH	1.95%	Cameroon	[53]
Ceiba pentandra L.	Bombacea	Bark	MeOH	DPPH	28.72%	Cameroon	[53]
Centella asiatica Urb.	Apiaceae	Whole plant	MeOH	DPPH/NO	-	Cameroon	[269]
Centella asiatica Urb.	Apiaceae	Whole plant	MeOH	DPPH/NOSA	-	Cameroon	[269]
Chrysanthellum americanum Vatke.	Asteraceae	Bark/leaf/ Rhizome	MeOH;CH_2Cl_2	Fe (II)-Ascorbate induced LP	17.20% at 200 μg/mL	Cameroon	[117]
Cissus populnea Guill & Perr.	Vitaceae	Root	MeOH	DPPH/NO	15.72/409 μg/mL	Cameroon	[269]
Cissus populnea Guill & Perr.	Vitaceae	Root	MeOH	DPPH/NOSA	15.72/409.00 μg/mL	Cameroon	[269]
Cissus quadrangularis L.	Vitaceae	Leaf	MeOH	DPPH	2.60%	Cameroon	[53]
Citrus aurantifolia (Christm.) Swingle.	Rutaceae	Bark/Leaf/ Rhizome	MeOH;CH_2Cl_2	Fe (II)-Ascorbate induced LP	54.59% at 200 μg/mL	Cameroon	[117]

Table 4 Antioxidants activities of Central African plants *(Continued)*

Citrus sinensis Pers.	Rutaceae	Bark/Leaf/ Rhizome	MeOH;CH_2Cl_2	Fe (II)-Ascorbate induced LP	100.00% at 200 μg/mL	Cameroon	[117]
Cleome ciliatea	Cleomaceae	Leaf	MeOH	DPPH	1.95%	Cameroon	[53]
Clerodendrum formicarum Gurke.	Lamiacea	Leaf	MeOH	DPPH	>200 μg/mL	Cameroon	[140]
Coffea arabica L.	Rubiaceae	Bark/Leaf/ Rhizome	MeOH;CH_2Cl_2	Fe (II)-Ascorbate induced LP	10.05% at 200 μg/mL	Cameroon	[117]
Coffea robusta L. Linden	Rubiaceae	Bark/Leaf/ Rhizome	MeOH;CH_2Cl_2	Fe (II)-Ascorbate induced LP	41.23% at 200 μg/mL	Cameroon	[117]
Coleus coprosijblius	Lamiaceae	Leaf	MeOH	DPPH	39.58%	Cameroon	[53]
Cordyline fruticosa (L.) A. Chev.	Agavaceae	Leaf	MeOH	DPPH	181.30 μg/mL	Cameroon	[270]
Costus afer L.	Costaceae	Bark/Leaf/ Rhizome	MeOH;CH_2Cl_2	Fe (II)-Ascorbate induced LP	68.16% at 200 μg/mL	Cameroon	[117]
Costus afer L.	Costaceae	Leaf	MeOH	DPPH	3.04%	Cameroon	[53]
Crinum sp.	Amarillidaceae	Leaf	MeOH	DPPH	4.69%	Cameroon	[53]
Crotalaria lachnophora Hochst. ex. R.	Fabaceae	Bark/Leaf/ Rhizome	MeOH;CH_2Cl_2	Fe (II)-Ascorbate induced LP	97.41% at 200 μg/mL	Cameroon	[117]
Curcuma longa L.	Zingiberaceae	Bark/Leaf/ Rhizome	MeOH;CH_2Cl_2	Fe (II)-Ascorbate induced LP	90.36% at 200 μg/mL	Cameroon	[117]
Cylicodiscusgabunensis Harms.	Mimosaceae	Bark	MeOH	DPPH	28.00%	Cameroon	[53]
Cymbopogon citrates Stapf.	Poaceae	Leaf	BtOH	DPPH/FRAP/RP/ H_2O_2/NO	-	Angola	[271]
Cymbopogon citrates Stapf.	Poaceae	Leaf	MeOH	DPPH	6.05%	Cameroon	[53]
Cymbopogon citrates Stapf.	Poaceae	Bark/Leaf/ Rhizome	MeOH;CH_2Cl_2	Fe (II)-Ascorbate induced LP	−9.66% at 200 μg/mL	Cameroon	[117]
Dacryodes edulis (G.Don) H.J. Lam.	Burseraceae	Leaf	MeOH	DPPH	93.01%	Cameroon	[53]
Dacryodes edulis (G.Don) H.J. Lam.	Burseraceae	Bark/Leaf/ Rhizome	MeOH;CH_2Cl_2	Fe (II)-Ascorbate induced LP	−8.20% at 200 μg/mL	Cameroon	[117]
Dichrocephala integrifolia (L.F) Knntze.	Asteraceae	Bark/Leaf/ Rhizome	MeOH;CH_2Cl_2	Fe (II)-Ascorbate induced LP	25.43% at 200 μg/mL	Cameroon	[117]
Dichrostachys glomerata Chi.	Mimosaceae	Seed	EtOAc/MeOH	DPPH	High	Cameroon	[272]
Dissotis perkinsiae Gilg.	Melastomaceae	Leaf	EtOH	DPPH	130.66 μg/mL	Cameroon	[265]
Dorstenia barteri Bureau.	Moraceae	Leaf/Twig	EtOAc/MeOH	DPPH	60.46/48.12 μg/mL	Cameroon	[31]
Dracaena deisteliana Engl.	Dracaenaceae	Leaf	MeOH	DPPH	6.66%	Cameroon	[53]
Draceana deisteliana Engl.	Agavaceae	Bark/Leaf/ Rhizome	MeOH;CH_2Cl_2	Fe (II)-Ascorbate induced LP	−0.46% at 200 μg/mL	Cameroon	[117]
Ekebergia senegalensis Fuss.	Meliaceae	Back	MeOH	DPPH	15.83 μg/mL	Cameroon	[269]
Ekebergia senegalensis Fuss.	Meliaceae	Bark	MeOH	DPPH/NOSA	15.83/299 μg/mL	Cameroon	[269]
Eleusine indica Gaertn.	Poaceae	Leaf	MeOH	DPPH	1.36%	Cameroon	[53]
Emilia coccinia Cass.	Asteraceae	Bark/Leaf/ Rhizome	MeOH;CH_2Cl_2	Fe (II)-Ascorbate induced LP	−1.51% at 200 μg/mL	Cameroon	[117]
Emilia cocinea Cass.	Asteraceae	Leaf	MeOH	DPPH	2.99%	Cameroon	[53]
Enantia chlorantha Oliv.	Anonaceae	Bark/Leaf/ Rhizome	MeOH;CH_2Cl_2	Fe (II)-Ascorbate induced LP	53.97% at 200 μg/mL	Cameroon	[117]
Entada africana Guill & perr.	Mimosaceae	Bark/Leaf/ Rhizome	MeOH;CH_2Cl_2	Fe (II)-Ascorbate induced LP	82.73% at 200 μg/mL	Cameroon	[117]
Entandophragma angolense L.	Meliaceae	Bark	MeOH	DPPH	7.60	Cameroon	[53]
Eremomastas speciosa (Hochst.) Cufod.	Acanthaceae	Bark/Leaf/ Rhizome	MeOH;CH_2Cl_2	Fe (II)-Ascorbate induced LP	46.16% at 200 μg/mL	Cameroon	[117]
Eremomastas speciosa (Hochst.) Cufod.	Acanthaceae	Leaf	MeOH	DPPH/NO	454/278 μg/mL	Cameroon	[269]

Table 4 Antioxidants activities of Central African plants *(Continued)*

Eremomastas speciosa (Hochst.) Cufod.	Acanthaceae	Leaf	MeOH	DPPH	454 µg/mL	Cameroon	[269]
Eremomastas speciosa (Hochst.) Cufod.	Acanthaceae	Leaf	MeOH	DPPH	5.43%	Cameroon	[53]
Eriobotrya japonica (Thunb) Lindl	Rosaceae	Stem bark	MeOH	DPPH	16.55 µg/mL	Cameroon	[270]
Erythrina Senegalensis L.	Fabaceae	Stem bark	EtOH	ß-CLAMS/FRAP/MLP	12.35/, 10.24/1.47 µg/mL	Cameroon	[273]
Erythrina Senegalensis L.	Fabaceae	Stem bark	MeOH	DPPH	46.9 µg/mL	Cameroon	[274]
Erythrina senegalensis L.	Fabaceae	Bark/Leaf/Rhizome	MeOH;CH_2Cl_2	Fe (II)-Ascorbate induced LP	94.25% at 200 µg/mL	Cameroon	[117]
Erythrina vogelii Hook. f.	Fabaceae	Leaf	MeOH	DPPH	>200 µg/mL	Cameroon	[140]
Eucalyptus oblique L Her.	Myrtaceae	Bark/Leaf/Rhizome	MeOH;CH_2Cl_2	Fe (II)-Ascorbate induced LP	76.19% at 200 µg/mL	Cameroon	[117]
Faraga macrophylla	Rutaceae	Bark	MeOH	DPPH	2.29%	Cameroon	[53]
Ficus asperifolia Miq.	Moraceae	Stem bark	MeOH	DPPH	Least activity	Cameroon	[272]
Ficus exasperata Vahl.	Moraceae	Bark/Leaf/Rhizome	MeOH;CH_2Cl_2	Fe (II)-Ascorbate induced LP	−6.98% at 200 µg/mL	Cameroon	[117]
Ficus sur Forssk.	Moraceae	Leaf	MeOH	DPPH	4.91%	Cameroon	[53]
Garcinia lucida Vesque.	Clusiaceae	Fruit/Bark	MeOH	DPPH, NO, HO	1.83,3.12,1.99/2.35,3.59,2.01 µg/mL	Cameroon	[52]
Gardenia aqualla J.Ellis	Rubiaceae	Leaf	MeOH	DPPH/NO	105.9/253 µg/mL	Cameroon	[269]
Gardenia aqualla J.Ellis	Rubiaceae	Leaf	MeOH	DPPH/NOSA	105.90/278.00 µg/mL	Cameroon	[269]
Gladiolus dalenii L.	Iridaceae	Bark/Leaf/Rhizome	MeOH;CH_2Cl_2	Fe (II)-Ascorbate induced LP	−8.23% at 200 µg/mL	Cameroon	[117]
Gosypium barbadense L.	Malvaceae	Bark/Leaf/Rhizome	MeOH;CH_2Cl_2	Fe (II)-Ascorbate induced LP	56.98% at 200 µg/mL	Cameroon	[117]
Harungana madagascariensis Lam.	Hypercaceae	Leaf	MeOH	DPPH	90.15%	Cameroon	[53]
Harungana madagascariensis Lam.	Hypericaceae	Bark/Leaf/Rhizome	MeOH;CH_2Cl_2	Fe (II)-Ascorbate induced LP	81.75% at 200 µg/mL	Cameroon	[117]
Hibiscus asper Hook. f.	Malvaceae	Aerial parts	n-C_6H_{12}	DPPH	Least activity	Cameroon	[272]
Hymenocardia lyrata Miq.	Phllantaceae	Root/bark	MeOH	DPPH/NO/HO	1.96,3.82,2.43/1.74,2.46,3.30 µg/mL	Cameroon	[52]
Ipomea batatas Blackie.	Convolvulaceae	Bark/Leaf/Rhizome	MeOH;CH_2Cl_2	Fe (II)-Ascorbate induced LP	14.30% at 200 µg/mL	Cameroon	[117]
Irvingia wombolu Hook. f.	Irvingiaceae	Pulp	H_2O	DPPH/FRAP/ABTS.OH	37.86/15.55/55.53%31.63 at 1 mg/mL	Cameroon	[275]
Kalonchoe crenata (Andrews) Haw.	Crasulaceae	Bark/Leaf/Rhizome	MeOH;CH_2Cl_2	Fe (II)-Ascorbate induced LP	73.70% at 200 µg/mL	Cameroon	[117]
Khaya grandifoliola C. DC.	Meliaceae	Bark/Leaf/Rhizome	MeOH;CH_2Cl_2	Fe (II)-Ascorbate induced LP	78.91% at 200 µg/mL	Cameroon	[117]
Lannea kerstingii Engl. & K. Krause.	Anacardiaceae	Back	MeOH	DPPH/NO	34.40/306 µg/mL	Cameroon	[269]
Lannea kerstingii Engl. & K. Krause.	Anacardiaceae	Bark	MeOH	DPPH/NOSA	34.40/253.00 µg/mL	Cameroon	[269]
Lantana camara L.	Verbenaceae	Leaf	MeOH	DPPH	23.47%	Cameroon	[53]
Lippia adoensis L.	Lamiaceae	Leaf	MeOH	DPPH	10.41%	Cameroon	[53]
Lygopodium macrophyllum L.	Pteridophyte	Leaf	MeOH	DPPH	14.72%	Cameroon	[53]
Mangifera indica L.	Anacardiaceae	Bark/Leaf/Rhizome	MeOH;CH_2Cl_2	Fe (II)-Ascorbate induced LP	75.35% at 200 µg/mL	Cameroon	[117]
Manihot esculenta Crantz.	Euphorbiaceae	Bark/Leaf/Rhizome	MeOH;CH_2Cl_2	Fe (II)-Ascorbate induced LP	−4.80% at 200 µg/mL	Cameroon	[117]

Table 4 Antioxidants activities of Central African plants *(Continued)*

Melinis minutiflora P. Beauv.	Poaceae	Bark/Leaf/ Rhizome	MeOH;CH_2Cl_2	Fe (II)-Ascorbate induced LP	58.47% at 200 μg/mL	Cameroon	[117]
Mimosa pudica L.	Mimosaceae	Leaf	MeOH	DPPH	19.37%	Cameroon	[53]
Musa sapientum L.	Musaceae	Bark/Leaf/ Rhizome	MeOH;CH_2Cl_2	Fe (II)-Ascorbate induced LP	−9.33% at 200 μg/mL	Cameroon	[117]
Nauclea latifolia Sm.	Rubiaceae	Bark/Leaf/ Rhizome	MeOH;CH_2Cl_2	Fe (II)-Ascorbate induced LP	43.02% at 200 μg/mL	Cameroon	[117]
Occimum gratissimum L.	Labieae	Bark/Leaf/ Rhizome	MeOH;CH_2Cl_2	Fe (II)-Ascorbate induced LP	68.01% at 200 μg/mL	Cameroon	[117]
Ocimum basilicum L.	Lamiaceae	Leaf	MeOH	DPPH	39.98%	Cameroon	[53]
Olax subscorpioideae Oliv.	Olacaceae	Bark/Leaf/ Rhizome	MeOH;CH_2Cl_2	Fe (II)-Ascorbate induced LP	44.71% at 200 μg/mL	Cameroon	[117]
Paullinia pinnata L.	Sapindaceae	Leaf	n-C_6H_{12}	DPPH	Least activity	Cameroon	[272]
Pentadesma butyracea Sabine.	Clusiaceae	Fruits	MeOH	DPPH	High	Cameroon	[272]
Persea americana Mlill.	Lauraceae	Leaf	MeOH	DPPH	69.91%	Cameroon	[53]
Persea americana Mlill.	Lauraceae	Bark/Leaf/ Rhizome	MeOH;CH_2Cl_2	Fe (II)-Ascorbate induced LP	24.31% at 200 μg/mL	Cameroon	[117]
Persea americana Mlill.	Lauraceae	Bark/Leaf/ Rhizome	MeOH;CH_2Cl_2	Fe (II)-Ascorbate induced LP	44.85% at 200 μg/mL	Cameroon	[117]
Piliostigma thonningii Mlill.	Cesalpilaceae	Bark/Leaf/ Rhizome	MeOH;CH_2Cl_2	Fe (II)-Ascorbate induced LP	74.26% at 200 μg/mL	Cameroon	[117]
Polyscias fulva Harns (Hieram).	Araliaceae	Bark/Leaf/ Rhizome	MeOH;CH_2Cl_2	Fe (II)-Ascorbate induced LP	−0.01% at 200 μg/mL	Cameroon	[117]
Protea elliotii C.H. Wright.	Proteaceae	Back	MeOH	DPPH/NO	14.20/205 μg/mL	Cameroon	[269]
Protea elliotii C.H. Wright.	Proteaceae	Bark	MeOH	DPPH/NOSA	14.20/306.00 μg/mL	Cameroon	[269]
Prunus Africana (Hook. f.)	Rosaceae	Bark	MeOH	DPPH	22.10%	Cameroon	[53]
Psidium guajava L.	Myrsinacee	Leaf	MeOH	DPPH	39.84%	Cameroon	[53]
Psidium guayava L.	Myrtaceae	Bark/Leaf/ Rhizome	MeOH;CH_2Cl_2	Fe (II)-Ascorbate induced LP	50.47% at 200 μg/mL	Cameroon	[117]
Psorospermum febrifugum Spach.	Guttiferae	Stem bark	MeOH	DPPH	Least activity	Cameroon	[272]
Pycnocycla ledernanii Wolff.	Apiaceae	Leaf	MeOH	DPPH	8.57%	Cameroon	[53]
Rumex abyssinicus Jacq.	Polygonaceae	Bulb	MeOH	DPPH	High activity	Cameroon	[272]
Rumex bequaertii De wild.	Polygonaceae	Bulb	MeOH	DPPH	High activity	Cameroon	[272]
Senna alata L.	Fabaceae	Bark/Leaf/ Rhizome	MeOH;CH_2Cl_2	Fe (II)-Ascorbate induced LP	88.50% at 200 μg/mL	Cameroon	[117]
Senna siamea Lam.	Fabaceae	Leaf	MeOH	DPPH	236 μg/mL	Cameroon	[269]
Senna siamea Lam.	Fabaceae	Leaf	MeOH	DPPH	236 μg/mL	Cameroon	[269]
Solanum acaleastrum	Solanaceae	Bark/Leaf/ Rhizome	MeOH;CH_2Cl_2	Fe (II)-Ascorbate induced LP	28.57% at 200 μg/mL	Cameroon	[117]
Sonchus oleraceus L.	Asteraceae	Bark/Leaf/ Rhizome	MeOH;CH_2Cl_2	Fe (II)-Ascorbate induced LP	31.02% at 200 μg/mL	Cameroon	[117]
Spilanthes filicaulis (Schum. & Thonn.) C.D. Adam.	Asteraceae	Bark/Leaf/ Rhizome	MeOH;CH_2Cl_2	Fe (II)-Ascorbate induced LP	58.93% at 200 μg/mL	Cameroon	[117]
Syzyguim guineense Wall.	Myrtaceae	Leaf	MeOH;H_2O	DPPH/ABTS/OH	5.52 g/mL/16.25 mg/ mL/126.35 g/mL	Cameroon	[276]
Tectona grandis L.F.	Lamiaceae	Leaf	MeOH	DPPH	Least activity	Cameroon	[272]
Terminalia glaucescens Planch.	Combretaceae	Bark/Leaf/ Rhizome	MeOH;CH_2Cl_2	Fe (II)-Ascorbate induced LP	47.68% at 200 μg/mL	Cameroon	[117]
Terminalia macroptera Mart.	Combretaceae	Root	MeOH	DPPH/NO	19.90/290 μg/mL	Cameroon	[269]

Table 4 Antioxidants activities of Central African plants *(Continued)*

Terminalia macroptera Mart.	Combretaceae	Root	MeOH	DPPH/NOSA	19.90/205.00 μg/mL	Cameroon	[269]
Trema orientalis Blume.	Ulmaceae	Bark/Leaf/ Rhizome	MeOH;CH_2Cl_2	Fe (II)-Ascorbate induced LP	−5.23% at 200 μg/mL	Cameroon	[117]
Urena lobata L.	Malvaceae	Leaf	MeOH	DPPH	9.70%	Cameroon	[53]
Vernonia amygdalina Delile.	Asteraceae	Bark/Leaf/ Rhizome	MeOH;CH_2Cl_2	Fe (II)-Ascorbate induced LP	33.49% at 200 μg/mL	Cameroon	[117]
Vismia laurentii De Wild.	Guttiferae	Stem bark	EtOAc/MeOH	DPPH	High	Cameroon	[272]
Vitellaria paradoxa C.F.Gaertn.	Sapotaceae	Back	MeOH	DPPH/NO	22.14/108 μg/mL	Cameroon	[269]
Voacanga africana Stapf.	Apocynaceae	Bark/Leaf/ Rhizom	MeOH;CH_2Cl_2	Fe(II)-Ascorbate induced LP	100.00% at 200 μg/mL	Cameroon	[117]
Voacanga africana Stapf.	Apocynaceae	Bark	MeOH	DPPH	3.73%	Cameroon	[53]
Xanthosoma sagittifolium (L.) schott.	Araceae	Bark/Leaf/ Rhizome	MeOH;CH_2Cl_2	Fe(II)-Ascorbate induced LP	48.01% at 200 μg/mL	Cameroon	[117]
Zea mays L.	Poaceae	Leaf	MeOH	DPPH	12.06%	Cameroon	[53]

Key: *RSA* radical scavenging activity, *RC* reducing power capacity, *OH* hydroxyl ion, *NO* nitric oxide radical inhibition, H_2O_2 hydrogen peroxide inhibition activity, *LPO* lipid peroxidation inhibition activity, $ABTS^+$ 2,2′-azinobis-3–ethylbenzothiozolin-6–sulfonic acid cation decolourization test, ß-*CLAMS* ß-carotene-linoleic acid model system, *SORSA* superoxide anion radical scavenging activity (SORSA), *MLP* microsomal lipid peroxydation, *FRAP* fe^{2+} chelating ability and ferric reducing antioxidant properties, *DPPH* 1,1–dipheyl-2–picry-hydrazyl, *ORAC* oxygen radical absorbance capacity, *TEAC* trolox equivalent antioxidant capacity, *MeOH* methanol, CH_2Cl_2 dichloromethane, *EtOH* ethanol, *EtOAc* ethyl acetate, *n*-C_6H_{12} hexane, $(CH_3)_2CO$ acetone, H_2O aqueous, *BtOH* butanol

induced alterations in level of these biochemical parameters (Table 8).

Antioxidant activities of extracts of plants from Western Africa

A total of 341 plants species representing 77 families from Western Africa plants were documented to have antioxidant activities (Table 1). Plant extracts from twenty five plants showed significant antioxidant capacity (IC_{50} < 10 μg/mL). Fourty eight extracts revealed promising antioxidant activities with IC_{50} values ranging from 10 to 50 μg/mL; while 59 extracts showed moderate antioxidant activities with IC_{50} values ranging from 50 to 100 μg/mL.

Oke and Hamburger [38] and Omale [39] presented the antioxidants activities of some medicinal plant on the basis of degree of color changes in which methanol cortex, folium and radix extract of *Cnestis ferruginea, funtumia elastica, Gongronema latifolia, Sphenocentrum jollyanum, Voacanga africana and Landolfia owariensis* showed strong intensity of yellow coloration in DPPH radical scavenging assay and were considered to have very high antioxidants activities, while *Leea gunensis, Hedranthera barteri, Icacina trichantha, Crinum purpurascenc* and *Byrsocarpus coccineus* revealed moderate intensity of yellow colouration. Determination of antioxidant potential on the basis of FRAP, revealed that 9 plant extracts had minimal FRAP (<1 mM/L), 37 including *Althaeae radix, Foeniculi fructus, Cetrariae lichen* and *Phaseoli pericarpum* had low FRAP (1–5 mM/L), 15 had good FRAP (5–10 mM/L) while 8 had high FRAP (10–20 mM/L) with the leaf extract of *Mellisa officinalis* having significant FRAP of 2.52 mM/L [30]. The extract of the leaves of *Mellisa officinalis* could be considered as the most suitable candidate for development into antioxidant phytomedicine. The constituent compounds should also be evaluated for their antioxidant potential. Phytochemical investigation of plants from Western Africa exhibiting antioxidant and related activities led to isolation of lophirones B (**50**) and lophirones C (**51**) (Table 6 and Fig. 3), from chloroform stem bark of *Lophira alata*. These two compounds show significant antioxidants activities in DPPH assay (84.4%, and 90.0% respectively at 1 μg/mL) and in vivo antioxidants activity [40]. This study shows that treatments of normal rats with 5, 10, and 20 mg/kg body of lophirones B (**50**) and lophirones C (**51**) once daily for 2 days increases the activities of ROS detoxifying enzymes (SOD, CAT, GPx, and GR) in the liver of rats when compared to the control.

Antioxidant activities of extracts of plants from Northern Africa

A total of 345 plants species representing 72 families from Northern Africa plants were documented to have antioxidant activities (Table 2). The antioxidant activities of most plant extracts originating from Northern Africa were determined using the free radical scavenging assays carried out at constant concentration of 50 mg/mL, in order to evaluate the % radical scavenging activities (RSA). Using this criteria, plant extracts were reported to exhibit low, medium, high and significant activities when their % RSA were observed to be < 25%, 25–50%, 50–80% and > 80%, respectively. Based on this criteria 39

Table 5 Antioxidants activities of Eastern African plants

Plants	Family	Part used	Solvents	Assay Methods	Inhibition/EC_{50}	Country	References
Aframomum corrorima (A. Braun) P.C.M. Jansen.	Zingeberaceae	Seed	Oil	DPPH	34.9 μL/mL	Ethiopia	[277]
Afrocantharellus splendens (Buyck) Tibuhwa.	Cantherellaceae	Mushroom	EtOH	DPPH	<0.4 mg/mL	Tanzania	[278]
Afrocantharellus symoensii	Cantherellaceae	Mushroom	EtOH	DPPH	<0.2 mg/mL	Tanzania	[278]
Aloe harlana Reynolds.	Xanthorrhoeaceae	Latex	EtOH	DPPH	14.21 μg/mL	Ethiopia	[279]
Aloe otallensis Baker.	Asteraceae	Latex	EtOH	DPPH	26.9 mg/mL	Ethiopia	Paulos et al., 2012
Amaranthus dubius Mart.	Amaranthaceae	Leaf	EtOH	ORAC	928 μMTE/μg	Kenya	[56]
Apium leptophylum (Pers.) Sprague ex Britton & P.Wils	Apiaceae	Leaf	Oil	DPPH	4.3 μl/ml.	Ethiopia	[280]
Artemisia abyssinica Sch. Bip, ex A. Rich.	Compositae	Aerial parts	Oil	DPPH	28.9 μL/mL	Ethiopia	[281]
Artemisia afra Jacq. ex Wild.	Compositae	Aerial parts	Oil	DPPH	1.1 μL/mL	Ethiopia	[281]
Azadirachta indica A.Juss.	Meliaceae	Leaf	EtOH	ORAC	1761 μMTE/μg	Kenya	[56]
Bersama abyssinica Fresen.	melianthaceae	Leaf	EtOH	DPPH	7.5 μg/ml	Ethiopia	[58]
Brassica oleracea L.	Brassicaceae	Leaf	EtOH	ORAC	1184 μMTE/μg	Kenya	[56]
Cantharellus cascadensis Dunham, O Dell & R. Molina.	Cantharaceae	Mushroom	EtOH	DPPH	<0.2 mg/mL	Tanzania	[278]
Cantharellus cyanoxanthus R. Heim ex Heinem.	Cantharaceae	Mushroom	EtOH	DPPH	<0.4 mg/mL	Tanzania	[278]
Cantharellus pseudocibarius Henn.	Cantharaceae	Mushroom	EtOH	DPPH	0.14 mg/mL	Tanzania	[278]
Cantharellus rufopunctatus (Beeli) Heinem.	Cantharaceae	Mushroom	EtOH	DPPH	0.4 mg/mL	Tanzania	[278]
Cantharellus tomentosus Eyssart. & Buyck.	Cantharaceae	Mushroom	EtOH	DPPH	<0.4 mg/mL	Tanzania	[278]
Cheilanthes farinose Sw.	Pteridaceae	Aerial parts	EtOH	DPPH	52.5 μg/ml	Ethiopia	[58]
Cineraria abyssinica Sch. Bip. Ex A. Rich.	Asteraceae	Leaf	EtOH/H_2O	DPPH	5.78/6.27 μg/ml	Ethiopia	[57]
Cucurbita maxima Duschesne.	Cucurbitaceae	Leaf	EtOH	ORAC	447 μMTE/μg	Kenya	[56]
Delonix elata L.	*Fabaceae*	Flower	$CO(CH_3)_2$/MeOH/H_2O	DPPH	91.3/86/89.3% at 100 μL	Ethopia	[282]
Eriobotrya japonica (Thunbs) Lindl.	Rosaceae	Fruit	EtOH	ORAC	411 μMTE/μg	Kenya	[56]
Euclea racemosa L.	Ebenaceae	Leaf	$(CH_3)_2CO$	DPPH	11.3 μg/ml	Ethiopia	[58]
Hydnora abyssinica A.Braun ex Schweinf.	Hydnoraceae	Leaf	CH_2Cl_2: MeOH	DPPH	26.7 μg/mL	Kenya	[283]
Juniperus procera Hochst. ex Endl.	Cupressaceae	Aerial parts	Oil	DPPH	14.9 μL/mL	Ethiopia	[281]
Leucas glabrata (vahl)Sm.	Lamiaceae	Aerial parts	Oil	DPPH	10.4% at 100 ppm	Tanzania	[284]
Lippia adoensis Hochst. ex Walp.	Verbenaceae	Leaf	Oil	DPPH	2.2 μl/ml	Ethiopia	[285]
Lippia adoensis Hochst. ex Walp.	Verbenaceae	Aerial parts	Oil	DPPH	6.13 μL/mL	Ethiopia	[277]
Mangifera indica L.	Anacardiaceae	Leaf	EtOH	ORAC	5940 μMTE/μg	Kenya	[56]
Mentha aquatica L.	Lamiaceae	Leaf	Oil	DPPH	11.2 μl/ml.	Ethiopia	[286]
Ocimum americanum L.	Lamiaceae	Leaf	EtOH	ORAC	3190 μMTE/μg	Kenya	[56]
Ocimum americanum L.	Lamiaceae	Leaf	CH_2Cl_2	DPPH	50.47%	Kenya	[287]
Ocimum americanum L.	Lamiaceae	Aerial parts	Oil	DPPH	16 μg/mL	Ethiopia	[288]
Ocimum basilicum L.	Lamiaceae	Aerial parts	Oil	DPPH	0.04 μL/mL	Ethiopia	[277]
Ocimum basillicum L.	Lamiaceae	Aerial parts	Oil	DPPH	60 μg/mL	Ethiopia	[288]
Ocimum gratissimum L.	Lamiaceae	Leaf	EtOH	ORAC	1594 μMTE/μg	Kenya	[56]
Plectranthus parviflorus Willd.	Lamiaceae	Aerial parts	Oil	DPPH	3.8% at 100 ppm	Tanzania	[284]

Table 5 Antioxidants activities of Eastern African plants *(Continued)*

Psidium guajava L.	Myrtaceae	Leaf	EtOH	ORAC	3929 μMTE/μg	Kenya	[56]
Rubus apetalus Thunb.	Rosaceae	Leaf	EtOH	DPPH	12.3 μg/mL	Ethiopia	[289]
Rubus niveus Thunb.	Rosaceae	Leaf	EtOH	DPPH	19 μg/mL	Ethiopia	[289]
Rubus steudneri Schweinf.	Rosaceae	Leaf	EtOH	DPPH	6.5 μg/mL	Ethiopia	[289]
Salvia nilotica Jacq.	Lamiaceae	Leaf	Oil	DPPH	7.52 μg/mL	Ethiopia	[290]
Salvia nilotica Jacq.	Lamiaceae	Aerial parts	Oil	DPPH	76.2% at 100 ppm	Tanzania	[284]
Salvia schimperi Jansen, P.C.M.	Lamiaceae	Leaf	Oil	DPPH	6.79 μg/mL	Ethiopia	[290]
Satureja punctata (Beth.) Briq.	Lamiaceae	Aerial parts	H_2O	DPPH	9.7 μg/mL	Ethiopia	[291]
Senna singueana (Delile)	Fabaceae	Leaf	EtOH	DPPH	6.16 μg/mL	Ethiopia	[292]
Solanum scabrum Mill.	Solanaceae	Leaf	EtOH	ORAC	2675 μMTE/μg	Kenya	[56]
Stephania abyssinica Quart. Dill & A. Rich.	Menispermaceae	Root	EtOH	DPPH	220 μg/mL	Ethiopia	[293]
Vernonia smithiana Less.	Asteraceae	Aerial parts	Oil	DPPH	6.6% at 100 ppm	Tanzania	[284]
Vigna unguiculata (L.) Walp.	Fabaceae	Leaf	EtOH	ORAC	1233 μMTE/μg	Kenya	[56]
Vitex payos (Lour.) Merr.	Verbenaceae	Fruit	EtOH	ORAC	179 μMTE/μg	Kenya	[56]
Zanthoxylum chalybeum Engl.	Rutaceae	Leaf	EtOH	ORAC	2414 μMTE/μg	Kenya	[56]
Zingiber officinale Roscoe.	Zingiberaceae	Rhizome	Oil	DPPH	9.66 μL/mL	Ethiopia	[277]

Key: *RSA* radical scavenging activity, *RC* reducing power capacity, *OH* hydroxyl ion, *NO* nitric oxide radical inhibition, H_2O_2 hydrogen peroxide inhibition activity, *LPO* lipid peroxidation inhibition activity, $ABTS^+$ 2,2′-azinobis-3–ethylbenzothiozolin-6–sulfonic acid cation decolourization test, *ß-CLAMS* ß-carotene-linoleic acid model system, *SORSA* superoxide anion radical scavenging activity (SORSA), *MLP* microsomal lipid peroxydation, *FRAP* fe^{2+} chelating ability and ferric reducing antioxidant properties, *DPPH* 1,1–dipheyl-2–picry-hydrazyl, *ORAC* oxygen radical absorbance capacity, *TEAC* trolox equivalent antioxidant capacity, *MeOH* methanol, CH_2Cl_2 dichloromethane, *EtOH* ethanol, *EtOAc* ethyl acetate, *n*-C_6H_{12} hexane, $(CH_3)_2CO$ acetone, H_2O aqueous, *BtOH* butanol

plant extracts including; *Punica granatum, Bombax malabaricum, Schefflera actinophylla, Phalangium variegate, Eucalyptus rostrata, Didonia viscose, Myrtus Communis, Tecoma capensis, Vitex trifolia, Gazania splendens, Lagerstroemia indica, Acalypha marginata, Laurus nobilis, Pelargonium oderatissimum, Khaya senegalensis* and *Spathodea tilotica* had extremely high antioxidant power (>80% inhibition). At 5 mg/mL plant extracts of the following plants; *Chrysanthemum frutesence, Aspidistra lurida, Thuja orientalis* and *Ruscus hyphoglossum* exhibited very low antioxidant properties of < 1% RSA. In separate studies the antioxidant activities were determined at relatively higher concentration (100 mg/mL), where *Capsicum annuum, Camellia sinensis, Atriplex sp.*, and *Asphodelus microcarpus* showed high % RSA [41].

Geographical locations usually influence the accumulation of secondary metabolites in most plants. Variations of these substances may be observed on different parts of the plants used in the study. Solvent systems used for extraction process may also substantially affect the composition of the extracts and hence their bioactivities [4].

The percentage (%) RSA using DPPH of the methanol and chloroform extracts of 124 Egyptian plants was evaluated at 50 mg/mL. The chloroform extracts of these plants were less active demonstrating % inhibition ranging from 0.5 to 49%; while the methanol extracts elaborating more polar compounds showed % inhibition ranging from 3 to 96 % [42].

The variations in scavenging activities of the methanol and chloroform extracts are most probably attributed to the differences in polarities of the phytochemicals [43], and also the classes of compounds extracted by the two solvents. Phytochemical investigation of some plants from Northern Africa exhibiting antioxidant and related activities led to isolation of approximately 56 compounds (Table 6 and Fig. 3). The most potent compounds included; nifedipine (**47**), trilinolein (**42**), usnic acid monoacetate (**41**), 5–bromosalicylaldehyde (**39**), naphtho [2,1–b]furan-2(1 h)- one,decahydro-3α,6,6,9α–tetramethy (**38**) and 2,3 dihydroxypropyl elaidate (**47**) (obtained from the leaf extract of *Solanum nigrum)* with % RSA of 78.4%, 68.5%, 74%,72.5%, 74% and 76% at 100 μg/mL respectively [44], and catechin (**120**) obtained from the ethyl acetate leaf extract of *Hydnora abyssinica* with % RSA of 68.5% at 1 mM [45]. The presence of these important compounds and the significant antioxidants power they demonstrated is an indication that these compounds, if properly screened could yield drugs of pharmaceutical significant.

Antioxidant activities of extracts of plants from Southern Africa

A total of 178 extracts from 145 plants belonging to 43 families were identified from Southern Africa (Table 3). However, the ethanol extract of the bark of *Sclerocarya birrea* and the leaf extract of *Harpephyllum caffrum,*

Table 6 Isolated Compounds from African medicinal plants with antioxidants potential

Compounds	Plant species	Part used	Family	Solvent Used	Assay Method	Activity/IC_{50}	Country of origin	Reference
Stigmasterol (**1**)	*Dorstenia barteri* L.	Whole plant	Moraceae	EtOAc; MeOH	DPPH	62.18 μg/mL	Cameroon	[31]
Isobavachalcone (**2**)	*Dorstenia barteri* L.	Whole plant	Moraceae	EtOAc; MeOH	DPPH	84.33 μg/mL	Cameroon	[31]
6–Prenylapigenin (**3**)	*Dorstenia kameruniana* Engl.	Leaf	Moraceae	EtOAc; MeOH	DPPH	86.43 μg/mL	Cameroon	[31]
Dorsmanin F (**4**)	*Dorstenia mannii* Hook.f.	Leaf	Moraceae	EtOAc; MeOH	DPPH	53.89 μg/mL	Cameroon	[31]
Quercitrin (**5**)	*Mallotus oppositifolium* (Geiseler) Mull. Arg.	Leaf	Moraceae	EtOAc; MeOH	DPPH	28.16 μg/mL	Cameroon	[31]
6,8–Diprenyleridictyol (**6**)	*Dorstenia mannii* Hook.f.	Leaf	Moraceae	EtOAc; MeOH	DPPH	32.12 μg/mL	Cameroon	[31]
Bartericin A (**7**)	*Dorstenia barteri* L.	Whole plant	Moraceae	EtOAc; MeOH	DPPH	47.85 μg/mL	Cameroon	[31]
Isoquercetrin (**8**)	*Bersama abyssinica* Fresen.	Leaf	Melianthaceae	MeOH	DPPH	23.7 μM	Ethiopia	[58]
Hyperoside (**9**)	*Bersama abyssinica* Fresen.	Leaf	Melianthaceae	MeOH	DPPH	22.6 μM	Ethiopia	[58]
Quercetin-3–*O* -Arabinopyranoside (**10**)	*Bersama abyssinica* Fresen.	Leaf	Melianthaceae	MeOH	DPPH	20.7 μM	Ethiopia	[58]
Kaempferol-3–*O*-Arabinopyranoside (**11**)	*Bersama abyssinica* Fresen.	Leaf	Melianthaceae	MeOH	DPPH	>50 μM	Ethiopia	[58]
Mangiferin (**12**)	*Bersama abyssinica* Fresen.	Leaf	Melianthaceae	MeOH	DPPH	15.9 μM	Ethiopia	[58]
Rutin (**13**)	*Cheilanthes farinose* Sw.	Aerial parts	Pteridaceae	MeOH	DPPH	9.5 μM	Ethiopia	[58]
Rutin (**13**)	*Cineraria abyssinica* Sch. Bip. Ex A.	Leaf	Asteraceae	MeOH	DPPH	3.53 μg/ml	Ethiopia	[57]
Quercetin-3–*O*-Diglucosylrhamnoside (**14**)	*Cheilanthes farinose* Sw.	Aerial parts	Pteridaceae	MeOH	DPPH	15.1 μM	Ethiopia	[58]
Kaempferol-3–*O*-Diglucosylrhamnoside (**15**)	*Cheilanthes farinose* Sw.	Aerial parts	Pteridaceae	MeOH	DPPH	>58.1 μM	Ethiopia	[58]
Kaempferol-3–*O*-Glucorhamnoside (**16**)	*Cheilanthes farinose* Sw.	Aerial parts	Pteridaceae	MeOH	DPPH	>78.0 μM	Ethiopia	[58]
Caffeic Acid (**17**)	*Cheilanthes farinose* Sw.	Aerial parts	Pteridaceae	MeOH	DPPH	23.3 μM	Ethiopia	[58]
Chlorogenic acid (**18**)	*Cheilanthes farinose* Sw.	Aerial parts	Pteridaceae	MeOH	DPPH	22.6 μM	Ethiopia	[58]
Quercetrin (**19**)	*Euclea racemosa* L.	Leaf	Ebenaceae	$(CH_3)_2CO$	DPPH	26.8 μM	Ethiopia	[58]

Table 6 Isolated Compounds from African medicinal plants with antioxidants potential *(Continued)*

Myricitrin (**20**)	*Euclea racemosa* L.	Leaf	Ebenaceae	$(CH_3)_2CO$	DPPH	14.2 μM	Ethiopia	[58]
Myricetin-3–*O*-Arabinopyranoside (**21**)	*Euclea racemosa* L.	Leaf	Ebenaceae	$(CH_3)_2CO$	DPPH	15.8 μM	Ethiopia	[58]
Quercetin (**22**)	*Euclea racemosa* L.	Leaf	Ebenaceae	$(CH_3)_2CO$	DPPH	18.2 μM	Ethiopia	[58]
Aloin (**23**)	*Aloe harlana* Reynolds.	Latex	Asphodelaceae	MeOH	DPPH	0.026 mM	Ethiopia	[279]
7-*O*-Methylaloeresin (**24**)	*Aloe harlana* Reynolds.	Latex	Asphodelaceae	MeOH	DPPH	0.026 mM	Ethiopia	[279]
α-Amyrin (**25**)	*Echinops galalensis* Schweinf.	Aerial parts	Asteraceae	EtOH	CCl_4–induce cell damage on Huh7	Decreas AST, ALT, MDA level and increase SOD activities	Egypt.	[102]
β-Sitosterol (**26**)	*Echinops galalensis* Schweinf.	Aerial parts	Asteraceae	EtOH	CCl_4–induce cell damage on Huh7	Decreas AST, ALT, MDA level and increase SOD activities	Egypt.	[102]
β-Sitosterol (**26**)	*Tinospora bakis* DC.	Leaf	Menispermaceae	EtOH	SORSA	33% at 1 mM	Sudan	[45]
β-Sitosterol (**26**)	*Piper umbellatum* L.	Branch	Piperaceae		DPPH	Less Potent	Cameroon	[294]
Erythrodiol (**27**)	*Echinops galalensis* Schweinf.	Aerial parts	Asteraceae	MeOH	CCl_4–induce cell damage on Huh7	Decreas AST, ALT, MDA level and increase SOD activities	Egypt.	[102]
Lup-20(29)-ene- 1,3–diol (**28**)	*Echinops galalensis* Schweinf.	Aerial parts	Asteraceae	MeOH	CCl_4–induce cell damage on Huh7	Decreas AST, ALT, MDA level and increase SOD activities	Egypt.	[102]
1,5–Dicaffeoylquinic acid (**29**)	*Echinops galalensis* Schweinf.	Aerial parts	Asteraceae	MeOH	CCl_4–induce cell damage on Huh7	Decreas AST, ALT, MDA level and increase SOD activities	Egypt.	[102]
3,5–Dicaffeoylquinic acid (**30**)	*Echinops galalensis* Schweinf.	Aerial parts	Asteraceae	MeOH	CCl_4–induce cell damage on Huh7	Decreas AST, ALT, MDA level and increase SOD activities	Egypt.	[102]
3,4–Dicaffeoylquinic acid (**31**)	*Echinops galalensis* Schweinf.	Aerial parts	Asteraceae	MeOH	CCl_4–induce cell damage on Huh7	Decreas AST, ALT, MDA level and increase SOD activities	Egypt.	[102]
4,5– Dicaffeoylquinic acid (**32**)	*Echinops galalensis* Schweinf.	Aerial parts	Asteraceae	MeOH	CCl_4–induce cell damage on Huh7	Decreas AST, ALT, MDA level and increase SOD activities	Egypt.	[102]
Apigenin-7–*O*-β-D-glucoside (**33**)	*Echinops galalensis* Schweinf.	Aerial parts	Asteraceae	MeOH	CCl_4–induce cell damage on Huh7	Decreas AST,ALT, MDA level and increase SOD activities	Egypt.	[102]
2, 3–Dihydro-2′-hydroxyosajin (**34**)	*Erythrina senegalensis* L.	Stem bark	Fabaceae	EtOH	DPPH/β-CLAMS/ FRAP	41.28/19.17/15.99 μg/mL	Cameroon	[295]
Osajin (**35**)	*Erythrina senegalensis* L.	Stem bark	Fabaceae	EtOH	DPPH/β-CLAMS/ FRAP	61.18/49.15/44.04 μg/mL	Cameroo	[295]
6, 8–Diprenylgenistein (**36**)	*Erythrina senegalensis* L.	Stem bark	Fabaceae	EtOH	DPPH/β-CLAMS/ FRAP	53.00/24.95/19.17 μg/mL	Cameroon n	[295]
2,3–Dihydroxypropyl elaidate (**37**)	*Solanum nigrum* L.	Leaf	Solanaceae	EtOH	DPPH	80.5% at 100 μg/mL	Egypt	[44]
Naphtho [2,1–B]furan-2(1H)-one, decahydro-3a,6,6,9a-tetramethyl (**38**)	*Solanum nigrum* L.	Leaf	Solanaceae	EtOH	DPPH	65.6% at 100 μg/mL	Egypt	[44]
5–Bromosalicylaldehyde (**39**)	*Solanum nigrum* L.	Leaf	Solanaceae	EtOH	DPPH	50.5% at 100 μg/mL	Egypt	[44]
12–Sulfanyldodecanoic acid (**40**)	*Solanum nigrum* L.	Leaf	Solanaceae	EtOH	DPPH	65.3% at 100 μg/mL	Egypt	[44]
Usnic acid monoacetate (**41**)	*Solanum nigrum* L.	Leaf	Solanaceae	EtOH	DPPH	60% at 100 μg/mL	Egypt	[44]
Trilinolein (**42**)	*Solanum nigrum* L.	Leaf	Solanaceae	EtOH	DPPH	40.8% at 100 μg/mL	Egypt	[44]

Table 6 Isolated Compounds from African medicinal plants with antioxidants potential *(Continued)*

Niclofen (**43**)	*Solanum nigrum* L.	Leaf	Solanaceae	EtOH	DPPH	45.6% at 100 μg/mL	Egypt	[44]
8–Azabicyclo [3.2.1] octane-2–carboxylic acid, 3–hydroxy-8–methyl,(2–endo, 3–exo) (**44**)	*Solanum nigrum* L.	Leaf	Solanaceae	EtOH	DPPH	30.2% at 100 μg/mL	Egypt	[44]
5,6–Dichloro-2–methyl-1H-benzimidazole (**45**)	*Cassia italic* Mill.	Leaf	Fabaceae	EtOH	DPPH	48.7% at 100 μg/mL	Egypt	[44]
trans-2–Methyl-4–*N*-Pentylthiane, (**46**)	*Cassia italic* Mill.	Leaf	Fabaceae	EtOH	DPPH	34.8% at 100 μg/mL	Egypt	[44]
Nifedipine (**47**)	*Cassia italic* Mill.	Leaf	Fabaceae	EtOH	DPPH	78.4% at 100 μg/mL	Egypt	[44]
Propionic acid (3,6,7,8–tetrahydro-3,7–methano-2,4,6–trimethyl-2H-Oxocin-7–yl) methyl ester (**48**)	*Cassia italic* Mill.	Leaf	Fabaceae	EtOH	DPPH	68.4% at 100 μg/mL	Egypt	[44]
Octadecyl bromoacetate (**49**)	*Cassia italic* Mill.	Leaf	Fabaceae	EtOH	DPPH	56.7% at 100 μg/mL	Egypt	[44]
Lophirones B (**50**)	*Lophira alata* Bank ex Gaertn.	Stem bark	Ochnaceae	$CHCl_3$	DPPH	84.4% at 1 mg/mL.Increase activities of SOD, CAT, GPx, and GR in the liver of rats	Nigeria	[40] and 2014b
Lophirones C (**51**)	*Lophira alata* Bank ex Gaertn.	Stem bark	Ochnaceae	$CHCl_3$	DPPH	90.0% at 1 mg/mL. Increase activities of SOD, CAT, GPx, and GR in the liver of rats	Nigeria	[40] and 2014b
3–Friedelanone (**52**)	*Irvingia gabonensis* (AubryLecomte ex O Rorke) Baill.	Stem bark	Irvingiaceae	MeOH	β-CLAMS/FRAP	49.05/38.28 μg/mL	Cameroon	[296]
Betulinic acid (**53**)	*Irvingia gabonensis* (AubryLecomte ex O Rorke) Baill.	Stem bark	Irvingiaceae	MeOH	β-CLAMS/FRAP	31.95/27.52 μg/mL	Cameroon	[296]
Oleanolic acid (**54**)	*Irvingia gabonensis* (AubryLecomte ex O Rorke) Baill.	Stem bark	Irvingiaceae	MeOH	DPPH/β-CLAMS/FRAP	8.55/6.53/11.76 μg/mL	Cameroon	[296]
3, 3′,4′-Tri-*O*-methyl ellagic acid (**55**)	*Irvingia gabonensis* (AubryLecomte ex O Rorke) Baill.	Stem bark	Irvingiaceae	MeOH	DPPH/β-CLAMS/FRAP	14.20/15.18/12.47 μg/mL	Cameroon	[296]
Methyl gallate (**56**)	*Irvingia gabonensis* (AubryLecomte ex O Rorke) Baill.	Stem bark	Irvingiaceae	MeOH	DPPH/β-CLAMS/FRAP	14.78/8.88/6.35 μg/mL	Cameroon	[296]
Hardwiickic acid (**57**)	*Irvingia gabonensis* (AubryLecomte ex O Rorke) Baill.	Stem bark	Irvingiaceae	MeOH	DPPH/β-CLAMS/FRAP	-	Cameroon	[296]
3–β-Acetoxyursolic acid (**58**)	*Irvingia gabonensis* (AubryLecomte ex O Rorke) Baill.	Stem bark	Irvingiaceae	MeOH	DPPH/β-CLAMS/FRAP	8.84/7.66/12.47 μg/mL	Cameroon	[296]
Plumbagin (**59**)	*Diospyros bipindensis* Gurke.	Stem bark	Ebenaceae	CH_2Cl_2	DPPH/ABTS	3.5/2.7% at 40 μg/mL	Cameroon	[297]
Canaliculatin (**60**)	*Diospyros bipindensis* Gurke	Stem bark	Ebenaceae	CH_2Cl_2	DPPH/ABTS	4.7/4.3% at 40 μg/mL	Cameroon	[297]
Ismailin (**61**)	*Diospyros bipindensis* Gurke	Stem bark	Ebenaceae	CH_2Cl_2	DPPH/ABTS	4.7/4.0% at 40 μg/mL	Cameroon	[297]

Table 6 Isolated Compounds from African medicinal plants with antioxidants potential *(Continued)*

Betulinic acid (**62**)	*Diospyros bipindensis* Gurke	Stem bark	Ebenaceae	CH_2Cl_2	DPPH/ABTS	6.4/6.5 at 40 μg/mL	Cameroon	[297]
4–Hydroxy-5–methylcoumarin (**63**)	*Diospyros bipindensis* Gurke	Stem bark	Ebenaceae	CH_2Cl_2	DPPH/ABTS	14.9/15.0% at μg/mL	Cameroon	[297]
Betulinic acid (**62**)	*Ficus gnaphalocarpa* (Miq.) Steud. ex A. Rich.	Stem bark	Moraceae	MeOH	CCl_4–induced hepatoma cells damage	Prevented liver cell death and LDH leakage	Cameroon	[55]
3–Methoxyquercetin (**64**)	*Ficus gnaphalocarpa* (Miq.) Steud. ex A. Rich.	Stem bark	Moraceae	MeOH	CCl_4–induced hepatoma cells damage	Prevented liver cell death and LDH leakage	Cameroon	[55]
Catechin (**65**)	*Ficus gnaphalocarpa* (Miq.) Steud. ex A. Rich.	Stem bark	Moraceae	MeOH	CCl_4–induced hepatoma cells damage	Prevented liver cell death and LDH leakage	Cameroon	[55]
Epicatechin (**66**)	*Ficus gnaphalocarpa* (Miq.) Steud. ex A. Rich.	Stem bark	Moraceae	MeOH	CCl_4–induced hepatoma cells damage	Prevented liver cell death and LDH leakage	Cameroon	[55]
Quercetin (**67**)	*Ficus gnaphalocarpa* (Miq.) Steud. ex A. Rich.	Stem bark	Moraceae	MeOH	CCl_4–induced hepatoma cells damage	Prevented liver cell death and LDH leakage	Cameroon	[55]
Quercitrin (**68**)	*Ficus gnaphalocarpa* (Miq.) Steud. ex A. Rich.	Stem bark	Moraceae	MeOH	CCl_4–induced hepatoma cells damage	Prevented liver cell death and LDH leakage	Cameroon	[55]
1,7–Dihydroxyxanthone (**69**)	*Allanblackia floribunda* Oliv.	Root bark	Guttiferae	MeOH	DPPH	488.53 μg/mL	Cameroon	[266]
Morelloflavone (**70**)	*Allanblackia floribunda* Oliv.	Root bark	Guttiferae	MeOH	DPPH	62.8 μg/mL	Cameroon	[266]
7′-*O*-Glucoside morelloflavone (**71**)	*Allanblackia floribunda* Oliv.	Root bark	Guttiferae	MeOH	DPPH	49.08 μg/mL	Cameroon	[266]
Piperumbellactams A (**72**)	*Piper umbellatum* L.	Whole plant	Piperaceae	-	DPPH	Less Potent	Cameroon	[294]
Piperumbellactams B (**73**)	*Piper umbellatum* L.	Whole plant	Piperaceae	-	DPPH	Potent activity	Cameroon	[294]
Piperumbellactams C (**74**)	*Piper umbellatum* L.	Whole plant	Piperaceae	-	DPPH	Potent activity	Cameroon	[294]
Piperumbellactams D (**75**)	*Piper umbellatum* L.	Whole plant	Piperaceae	-	DPPH	Less Potent	Cameroon	[294]
Apigenin –8–C- β -D-glucopyranoside (**76**)	*Croton zambesicus* Mull. Arg.	Fruit	Euphorbiaceace	MeOH	DPPH	<80.5% at 1 mM	Sudan	[298]
ent-Kaurane –3 β, 16 β, 17–triol (**77**)	*Croton zambesicus* Mull. Arg.	Fruit	Euphorbiaceace	MeOH	DPPH	<80.5% at 1 mM	Sudan	[298]
Lupeol (20(29) lupene-3–ol, 3 β -form)-derivative (**78**)	*Croton zambesicus* Mull. Arg.	Fruit	Euphorbiaceace	MeOH	DPPH	<80.5% at 1 mM	Sudan	[298]

Table 6 Isolated Compounds from African medicinal plants with antioxidants potential *(Continued)*

Lupenone lup –20(29) -ene-3 β –one(**79**)	*Diospyros mespiliform* Hochst. ex A. DC.	Fruit	Euphorbiaceace	MeOH	DPPH	<80.5% at 1 mM	Sudan	[298]
Betulin lup- 20(29)-ene-3 β, 28–diol (**80**)	*Croton zambesicus* Mull. Arg.	Fruit	Euphorbiaceace	MeOH	DPPH	<80.5% at 1 mM	Sudan	[298]
Betulinic acid 3β- hydroxylup-20(29)-en-28–oic acid-derivative (**81**)	*Croton zambesicus* Mull. Arg.	Fruit	Euphorbiaceace	MeOH	DPPH	<80.5% at 1 mM	Sudan	[298]
Betulinic acid 3β- hydroxylup-20(29)-en-28–oic acid (**82**)	*Croton zambesicus* Mull. Arg.	Fruit	Euphorbiaceace	MeOH	DPPH	<80.5% at 1 mM	Sudan	[298]
Lupeol (20(29) lupene-3–ol, 3 β -form) (**83**)	*Croton zambesicus* Mull. Arg.	Fruit	Euphorbiaceace	MeOH	DPPH	<80.5% at 1 mM	Sudan	[298]
Moracin T (**84**)	*Morus mesozygia* Stapf.	Bark	Moraceae	MeOH	DPPH	4.12 μg/mL	Cameroon	[54]
Moracin U (**85**)	*Morus mesozygia* Stapf.	Bark	Moraceae	MeOH	DPPH	5.06 μg/mL	Cameroon	[54]
Moracin S (**86**)	*Morus mesozygia* Stapf.	Bark	Moraceae	MeOH	DPPH	6.08 μg/mL	Cameroon	[54]
Moracin R (**87**)	*Morus mesozygia* Stapf.	Bark	Moraceae	MeOH	DPPH	7.17 μg/mL	Cameroon	[54]
5,7,3′-Trihydroxy-3,8,4′,5′-trimethoxyflavone (**88**)	*Microglossa pyrifolia* DC.	Leaf	Asteraceae	EtOAc	DPPH	8.79 mg/mL	Kenya	[299]
5,7,4′-Trihydroxy-3,8,3′,5′-tetramethoxyflavone (**89**)	*Microglossa pyrifolia* DC.	Leaf	Asteraceae	EtOAc	DPPH	6.45 mg/mL	Kenya	[299]
8–Acetoxyisochiliolide lactone (**90**)	*Microglossa pyrifolia* DC.	Leaf	Asteraceae	EtOAc	DPPH	6.45 mg/mL	Kenya	[299]
Harunmadagascarins A (**91**)	*Harungana Madagascariensis* Lam.	Stem back	Hypericaceae	Not specified	DPPH	60.97 μM	Cameroon	[300]
Harunmadagascarins B (**92**)	*Harungana Madagascariensis* Lam.	Stem back	Hypericaceae	Not specified	DPPH	60.97 μM	Cameroon	[300]
Harunganol B (**93**)	*Harungana Madagascariensis* Lam.	Stem back	Hypericaceae	Not specified	DPPH	64.76 μM	Cameroon	[300]
Harungin anthrone (**94**)	*Harungana Madagascariensis* Lam.	Stem back	Hypericaceae	Not specified	DPPH	155.39 μM	Cameroon	[300]
Emodin (**95**)	*Psorospermum febrifugum* Spach.	Stem bark	Clusiaceae	EtOAc; MeOH	DPPH	>70 GEAC; μg/mL	Cameroon	[272]
3–Geranyloxyemodin (**96**)	*Psorospermum febrifugum* Spach.	Stem bark	Clusiaceae	EtOAc; MeOH	DPPH	<50 GEAC; μg/mL	Cameroon	[272]
2–Geranylemodin (**97**)	*Psorospermum febrifugum* Spach.	Stem bark	Clusiaceae	EtOAc; MeOH	DPPH	<40 GEAC; μg/mL	Cameroon	[272]
Afzeliixanthones A (**98**)	*Garcinia afzelii* Engl.	Stem bark	Clusiaceae	EtOAc; MeOH	DPPH	17.7 μg/mL	Cameroon	[301]
Afzeliixanthones B (**99**)	*Garcinia afzelii* Engl.	Stem bark	Clusiaceae	EtOAc; MeOH	DPPH	14.0 μg/mL	Cameroon	[301]
Bangangxanthone A (**100**)	*Garcinia polyantha* Oliv.	Leaf	Guttiferae	$CHCl_3$	DPPH	87.0 μM	Cameroon	[302]
Bangangxanthone B (**101**)	*Garcinia polyantha* Oliv.	Leaf	Guttiferae	$CHCl_3$	DPPH	>87.0 μM	Cameroon	[302]
2–Hydroxy-1,7–dimethoxyxanthone (**102**)	*Garcinia polyantha* Oliv.	Leaf	Guttiferae	$CHCl_3$	DPPH	>87.0 μM	Cameroon	[302]

Table 6 Isolated Compounds from African medicinal plants with antioxidants potential *(Continued)*

1,5–Dihydroxyxanthone (**103**)	*Garcinia polyantha* Oliv.	Leaf	Guttiferae	$CHCl_3$	DPPH	>87.0 μM	Cameroon	[302]
Rheediinoside A (**104**)	*Entada rheedii* Spreng.	Seed	Mimosaceae	-	ABTS/DPPH	Low activity	Cameroon	[303]
Rheediinoside B (**105**)	*Entada rheedii* Spreng.	Seed	Mimosaceae	-	ABTS/DPPH	Moderat e activity	Cameroon	[303]
Piperumbellactams D (**106**)	*Piper umbellatum* L.	Whole plant	Piperaceae	-	DPPH	Less Potent	Cameroon	[294]
N-Hydroxyaristolam II (**107**)	*Piper umbellatum* L.	Whole plant	Piperaceae	-	DPPH	Potent activity	Cameroon	[294]
4–Nerolidylcatechol (**108**)	*Piper umbellatum* L.	Whole plant	Piperaceae	-	DPPH	Less Potent	Cameroon	[294]
N-Transferuloyltyramine (**109**)	*Piper umbellatum* L.	Whole plant	Piperaceae	-	DPPH	Less Potent	Cameroon	[294]
E-3–(3,4–Dihydroxyphenyl)-N-2–[4–Hydroxyphenylethyl]-2–Propenamide (**110**)	*Piper umbellatum* L.	Whole plant	Piperaceae	-	DPPH	Less Potent	Cameroon	[294]
β-Amyrin (**111**)	*Piper umbellatum* L.	Whole plant	Piperaceae	-	DPPH	Less Potent	Cameroon	[294]
Friedelin (**112**)	*Piper umbellatum* L.	Whole plant	Piperaceae	-	DPPH	Less Potent	Cameroon	[294]
Apigenin 8–C-Neohesperidoside (**113**)	*Piper umbellatum* L.	Whole plant	Piperaceae	-	DPPH	Less Potent	Cameroon	[294]
Acacetin 6–C- B-D-glucopyranoside (**114**)	*Piper umbellatum* L.	Branch	Piperaceae	-	DPPH	Less Potent	Cameroon	[294]
Alpinumisoflavone (**115**)	*Ficus chlamydocarpa* Mildbr. & Burret.	Stem bark	Moraceae	MeOH	DPPH/β-CLAMS/FRAP	6/8.9/8.0 μg/mL	Cameroon	[99]
Genistein (4′,5,7– trihydroxyisoflavone) (**116**)	*Ficus chlamydocarpa* Mildbr. & Burret.	Stem bark	Moraceae	MeOH	DPPH	5.7 μg/mL	Cameroon	[99]
Luteolin (3′,4′,5,7– tetrahydroxy Flavone) (**117**)	*Ficus chlamydocarpa* Mildbr. & Burret.	Stem bark	Moraceae	MeOH	DPPH/β-CLAMS/FRAP	5.0/6.9/5.1 μg/mL	Cameroon	[99]
3,11,12,14,19–Pentahydroxy-5,8,11,13–abietatraen-7–pyran[4,6]-16–dione (**118**)	*Plectranthus punuctatus* L.	Leaf	Lamiaceae	MeOH	DPPH	9.65 μg/mL	Ethiopia	[304]
Tetradecanoic acid, 2–hydroxyhexadecyl ester (**119**)	*Hydnora abyssinica* A. Braun ex Schweinf.	Leaf	Hydnoraceae	EtOH	SORSA	37% at 1 mM	Sudan	[45]
Catechin (**120**)	*Hydnora abyssinica* A. Braun ex Schweinf.	Leaf	Hydnoraceae	EtOH	SORSA	68.5% at 1 mM	Sudan	[45]
Tyrosol (**121**)	*Hydnora abyssinica* A. Braun ex Schweinf.	Leaf	Hydnoraceae	EtOH	SORSA	26% at 1 mM	Sudan	[45]
Benzoic acid, 3, 4–dihydroxy-, ethyl ester (**122**)	*Hydnora abyssinica* A. Braun ex Schweinf.	Leaf	Hydnoraceae	EtOH	SORSA	59% at 1 mM	Sudan	[45]
Columbin (**123**)	*Tinospora bakis* (A.Rich.)Miers.	Leaf	Menispermaceae	EtOH	SORSA	20% at 1 mM	Sudan	[45]
Przewalskinone B (**124**)	*Tinospora bakis* (A.Rich.)Miers.	Leaf	Menispermaceae	EtOH	SORSA	29% at 1 mM	Sudan	[45]

Table 6 Isolated Compounds from African medicinal plants with antioxidants potential *(Continued)*

1–Tetracontanol (**125**)	*Tinospora baki* (A.Rich.) Miers.	Leaf	Menispermaceae	EtOH	SORSA	26% at 1 mM	Sudan	[45]
Di-P,octyl phenoxy 1,5 naphthalene dicarboxylase ester (**126**)	*Cassia italic* Mill.	Leaf	Fabaceae	EtOH	DPPH	30.2% at 100 μg/mL	Egypt.	[44]
Propionic acid (3,6,7,8–tetrahydro-3,7–methano-2,4,6–trimethyl-2 h-oxocin-7–yl) methyl ester (**127**)	*Cassia italic* Mill.	Leaf	Fabaceae	EtOH	DPPH	68.4% at 100 μg/mL	Egypt.	[44]
Octadecyl bromoacetate (**128**)	*Cassia italic* Mill.	Leaf	Fabaceae	EtOH	DPPH	56.7% at 100 μg/mL	Egypt.	[44]
11–*O*-Phydroxybenzoylnorbergenin (**129**)	*Diospyros sanza-minika* A. Chev.	Stem bark	Ebenaceae	-	DPPH	-	Cameroon	[305]
4–*O*-(30–Methylgalloyl) Norbergenin (**130**)	*Diospyros sanza-minika* A. Chev.	Stem bark	Ebenaceae	-	DPPH	-	Cameroon	[305]
4–*O*-Syringoylnorbergenin; Norbergenin (**131**)	*Diospyros sanza-minika* A. Chev.	Stem bark	Ebenaceae	-	DPPH	-	Cameroon	[305]
4–*O*-Galloylnorbergenin (**132**)	*Diospyros sanza-minika* A. Chev	Stem bark	Ebenaceae	-	DPPH		Cameroon	[305]
Quercitol (**133**)	*Diospyros sanza-minika* A. Chev	Stem bark	Ebenaceae	-	DPPH		Cameroon	[305]

Key: *RSA* radical scavenging activity, *RC* reducing power capacity, *OH* hydroxyl ion, *NO* nitric oxide radical inhibition, H_2O_2 hydrogen peroxide inhibition activity, *LPO* lipid peroxidation inhibition activity, $ABTS^+$ 2,2′-azinobis-3–ethylbenzothiozolin-6–sulfonic acid cation decolourization test, ß-*CLAMS* ß-carotene-linoleic acid model system, *MLP* microsomal lipid peroxydation, *FRAP* fe^{2+} chelating ability and ferric reducing antioxidant properties, *DPPH* 1,1–dipheyl-2–picry-hydrazyl, *ORAC* oxygen radical absorbance capacity, *TEAC* trolox equivalent antioxidant capacity, *MeOH* methanol, CH_2Cl_2 dichloromethane, *EtOH* ethanol, *EtOAc* ethyl acetate, $n\text{-}C_6H_{12}$, hexane, $(CH_3)_2CO$ acetone, H_2O aqueous, *BtOH* butanol

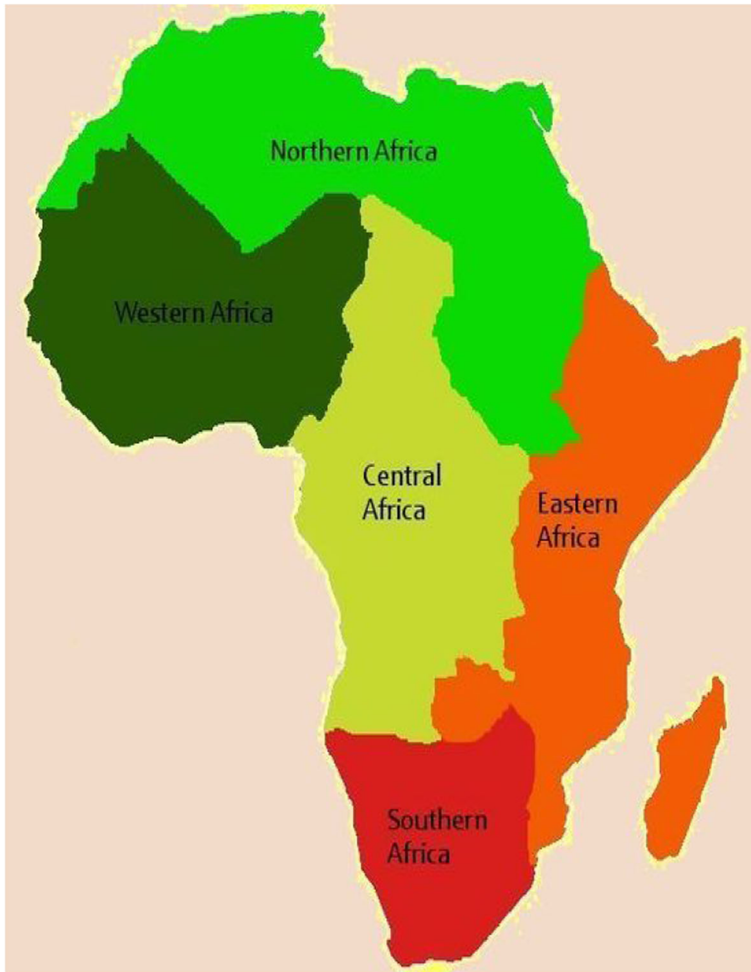

Fig. 1 Map of Africa showing the different subregions

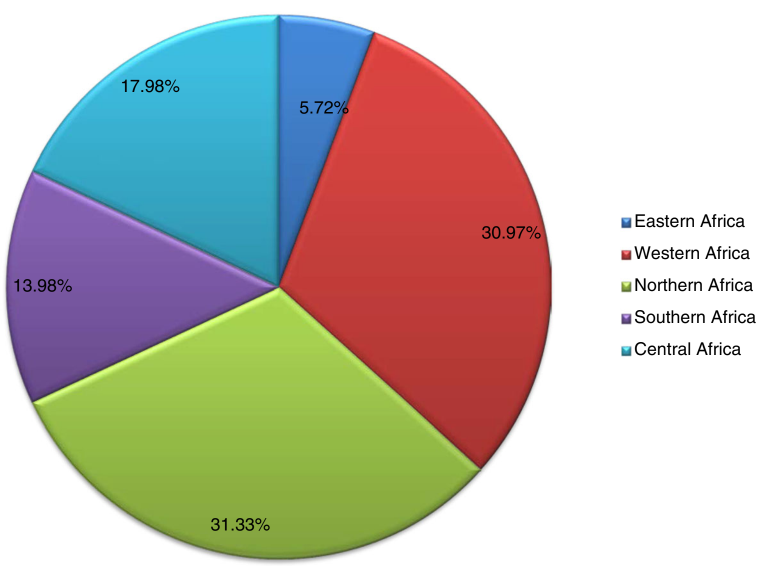

Fig. 2 Regional distribution of of investigated African plants with antioxidant potentials

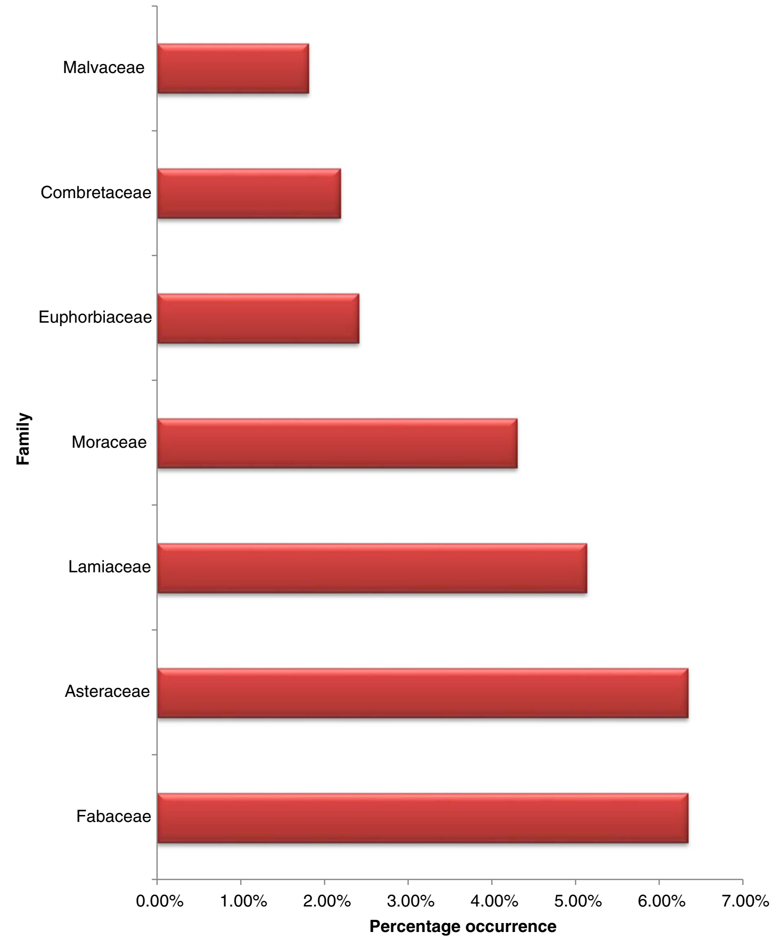

Fig. 3 Percentage occurrence of the most investigated African plants families for antioxidants activities

Aspalathus lineari and *Combretum apiculatum* demonstrated the most significant DPPH scavenging activities with IC_{50} values of 2.06 ± 0.03, 2.6 ± 0.21, 3.5 ± 0.5 and 1.6 ± 0.02 μg/mL, respectively while leaf extract of *Galenia africana* revealed weak antioxidants activity with an IC_{50} value of 90.92 ± 1.2 μg/mL [46]. The antioxidant capacity of plant extracts were found to vary with the antioxidant assays used, for instance, Katerere et al. [47] reported Trolox equivalents (TEAC) per 100 g of plant material of *Vigna unguiculata, Lippia javanica, Tagetes minuta, Bidens pilosa, Telfairia occidentalis* and *Corchorus olitarius* which ranged from 0.76 to 5.77 mmol Trolox/100 g in ABTS assay and 16.29–1711.22 mmol Trolox/100 g for the DPPH assay. Similarly, Thozama [48] reported the percentage (%) inhibition of *Chenopodium album, Solanum nigrum, Urtica lobulata* and *Amaranthus dubius* ranging from 35 to 50% in DPPH assay and from 60 to 75% in ABTS assay. The difference in the antioxidant potencies among the assays was expected as each method has a unique mechanism of action under different reaction conditions [49]. For instance, $ABTS^{+}$ is soluble in both aqueous and organic solvents and thus can be used to determine the antioxidant capacities of both lipophilic and hydrophilic substance [49, 50]. Viol [51] studied the antioxidants activity of 27 Zimbabwe medicinal plants extracts. Eight of these extracts exhibited antioxidant activities using DPPH with the leaves and root extracts of *Rhus chirindensis* and the bark of *Khaya anthotheca* exhibiting significant RSA of 96.9% and 96.1%, respectively. However, the roots of *Dichrostachys cinerea* revealed modest activities with RSA of 27.4% [51].

Antioxidant activities of extracts of plants from Central Africa

A total of 198 extracts from 166 plants belonging to 38 families originating from Central Africa, predominantly from Cameroon, have been investigated for their antioxidant potential (Table 4). The extracts that exhibited the highest antioxidant activities included; methanol extracts of the leaves and stem of *Acalypha racemosa* with IC_{50} values of 2.11 and 2.28 μg/mL, respectively; of the fruits and bark of *Garcinia lucida* with IC_{50} 1.83 and 2.35 μg/mL, respectively and of

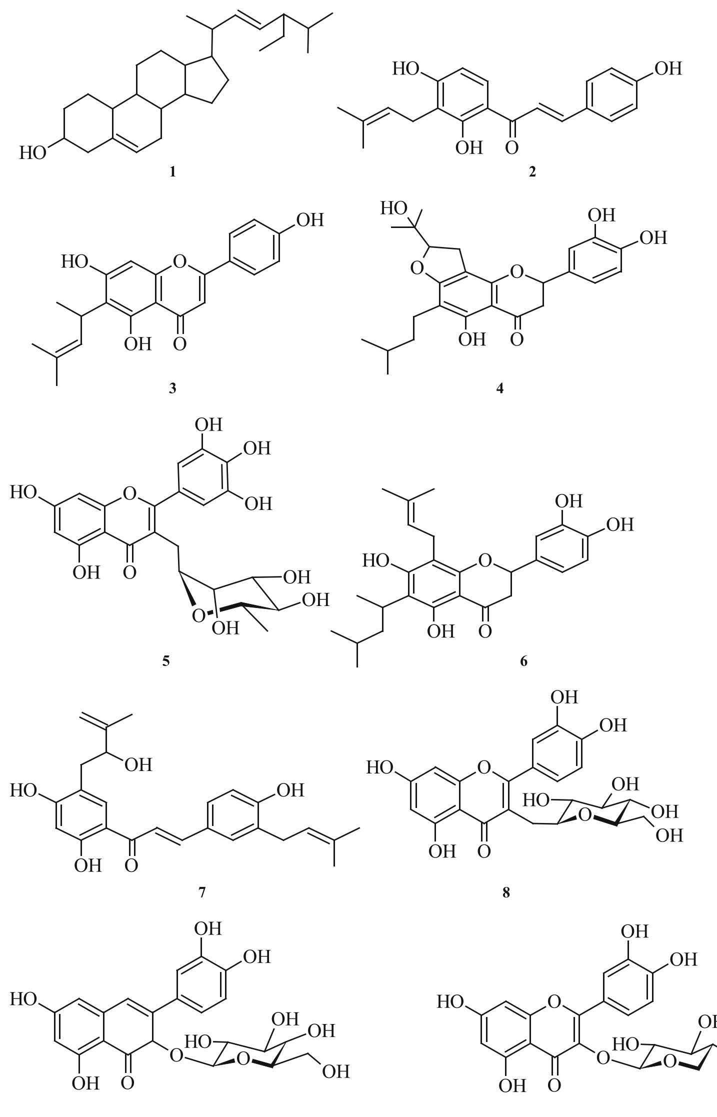

Fig. 4 Structure of chemical compounds isolated from African plants with potential antioxidants and hepatoprotectives properties (Additional file 1)

the roots and bark of *Hymenocardia lyrata* with IC_{50} values of 1.96 and 1.74 μg/mL, respectively [52]. Agbor et al. [53] investigated different extracts of 42 medicinal plants for their antioxidant activities. The methanol extract of the leaves of *Harungana madagascariensis,* bark of *Azadirachta indica,* leaves of *Psidium guqjava* and leaf of *Alchornea* were considered to have the highest activities using three different assay systems for antioxidant analysis. Detailed phytochemical studies of ethnomedicinal plants from Central Africa having antioxidant activities led to isolation of approximately 62 compounds (Table 6, Fig. 3). The most active compound included; moracin T, U, S and R (**84**–**87**) isolated from the bark of *Morus mesozygia*. These compounds revealed significant DPPH scavenging potential exhibiting IC_{50} values of 4.12, 5.06, 6.08 and 7.17 μg/mL, respectively [54]. Additionally, Donfack et al. [55], studied the in vitro hepatoprotective activity of six (6) compounds from methanol stem bark of *Ficus gnaphalocarpa*; betulinic acid (**53**), catechin (**65**), quercetin (**67**), quercitrin (**68**), epicatechin (**66**) and 3–methoxyquercetin (**64**). In this study, simultaneous treatment of hepatoma cells with these compounds exhibited antioxidants and hepatoprotective effects as judged by their ability to prevent liver cell death and LDH leakage during CCl_4 intoxication. The hepatoprotection, showed by the aptitude of these molecules to preserve cellular viability and to inhibit the leakage of LDH in extracellular medium was particularly pronounced with compounds (**64**, **67**–**68**).

Table 7 Total phenol, total flavonoids and folic acid content of some African medicinal plants with Antioxidant potential

Plants	Family	Part studied	Solvents used	Total Phenol contents	Folic acid contents	Total flavonoids contents	Country of origine	Reference
Adansonia digitata L.	Bombacaceae	Fruit	-	<14.08 g/100 g	–	–	Zimbabwe	[306]
Adasonia digitata L.	Bombacaceae	Leaf	MeOH	170.9 mg/g	–	25.38 mg/g	Nigeria	[175]
Ajuga iva (L.) Schreb.	Lamiaceae	Aerial parts	MeOH	3.96 mg/g		0.87 mg/g	Algeria	[193]
Albizia amara (Roxb,) Boiv.	Fabaceae	Leaf Stem	EtOH	0.077 mg/100 g			Zimbabwe	[307]
Allium sativum L.	Alliaceae			12.42 mg/g		0.0021 g/g	Nigeria	[308]
*Aloe barbadensis (*L.). Burm. f.	Aloaceae	Leaf		0.232 g/100 g		3.246 g// 100 g	Nigeria	[309]
Amaranthus dubius Mart. ex Thell.	Amaranthaceae	Leaf	MeOH	18.03 mg/g	-	11.08 mg/g	South Africa	[48]
Amaranthus hybridus L.	Amaranthaceae	Leaf	MeOH	39.32 mg/g			Nigeria	[150]
Amaranthus viridis L.	Amaranthaceae	Leaf	MeOH	49.3 mg/g			Nigeria	[150]
Anacyclus clavatus (Desf.) Pers.		Aerial parts	MeOH	71.09 mg/g		3.60 mg/g	Algeria	[193]
Anogeissus leiocarpus (DC.) Guill & Perr.	Combretaceae	Leaf	MeOH	223.1 mg/g	-	223.1 mg/g	Mali	[310]
Bauhinia rufescens Lam.	Caesalpiniaceae	Leaf	MeOH	68.40 mg/g		-	Nigeria	[154]
Beilschmiedia mannii Nees.	Lauraceae	Seed		206.4 g/100 g			Ivory coast	[165]
Blighia sapida K.D. Koenig.	Sapindaceae	Mushroom	MeOH	91.8 mg/g		72.8 mg/g	Nigeria	[311]
Calycotome spinosa L.	Fabaceae	Leaf	MeOH	143.55 mg/g		4.87 mg/g	Algeria	[193]
Cantharellus Cibarius Fr.	Cantharellaceae	Mushroom	-	-	5.07 ± 0.39		Nigeria	[160]
Cassia abbreviate Oliv.	C aesalpinioidaeae	Bark/leaf/ root	MeOH	0.41/0.24/ 0.398 mg/mg	-	-	Zimbabwe	[51]
Celosia argentea L.	Amaranthaceae	Leaf	MeOH	212.16 mg/g	-	47.88 mg/g	Nigeria	[175]
Centaurea calcitrapa L.	Asteraceae	Aerial parts	MeOH	57.50 mg/g	-	3.28 mg/g	Algeria	[193]
Ceratotheca sesamoides Endl.	Pedaliaceae	Leaf	MeOH	186.2 g/100 g			Ivory coast	[165]
Chenopodium album L.	Amaranthaceae	Leaf	MeOH	9.34 mg/g	-	9.14 mg/g	South Africa	[48]
Cissus populnea Guill & Perr.	Vitidaceae	Root back		76.4 mg/g	-	27.6 mg/g	Mali	[310]
Cleome gynandra L.	Capparidaceae	Leaf	CH_2Cl_2	188.2 g/100 g		-	Ivory coast	[165]
Clitocybe odora (Fr.) P. Kumm.	Tricholometaceae	Mushroom	Not stated	-	4.79 g/ 100 g	-	Nigeria	[160]
Cnestis ferruginea DC.	Connaraceae	Leaf	H_2O	125.58 mg/g	-	27.95 mg/g	Ivory coast	[166]
Corchorus olitorius L.	Malvaceae	Leaf	MeOH	330.07 mg/g	-	157.38 mg/ g	Nigeria	[175]
Crinum bulbispermum (Burm.f) Milne-Redhead & Schweick.	Amaryllidaceae	Root	EtOAc	202.38 mg/g	-	9.18 mg/g	South Africa	[234]
Cupressus sempervirens L.	Cupressaceae	Leaf	MeOH	143.5 mg/g	-	3.09 mg/g	Algeria	[193]
Dialium dinklagei Harms.	Caesalpiniaceae	Leaf	H_2O	185.59 mg/g	-	6.78 mg/g	Ivory coast	[166]
Dichrostachys cinerea Wight et Arn.	Mimosaceae	Leaf/Root	MeOH	0.28/0.10 mg/mg	-	-	Zimbabwe	[51]
Diospyros monbuttensis L.	Ebenaceae	Leaf	H_2O	136.54 mg/g	-	62.18 mg/g	Ivory coast	[166]
Elaedendron malanorpum F. Muell.	Celastraceae	Root	MeOH	0.357 mg/mg	-	-	Zimbabwe	[51]
Elephantorrhiza goetzei	Leguminosae	Root	MeOH	0.339 mg/mg	-	-	Zimbabwe	[51]
Elionurus muticus (Spreng.) Kuntze.	Poaceae	Whole Plant		0.076 mg/100 g	-	-	Zimbabwe	[307]
Ethulia conyzoides Lf.	Asteraceae	Leaf	MeOH	425 mg/100 g	-	-	Nigeria	[172]
Fadogia ancylantha Hiern.	Rubiaceae	Leaf	MeOH	<14.08 g/100 g	-	-	Zimbabwe	[306]

Table 7 Total phenol, total flavonoids and folic acid content of some African medicinal plants with Antioxidant potential *(Continued)*

Ficus carica L.	Moraceae	Leaf	MeOH	23.70 mg/g		3.75 mg/g	Algeria	[193]
Ficus asperifolia L.	Moraceae	Leaf	H_2O	69.20 mg/g	–	39.90 mg/g	Nigeria	[174]
Ficus dicranostyla E.J. & Ake Assi, L.	Moraceae	Leaf	CH_2Cl_2	178.5 g/100 g	–	–	Ivory coast	[165]
Ficus sycamore L.	Moraceae	Leaf		14.08 g/100 g	–	–	Zimbabwe	[306]
Flacourtia indica (Burm.f.) Merr.	Flacourticaceae	Leaf/Root	MeOH	0.431/0.21 mg/mg	–	–	Zimbabwe	[51]
Globularia alypum L.	Plantaginaceae	Leaf	MeOH	25.38 mg/g	–	3.76 mg/g	Algeria	[193]
Gnetum africanum L.	Gnetaceae	Leaf	MeOH	227.47 mg/g	–	91.75 mg/g	Nigeria	[175]
Gongronema latifolium (Endl.)	Apocyanaceae	Leaf	MeOH	186.60 mg/g	–	51.87 mg/g	Nigeria	[175]
Gymnosporia senegalensis Lam.	Celastraceae	Leaf/Root/ Twig	MeOH	0.34/0.22/0.268 mg/ mg	–	–	Zimbabwe	[51]
Helychrisum stoechas Mill.	Asteraceae	Aerial parts	MeOH	15.43 mg/g	–	4.36 mg/g	Algeria	[193]
Hericium erinaceus (Bull.) Persoon.	Hericiaceae	Mushroom	MeOH	–	5.51 g/ 100 g		Nigeria	[160]
Herniaria glabra L.	Caryophyllacea	Aerial parts	MeOH	34.48 mg/g		4.90 mg/g	Algeria	[193]
Heteropyxis natalensis L.	Heteropyxidaceae	Leaf Stem	EtOH	0.096 mg/100 g	–	–	Zimbabwe	[307]
Hibiscus sabdariffa L.	Malvaceae	Leaf	MeOH	104.8 mg/g	–	–	Nigeria	[177]
Hibiscus sabdariffa L.	Malvaceae	Leaf	MeOH	388.46 mg/g	-	87.00 mg/g	Nigeria	[175]
Hoslundia opposita Engl.	Lamiaceae	Leaf Stem	EtOH	0.054 mg/100 g	-	-	Zimbabwe	[307]
Hypoxis hemerocallidea Fisch. Mey. & Ave-Lall.	Hypoxidaceae	Tuber	MeOH	0.476 mg/mg	-	-	Zimbabwe	[51]
Justicia galeopsis T. Anderson ex C.B. Clarke	Acanthaceae	Leaf	CH_2Cl_2	189.8 g/100 g	-	-	Ivory coast	[165]
Khaya anthotheca (Welw.) C. DC.	Meliaceae	Bark/Root	MeOH	0.596/0.336 mg/mg	-	-	Zimbabwe	[51]
Kigelia africana DC.	Bignoniaceae	Bark/Fruit/ Root	MeOH	0.224/0.327/ 0.184 mg/mg	-	-	Zimb	[51]
Laccaria amethysta (Huds.) Cooke	Hydnangiaceae	Mushroom	Not stated	-	5.30 g/ 100 g	-	Nigeria	[160]
Laccaria laccata (Scop.) Cooke	Hydnangiaceae	Mushroom	Not stated	-	4.87 g/ 100 g	-	Nigeria	[160]
Lactarius deliciousus (L.ex Fr) S.F. Gray.	Russulaceae	Mushroom	Not stated	-	4.93 g/ 100 g	-	Nigeria	[160]
Lactuca taraxicofolia (Wild.) Schum.	Asteraceae	Leaf	MeOH	28.38 mg/g	-	-	Nigeria	[150]
Lannea schweinfurthii Engl.	Anacardiaceae	Root	MeOH	10127 mg/g	-	13.58 mg/g	South Africa	[234]
Laportea aestuans (L.) Chew	Urticaceae	Leaf	Not stated	199.3 mg/100 g	52.0 mg/ 100 g	90.7 mg/ 100 g	Nigeria	[179]
Lepista nuda (Bull.)H.E. Bigelow & A.H. Sm.	Tricholomataceae	Mushroom	Not stated	-	5.02 g/ 100 g	-	Nigeria	[160]
Lepista saeva (Fr.) Cooke.	Tricholomataceae	Mushroom	Not stated	-	5.17 g/ 100 g	-	Nigeria	[160]
Lippia javanica L.	Verbenaceae	Leaf	Not stated	<14.08 g/100 g	-	-	Zimbabwe	[306]
Lippia javanica L.	Verbenaceae	Leaf Stem	Not stated	0.064 mg/100 g	-	-	Zimbabwe	[307]
Macrolepiot ataprocera (Scop.) Singer.	Lepiotaceae	Mushroom	Not stated	-	4.72 g/ 100 g	-	Nigeria	[160]
Marrubium vulgare L.	Lamiaceae	Aerial parts	MeOH	47.58 mg/g		2.01 mg/g	Algeria	[193]
Mitragyna inermis Korth.	Rubiaceae	Trunk bark		19.5 mg/g	-	11.1 mg/g	Mali	[310]
Moringa oleifera Lam	Moringaceae	Leaf	MeOH	366.66 mg/g		34.16 mg/g	Nigeria	[175]
Myrianthus arboreus P. Beauv.	Cecropiaceae	Leaf	Not stated	263.9 g/100 g	-	-	Ivory coast	[165]

Table 7 Total phenol, total flavonoids and folic acid content of some African medicinal plants with Antioxidant potential *(Continued)*

Myrothamnus flabellifolius Welw.	Myrothamnaceae	Leaf	CH_2Cl_2	<14.08 g/100 g	-	–	Zimbabwe	[306]
Newbouldia laevis (P.Beauv.Seem. ex Bureau.	Bignoniaceae	Leaf	H_2O	91.49 mg/g	-	22.42 mg/g	Ivory coast	[166]
Ocimum urticifolia (N.E.Br) A.J. Paton.	Lamiaceae	Leaf Stem		0.024 mg/100 g	-	-	Zimbabwe	[307]
Origanum glandulosum Desf.		Aerial parts	MeOH	96.36 mg/g	-	7.56 mg/g	Algeria	[193]
Pinus halipensis	Pinaceae	Leaf	MeOH	108.66 mg/g	-	2.80 mg/g	Algeria	[193]
Piper capense L.f. var. Capense.	Piperaceae	Root	MeOH	237.60 mg/g	-	18.14 mg/g	South Africa	[234]
Piper guineense Sw.	Piperaceae	Leaf	MeOH	319.17 mg/g	-	85.41 mg/g	Nigeria	[175]
Pistacia lentiscus L.		Leaf	MeOH	205.22 mg/g	-	8.21 mg/g	Algeria	[193]
Plantago major L.	Plantaginaceae	Aerial parts	MeOH	106.70 mg/g	-	1.54 mg/g	Algeria	[193]
Pleurotus ostreatus (Jacq. ex Fr.) P.Kumm.	Pleurotaceae	Mushroom	Not stated	-	4.75 g/ 100 g		Nigeria	[160]
Populus trimula L.	Salicaceae	Leaf	MeOH	116.60 mg/g	-	3.98 mg/g	Algeria	[193]
Psalliota campestris L.	Agaricaceae	Mushroom		6.012 mg/g	-	0.031 g/g	Nigeria	[308]
Psorospermum febrifugum Spach	Hypericaceae	Leaf	MeOH	29.18 mg/100 g	-		Ivory coast	[165]
Pterocarpus midbraedii Jacq.	Fabaceae	Leaf	MeOH	499.78 mg/g	-	127.88 mg/ g	Nigeria	[175]
Rhamnus alaternus L.	Rhamnaceae	Leaf	MeOH	107.95	-	26.84 mg/g	Algeria	[193]
Rhus chirindensis Baker f.	Anacardiaceae	Leaf/Root	MeOH	0.323/0.258 mg/mg	-		Zimbabwe	[51]
Rhynchosia buettneri	Fabaceae	Leaf	MeOH	224.5 g/100 g	-		Ivory coast	[165]
Salix alba L.		Cortex	MeOH	259.65 mg/g	–	1.13 mg/g	Algeria	[193]
Sclerocarya birrea (A.Rich.) Hochst.	Celastraceae	Bark	MeOH	0.439 mg/mg	-		Zimbabwe	[51]
Securidaca longepedunculata Engl.	Polygalaceae	Root	MeOH	0.406 mg/mg	-	-	Zimbabwe	[51]
Sesamum radiatum Sendtn.	pedaliaceae	Leaf	MeOH	273.32 mg/g	–	48.50 mg/g	Nigeria	[175]
Sesamum radiatum Sendtn.	Pedaluiaceae	Leaf	MeOH	273.32 mg/g	-	48.50 mg/g	Nigeria	[175]
Solanium aethiopium L.	Solanaceae	Leaf	MeOH	40.60 mg/g	-	-	Nigeria	[150]
Solanum macrocarpum L.	Solanaceae	Leaf	MeOH	183.1 g/100 g	-	-	Ivory coast	[165]
Solanum melongena L.	Solanaceae	Leaf	MeOH	178.74 mg/g	-	85.33 mg/g	Nigeria	[175]
Solanum nigrum L.	Solanaceae	Leaf	MeOH	30.00 mg/g	-	13.30 mg/g	South Africa	[48]
Sysimbrium officinalis (L.) Scop.	BrassicaceaE	Flower	MeOH	48.87 mg/g	-	4.86 mg/g	Algeria	[193]
Telfaria occidentalis Hook. f	Cucurbitaceae	Leaf	MeOH	49.32 mg/g	-	-	Nigeria	Adetutu et al., 2015
Terminalia macroptera Guill. & Perr.	Combretaceae	Trunk bark		48.5 mg/g	-	14.2 mg/g	Mali	[310]
Terminalia sericea Burch. ex DC.	Combretaceae	Root	MeOH	36.73 mg/g	-	73.05 mg/g	South Africa	[234]
Terminalia sericea Burch. ex DC.	Combretaceae	leaf/Root	MeOH	0.208/0.228 mg/mg	-	-	Zimbabwe	[51]
Teucrium polium L.	Lamiaceae	Aerial parts	MeOH	134.00 mg/g	-	3.44 mg/g	Algeria	[193]
Trema orientalis (L.) Blume.	Cannabaceae	Leaf	H_2O	240.73 mg/g	-	59.59 mg/g	Ivory coast	[166]
Trichaptum biforme	Polyporaceae	Mushroom	-	4.41 mg/g	-	0.0174 g/g	Nigeria	[308]
Tricholoma nudum (L.) P. Kumm.	Tricholometaceae	Mushroom	-	64.122 mg/g	-	0.0164 g/g	Nigeria	[308]
Ulmus campestris Mill.	Urticaceae	Leaf	MeOH	24.21 mg/g	-	3.60 mg/g	Algeria	[193]
Urtica lobulata E. Mey. Ex Bl.	Urticaceae	Leaf	MeOH	20.25 mg/g	-	11.01 mg/g	South Africa	[48]
Vepris heterophylla (Engl.) Letouzey.	Rutaceae	Leaf		51.5 mg/g	-	9.3 mg/g	Mali	[310]

Table 7 Total phenol, total flavonoids and folic acid content of some African medicinal plants with Antioxidant potential *(Continued)*

Vitellaria paradoxa C.F. Gaetn.	Sapotacee	Mushroom	MeOH	55.6 mg/g	-	64.8 mg/g	Nigeria	[311]
Vitex doniana L.	Verbernaceae	Mushroom	MeOH	96.4 mg/g	-	20.8 ± 0.05 mg/g	Nigeria	[311]
Warburgia salutaris (Bertol.f) Chiov.	Canellaceae	Leaf/Stem	EtOH	0.065 mg/100 g	-	-	Zimbabwe	[307]
Warburgia salutaris (Bertol.f) Chiov.	Canellaceae	Bark/Leaf/ Root/Twig	MeOH	0.208/0.228/0.296/ 0.278 mg/mg	-	-	Zimbabwe	[51]
Zanthoxylum davyi (I. Verd.) Waterm.	Rutaceae	Root	MeOH	97.26 mg/g	-	8.66 mg/g	South Africa	[234]
Zingiber officianale Roscoe.	Zingiberaceae	Leaf	MeOH	64.42 mg/g	-	0.045 g/g	Nigeria	[308]
Ziziphus mucronata Wild.	Rhamnaceae	Root	MeOH	73.86 mg/g	-	17.76 mg/g	South Africa	[234]
Zizyphus mucronata Wild.	Rhamnaceae	Leaf	-	52.2 mg/g	-	14.4 mg/g	Mali	[310]

Key: *MeOH* methanol, CH_2Cl_2 dichloromethane, *EtOH* ethanol, *EtOAc* ethyl acetate, *n*-C_6H_{12} hexane, $(CH_3)_2CO$ acetone, H_2O aqueous, *BtOH* butanol

Antioxidant activities of extracts of plants from Eastern Africa

A total of 63 extracts from 51 plants belonging to 23 families were identified to exhibit antioxidant activities (Table 5). Tufts et al. [56] evaluated the ethanol extract of 13 medicinal plants for antioxidant activities using the oxygen radical absorbance capacity (ORAC) assay. Out of these extracts *Mangifera indica*, *Psidium guajava* and *Ocimum americanum* showed the highest antioxidant activities of 5940, 3929 and 3190 μMTE/μg respectively. These extracts also exhibited significant anti-inflammatory effect. The significant antioxidant and anti-inflammatory effect of these plants may confer hepatoprotective virtue to the plants. Detailed phytochemical studies of ethnomedicinal plants from Eastern Africa having antioxidant activities led to isolation of approximately 19 compounds (Table 6, Fig. 3). The most potents of these compounds included; rutin (**13**) with IC_{50} of 3.53 μg/ml using DPPH free radicals [57], myricitrin- based glycosides including; myricitrin (**20**) (IC_{50} = 14.2 μM), myricetin-3–*O*-arabinopyranoside (**21**) (IC_{50} = 15.8 μM), and quercetin-based glycosides including; quercetin-3–*O*-diglucosylrhamnoside (**14**) (IC_{50} = 20.7 μM) and quercetrin (**19**) (IC_{50} = 26.8 μM) [58]. The radical scavenging activities of the quercetin-based glycosides appears to be much higher than those of the kaempferol-based glycosides. This can be attributed to the presence *ortho*-dihydroxyl groups in the B ring of the former, which is not exemplified in the latter. Similarly, myricitrin-based glycosides which contain *ortho*-trihydroxy groups in the B ring were shown to be more potent scavengers than their corresponding quercetin-based glycosides. Thus, structure-activity considerations for the present series of flavonoids indicate the importance of multiple OH substitutions for antiradical action towards DPPH with *ortho*-trihydroxyl group in the B ring elevating the radical scavenging efficiency above that of the *ortho*-dihydroxyl group.

Hepatoprotective activities of extracts of plants from Africa

The liver is a vital organ which regulates many important metabolic functions and is responsible for maintaining homeostasis of the body [59]. The aetiology of liver diseases is diverse and a variety of plants has been reported to show hepatoprotective activity and so may be useful in the treatment of these diseases [25]. The mechanism of hepatic injury invariably involves peroxidation of hepatocyte membrane fatty acids causing destruction of the cells and their intracellular organelles. Oxidative stress plays a pivotal role in the initiation and progression of hepatic damage following insult to a variety of hepatotoxins [60]. These toxicants damage the hepatocyte primarily by producing reactive oxygen species which form covalent bond with the lipid moiety of the hepatic cell membranes. The drugs/chemicals and plants with antioxidant properties have been shown to protect against toxin induced hepatotoxicity through inhibition of the generation of free radicals. A list of plants reported to have significant hepatoprotective activity is shown in Table 8 in alphabetical order of their family, together with their scientific names, origin, plant part used, kind of extract used, type of assay and inducer of liver damage. Most of these planta are discussed in greater details below.

Moringa oleifera

Moringa oleifera Lam. (Moringaceae) locally known as "ben oil or drumstick tree" is a small, graceful, deciduous tree with sparse foliage [61]. The plant grows abundantly in many tropical and subtropical countries. *Moringa* is an ancient magic plant with a plethora of medicinal and nutritional value. The leaves, flowers, root, gums, fruit, and seed of *M. oleifera* have been extensively used in traditional medicine for the treatment of liver disease, lipid disorders, arthritis, and other inflammatory disorders [62]. The ethanolic extract of the leaves of *M. oleifera* was found to exhibit hepatoprotective effect against alcohol induced

Table 8 Hepatoprotective activity of some African medicinal plants

Plants	Family	Part used	Solvents	Toxicant	Dose of extract (mg/kg)	Ameliorative effect demonstrated by the extract on toxin induced alterations in biomarkers of liver integrity	Country of origine	References
Acalypha racemosa H.M.	Euphorbiaceae	Leaf	H_2O	CCL_4	60	Decrease serum AST, ALT, and total bilirubin and increase serum TP and ALB concentrations	Nigeria	[312]
Acalypha wilkesiana L.	Euphorbiaceae	Leaf	H_2O	PCM	100/ 200/ 300	Decrease serum AST, ALT and ALP activities and prevent histopathological alterations in liver	Nigeria	[313]
Aframomum melegueta K. Schum.	Zingiberaceae	Fruit	H_2O	EtOH	100	Decrease serum AST, ALT and TG. Increase serum SOD GSH and prevent histopathological alterations in liver	Nigeria	[314]
Ajuga iva (L.)	Lamiacea	Aerial parts	Oil	CCL_4	50	Decreas serum ALP,AST, ALT	Libya	[315]
Alchornea cordifolia Mull. Arg.	Euphorbiaceae	Leaf	MeOH	CCL_4	300	Decrease serum AST, ALT, ALP and TB	Nigeria	[147]
Allanblackia gabonensis (Pellegr.) Bamps.	Guttiferae	Stem bark	H_2O	PCM	100/ 200	Decrease serum ALT, AST, bilirubin and MDA, increase SOD, CAT and GSH	Cameroon	[111]
Anacardium occidentale L.	Anacardiaceae	Leaf	MeOH	CCL_4	500/ 1000	Decrease serum AST, ALT and ALP	Nigeria	[316]
Andrographis paniculata Bum.F.	Acanthaceae	Leaf	H_2O	CCL_4	100–300	Decrease serum AST, ALT, ALP, TB,DBL,CHL, TG, LDL, VLDL and MDA	Nigeria	[317]
Annona muricata L.	Annonaceae	Leaf	EtOH	PCM	400	Decrease serum AST, ALT, ALP, TP and TB levels. Prevented toxins-induced liver necrosis	Nigeria	[318]
Azadirachta indica A, Juss.	Meliaceae	Leaf	EtOH	PCM	300	Decrease serum AST, ALT, ALP, GGT, CHOL and TG. Prevented toxins induced alterations in haematological parameters	Nigeria	[319]
Balanites aegyptiaca (L.) Delile.	Balantitiaceae	Stem bark	H_2O	PCM	100	Decrease serum AST, ALT and ALP activities	Nigeria	[320]
Camellia sinensis (L.) Kuntze	Theaceae	Leaf	H_2O	Tamoxifen	45	Decrease serum AST, ALT and TBARS	egypt	[321]
Carica papaya L.	*Caricaceae*	Leaf	H_2O	PCM and $CC1_4$	100/ 300	Decrease serum AST, ALT, ALP, BIL and MDA. Increase GSH, CAT and SOD	Nigeria	[322]
Cassia italic Mill.	cesalpiniaceae	Leaf	EtOH	CCL_4	200	Decrease serum and liver AST, ALT, ALP and GGT.	Nigeria	[323]
Cassia Occidentalis L.	Caesalpinoidae	Leaf	H_2O	PCM	250/ 500	Prevented vascular congestion, periportal infiltrates of chronic inflammatory cells and periportal oedema.	Nigeria	[324]
Cassia sieberiana DC.	Fabaceae	Leaf	MeOH	CCL_4	100/ 200/ 400	Decrease serum AST, ALT, ALP MDA. Increase serum CAT	Nigeria	[163]
Cassia singueana Burkill. H.M.	Fabaceae	Root	MeOH	CCL_4	50	Decrease serum AST, ALT BIL, MDA and LDL Increase serum HDL,SOD, CAT,	Nigeria	[325]
Chrysophyllum Albidum G. Don.	Sapotaceae	Leaf	EtOH	CCL_4	500/ 1000/ 1500	Decrease serum AST, ALT, ALP and TB. Prevented toxins-induced centrilobular fat ty degeneration and necrosis in liver	Nigeria	[326]

Table 8 Hepatoprotective activity of some African medicinal plants *(Continued)*

Cochlospermum tinctorium A. Rich.	Cochlospermaceae	Leaf	MeOH	CCL_4	200	Decrease serum ALT, AST, bilirubin and MDA and prevent histopathological alterations in liver	Nigeria	[72]
Cochlospermum Tinctorium A. Rich.	Cochlospermaceae	Leaf	MeOH	CCL_4	200	Decrease serum AST, ALT, CHOL, MDA and BIL levels.	Nigeria	[72]
Costus afer L.	Zingiberaceae	Stem	MeOH	ALC	60/120	Decrease serum AST, ALP	Nigeria	[327]
Echinops galalensis Schweinf.	Asteraceae	Aerial parts	MeOH	CCL_4	100 μg/ mL	Decreas AST, ALT, MDA level and increase SOD activities	Egypt	[102]
Erythrina senegalensis L.	Fabaceae	Stem bark	EtOH	CCL_4	100	Decrease serum ALT, AST and lipid peroxidationin liver homogenate	Cameroon	[116]
Ficus chlamydocarpa Mildbr. & Burret	Moraceae	Stem bark	MeOH	CCL_4	50–200	Increase hepatic GSH, decrease liver MDA decrease AST, ALT and LDH	Cameroon	[99]
Ficus exasperate Vahl.	Moraceae	Leaf	EtOH	PCM	125/ 150/ 500	Decrease serum AST,ALT,ALP and TB	Nigeria	[115]
Ficus exasperata Vahl.	Moraceae	Leaf	EtOH	PCM	125– 500	Increase liver ALT, AST but decrease liver ALP and bilirubin level	Nigeria	[115]
Gongronema latifolium	Asclepiadaceae,	Leaf	H_2O	CCL_4	500	Decrease serum AST, ALT, ALP TB,CRT, urea, CHOL andTG	Nigeria	[328]
Harungana madagascariensis Lam. ex Poiret.	Hypericaceae	Root	H_2O	PCM	100– 500	Decrease serum ALT, AST, ALP and FBG but increase serum levels of TP and ALB	Nigeria	[329]
Hibiscus cannabinus L.	Malvaceae	Leaf	H_2O	PCM/cm^3	1600	Decrease serum AST, ALT, BIL and MDA. Prevented toxin induced severe inflamm at ion and liver necrosis	Nigeria	[330]
Hibiscus sabdariffa L.	Malvaceae	Flower	EtOH	CCL_4	200/ 300	Decrease serum ALT, AST, ALP,TC, LDL-C, TG and liver MDA level. 1ncrease in HDL-C, vitamins A, C, and β-carotene level	Nigeria	[331]
Hibiscus sabdariffa L.	Malvaceae	Leaf	MeOH	CCL_4	500/ 1000	Decrease serum ALT, AST, ALP, LDH and TBARS but increase serum GSH, SOD and CAT	Nigeria	[177]
Hibiscus Sabdariffa L.	Malvacea	Leaf	MeOH	CCL_4	600/ 1000	Increase serum SOD, CAT, GSH and decrease serum ALP	Nigeria	[332]
Irvingia gabonensis	Irvingiaceae	Leaf	EtOH	Sodium arsenite	250/ 500	Decrease serum ALT, AST and γGT and prevent histopathological alterations in liver	Nigeria	[100]
Khaya grandifoliola C.DC.	Meliaceae	Stem bark	EtOAc/ MeOH	CCL_4	25/100	Decreas serum ALP,AST, ALT and TP; Increase liver TBARS, SOD,GSH and GR) in liver.	Cameroon	[83]
Khaya senegalensis (Desr.) A Juss.	Meliaceae	Stem bark	H_2O	PCM	100	Decrease serum AST, ALT and ALP activities	Nigeria	[320]
Lawsonia inermis L.	Lythraceae	Leaf	H_2O	CCL_4	100/ 150	Decrease serum AST and ALT	Nigeria	[107]
Lawsonia inermis L.	Lythraceae	Leaf	MeOH	$CC1_4$	100/ 200	Decrease serum AST, ALT, ALP. TP and BIL. Prevented toxin induced necrosis of hepatic architecture with vacuolization and congestion of sinusoids	Sudan	[106]
Mangifera Indica L.	Anacardiaceae	Stem bark	H_2O/ EtOH	PCM	200	Decrease serum AST, ALT, ALP and MDA increase TP, GSH, CAT and SOD	Nigeria	[333]

Table 8 Hepatoprotective activity of some African medicinal plants *(Continued)*

Marrubium vulgare L.	Lamiacea	Aerial parts	Oil	CCL_4	50	Decreas serum ALP,AST, ALT	Libya	[315]
Moringa oleifera L.	Moringaceae	Leaf	EtOH	Alcohol	300	Decrease serum AST, ALT, ALP, GGT andprevented histopathological changes in liver.	Nigeria	[63]
Nauclea latifolia L.	Rubiaceae	Leaf	EtOH	PCM	400	Decrease serum AST, ALT, increase serum TP, ALB, CAT,GPx andSOD concentrations	Nigeria	[334]
Newbouldia Laevies (P. Beauv) Seem. Ex Burea	Bignoniaceae	Leaf	EtOH	CCL_4	100/ 300	Decrease serum AST, ALT,ALP,TB,TP andCHL	Nigeria	[335]
Ocimum americanum L.	Lamiaceae	Leaf	H_2O	PCM	200/ 400	Decrease serum ALP, AST, ALT. TBIL and preserve liver architecture	Nigeria	[94]
Ocimum gratissimum L.	Lamiaceae	Leaf	H_2O	CCL_4	500	Decrease serum AST, ALT, ALP TB,CRT, urea, CHOL andTG	Nigeria	[328]
Prosopis africana (Guill. & Perr.) Taub.	Mimosaceae	Stem bark	H_2O	PCM	100	Decrease serum AST, ALT and ALP activities	Nigeria	[320]
Rosmarinus officinalis L.	Lamiacea	Aerial parts	Oil	CCL_4	50	Decreas serum ALP,AST, ALT	Libya	[315]
*Senna alata (*L.) Roxb.	Fabaceae	Leaf	MeOH	CCL_4	400	Decrease serum ALT, AST, ALP, total and direct bilirubin and liver TBARS, increase serum total protein and albumin and prevent histopathological alterations in liver	Nigeria	[68]
Spathodea campanulata P. Beauv.	Bignoniaceae	Stem bark	H_2O	CCL_4	100/ 300/ 625	Decrease serum AST, ALT and GGT and prevent histopathological alterations in liver	Ghana	[86]
Sphenocentrum jollyanum L.	Menispermaceae	Stem bark	MeOH	CCL_4	50/100/ 200	Decrease serum AST,ALT, ALP, TB and LP and Increase liver TP, SOD, CAT, GPx GST	S. Africa	[96]
Swietenia Mahogani (L.) Jacq.	Maliaceae	Leaf	H_2O	Alcohol	250/ 500	Decrease serum AST, ALT, ALP BIL and CRT	Nigeria	[336]
Telfairia occidentalis Hook. F.	Cucurbitaceae	Leaf	EtOH	CCL_4	500	Increase livee AST, ALT, ALP and prevented toxin-induced central vein congestion with eroded endothelium and haemolised blood vessels, pkynotic nucleic and fats infiltration	Nigeria	[337]
Thymus capitatus L.	Lamiacea	Aerial parts	Oil	CCL_4	50	Decreas serum ALP,AST, ALT	Libya	[315]
Tulbaghia violacea Harv.	Alliaceae	Rhizome	–	Atherosclerogenic (ath)	250/ 500	Decrease Serum TG, TC, LDL-C, VLDL-C, TBARS, fibrinogen, LDH, AST,ALT, ALP, BIL,CRET and prevent histopathological alterations in liver	South Africa	[263]
Uvaria afzelii P. Beauv.	Annonaceae	Root	MeOH	CCL_4	125/ 250/ 500	Decreases serum ALT, AST, ALP, total and un-conjugated bilirubin	Nigeria	[76]
Vernonia ambigua L.	Asteraceae	Leaf	EtOH	CCL_4	250/ 500	Decrease serum ALT, AST and ALP, TB, CHOL, TGA increase TP and ALB	Nigeria	[90]
Vernonia amygdalina Delile.	Asteraceae	Leaf	EtOH	PCM	300	Decrease serum AST, ALT, ALP, GGT, CHOL and TG. Prevented toxins induced alterations in haematological parameters	Nigeria	[319]

Table 8 Hepatoprotective activity of some African medicinal plants *(Continued)*

Vernonia amygdalina Delile.	Asteraceae	Leaf	MeOH		20/60	Increase liver and kidney AST and ALT,	Nigeria	[338]
Vitellaria paradoxa C.F. Gaertn.	Sapotaceae	Stem bark	H_2O	PCM	100	Decrease serum AST, ALT and ALP activities	Nigeria	[320]
Xylopia aethiopica Delile.	Annonaceae	Stem bark	H_2O	CCL_4	250/ 500	Decrease serum AST, ALT, ALP and BIL	Nigeria	[339]
Satureja punctata (Benth.) Briq.	Lamiaceae	Aerial parts	H_2O	Fe-NTA	250/ 500	Decrease serum AST, ALT, ALP	Ethiopia	[291]
Solanecio angulatus (Vahl) C. Jeffrey	Asteraceae	Leaf	H_2O	Fe-NTA	250/ 500	Decrease serum AST and ALT,	Ethiopia	[291]
Cineraria abyssinica Sch. Bip.ex A.	Asteraceae	Leaf	MeOH/ H_2O	CCL_4	200	Decrease serum AST, ALT, ALP. Prevented toxins induced liver necrosis and inflammation	Ethiopia	[340]

Key: *ALT* alanine aminotransferase, *AST* aspartate amino transferase, *ALP* alkaline phosphatase, *TP* total bilirubin, *DB* direct bilirubin, *LDL* low density lipoprotein, *VLDL* very low density lipoprotein, *MDA* malondialdehyde, *CAT* catalase, *GPx* glutathione peroxidase, *SOD* superoxide dismutase, *CRT* creatinine, *CHOL* cholesterol, *TG* triglyceride, CCL_4 carbon tetrachloride, *Fe-NTA* ferric nitrilotriacetate, *PCM* paracetamol, *MeOH* methanol, CH_2Cl_2 dichloromethane, *EtOH* ethanol, *EtOAc* ethyl acetate, $n\text{-}C_6H_{12}$ Hexane; $(CH_3)_2CO$ acetone, H_2O aqueous, *btoh*:butanol

hepatotoxicity in rats [63]. This research proved that animal pretreatment with ethanolic extract of *M. oleifera* (300 mg/kg of weight) significantly attenuated hepatotoxin induced biochemical (serum AST, ALT, ALP, and GGT) and histopathological changes in the liver. Additionally, *M. oleifera* leaves also showed significant anti-inflammatory [64], and antioxidant potencies [63], [65], which may be contributing to its hepatoprotective activity. A number of phytochemicals with antioxidant activities have been characterized from *Moringa oleifera* including; quercetin (**22**), rutin (**13**), kaempferol and caffeoyqumic acids.

Senna alata

Senna alata (L.) Roxb) (Fabaceae) is commonly known as candle bush, with reference to the shape of its inflorescences, or ringworm tree for it traditional use. It is an annual, erect, tropical herb of 0.15 m high [66]. The leaves are well known for their medicinal used for various diseases of the liver [67]. The hepatoprotective effect of the plant has been shown in Wistar albino rat intoxicated with CCl_4. This study reported that methanol extract and fractions (ethanol and butanol) of *S. alata* leaves administered orally at 400 mg/kg decreased hepatic enzyme levels (serum ALT, AST, ALP,) total and direct bilirubin, liver TBARS induced by CCl_4 damage. Administration of the methanol extract of this plant showed maintenance of the hepatocytes membrane's structural integrity [68]. The extract also showed strong antioxidant and anti-inflammatory [69], activities which may contribute to its hepatoprotective property.

Cochlospermum tinctorium

Cochlospermum tinctorium (*Cochlospermaceae*) is a bushy savannah plant, commonly found in fallow farms across northern Nigeria. It is a shrub that grows up to 10 m high [70]. Decoctions of the whole roots of *C. tinctorium* have been reported to be used as remedy for gonorrhoea, jaundice, gastrointestinal diseases, helminthes, bilharzias infest ations, as well as for the management of epilepsy [71]. The hepatoprotective effect of methanol extracts of *C. tinctorium* leaf has been studied against CCl_4 induced liver injury [72]. The extract attenuated CCl_4 induced rise in liver enzymes including AST and ALT, bilirubin, MDA level and prevented histopathological alterations in the liver [72]. The hepatoprotective activities of the extract have been linked to both enzymic and non-enzymic antioxidants that could bring about free radical suppressing activity.

Uvaria afzelii

Uvaria afzelii Sc Elliot (Annonaceae) is widely distributed and grown in the South and eastern part of Nigeria, where it is known by various local names such as "gbogbonishe" (Yoruba), "Umimi ofia" (Igbo) and "Osu-umimi" (Ukwani) [73]. Locally it is used in the treatment of cough, vaginal tumour, gonorrhea, jaundice, infections of the liver, kidney and bladder [74, 75]. The hepatoprotective activity of this plant was evaluatedin the experimental acute hepatic damage induced by CCl_4 in rat [76]. In this study, it was reported that the methanolic extracts of the root of *Uvaria afzelii*, at doses of 125 mg/kg, 250 mg/kg and 500 mg/kg, significantly reduced the serum hepatic enzymes, total and un-conjugated bilirubin. Phytochemical studies of this plant has shown the presence of syncarpic acid, dimethoxym atteucinol, emorydone, 2–hydroxydemethoxym at-teucinol, uvafzelic acid, syncarpurea, afzeliindanone, flavonoids, triterpenoids and phenols [76–78]. Some of these compounds have also been credited for their antiparasitic and antioxidant activities [79].

Sphenocntrum jollyanum

Sphenocntrum jollyanum Pierre (Menispermaceae) is locally known as Aduro kokoo (red medicine) and Okramankote (dog's penis) in Ghana. It is a small erect sparsely branched rub which grows up to 1.5 m in height. Different part of *S. jollyanum* has been used extensively for the treatment of various ailments in Western Africa Sub-region. The methanolic extract of *S. jollyanum* stem bark showed significant hepatoprotective activity against CCl_4 induced liver injury [80]. In addition, this extract possesses significant antioxidant activities with IC_{50} values of 13.11 and 30.04 μg/mL in superoxide and hydrogen radical scavenging activity, respectively [80] and anti-inflammatory [81], activities which may be contributing to its hepatoprotective effects.

Khaya grandifoliola

Khaya grandifoliola (Meliaceae) is commonly used in traditional medicine by the Bamun (a tribe of Western Cameroon) for curing liver related diseases [82]. The hepatoprotective effect of *K. grandifoliola* has been studied against PCM [83], and CCl_4 induced hepatotoxicity [84] in rats. The methanol; methylchloride extract of the stem bark of this plant at 25 and 100 mg/kg dose dependently attenuated hepatotoxin induced alterations in biochemical parameters (serum ALP, AST, ALT and TP and liver TBARS, SOD, GSH and GR) and prevented toxin induced alteration in liver histopathology. The extract also showed antioxidant and anti-inflammatory activities [84] which may be contributing to its hepatoprotective activity.

Spathodea campanulata

Spathodea campanulata, (Bignoniaceae), it's a widely used traditional African medicinal plant for skin diseases and stomach aches [85]. The extract of the stem bark of *Spathodea campanulata* produced significant hepatoprotection [86]. In this study it was reported that the methanolic extracts of the stem bark of *S. campanulata*, at doses of 100, 300, and 625 mg/kg significantly attenuated CCl_4 induced rise in biochemical (serum AST, ALT and GGT) and histopathological changes in the liver [86]. Phytochemical studies on *S. campanulata* showed the presence of flavonoids, tannins, spathoside, *n*-alkanes, linear aliphatic alcohols, beta-sitosterol-3–*O*-beta-D-glucopyranoside, oleanolic acid, pomolic acid, *p*-hydroxybenzoic acid, phenylethanol esters, reducing sugars. The in vitro testing which gave positive results for reducing power and total phenolic content [86–88], also support the activity of the plant extract with reference to its hepatoprotection.

Vernonia ambigua

Vernonia ambigua (Asteraceae) is an annual shrub growing up to 6 m high. It is widely distributed in areas like Angola, Sudan, Tanzania, Uganda and tropical Western Africa. In Nigeria it is used for gastrointestinal disorders, as a general tonic and appetite stimulant, for skin diseases and as a medication for fever, dysentery, malaria, diabetics and constipation [89]. The hepatoprotective activity of leaf extract of *V. ambigua* has been investigated using CCl_4 induced hepatotoxicity in albino rats. The extract significantly attenuated CCl_4 induced biochemical (ALT, AST and ALP, TB, CHOL, TGA, TP and ALB [90]. Plants of the genus *Vernonia* are known to produce characteristic compounds such as sesquiterpene lactones, with several reported biological activities, such as fungistatic [91], and cytotoxic activities [92]. The hepatoprotective properties of plants from genus *Vernonia* may be attributed to presence of mainly; flavonoids, steroids and polysaccharides [93], that has been characterized previously from this genus.

Ocimum americanum

Ocimum americanum (Lamiaceae) commonly known as "African basil" It is a wild herb with a distinct mint flavor, hairy leaves and scented flowers that is native to tropical Africa. The aqueous extract of *O. americanum* (200 and 400 mg/kg) significantly attenuated PCM induced biochemical (serum ALP, AST, ALT and TBIL level) and histopathological alterations in the liver [94]. The hepatoprotective activity of *Ocimum americanum* may be attributed to its antioxidant activities [95].

Tulbaghia violacea

Tulbaghia violacea (Alliaceae) is a fast-growing, bulbous plant that reaches a height of 0.5 m. In the Eastern Cape of South Africa rhizomes of *Tulbaghia violacea* has been used for the treatment of jaundice, gall bladder stones, liver diseases and heart disease [96]. The rhizomes extract of *T. violacea* dose dependently attenuated atherosclerogenic induced alteration in markers of endothelial dysfunction, lipid profile, liver enzymes and histological changes [97]. The antioxidant and cytotoxicity activities of *T. violacea* as well as its phytochemical components such flavonoids and saponins [98] may be responsible for its hepatoprotective properties.

Irvingia gabonensis

Irvingia gabonensis (Irvingiaceae) locally known as "bush mango or African mango" since the trees bear fruits that look like small mango (Matos et al., 2010). In Senegal, the decoction of the stem bark is used in the treatment of gonorrhoea, hepatic and gastrointestinal disorders [99]. The thanol extract of the leaves of this plant has been investigated for its hepatoprotective activity in sodium arsenite (SA) induced hepatotoxicity and clastogenicity in male Wistar rats [100]. The extract at 250 or 500 mg/kg dose dependently attenuated sodium arsenite induced rise in liver enzymes including AST, ALT and and gamma glutamyltransferase (γGT) and prevented histopathological alterations in the liver [100]. Phytochemical studies on the ethanol extract of *Irvingia gabonensis* showed the presence of of tannins, saponins, alkaloids, terpenoids, flavonoids and phenols [100]. Tannins have been reported to have anti-inflammatory and antiulcer property in rodents and they also exhibit strong antioxidant properties [101].

Echinops galalensis

The methanol extract of the flowering aerial parts of *Echinops galalensis* (Asteraceae), its fractions and the isolated compounds (**25**–**33**) have been reported for their hepatoprotective effects agaisnt CCl_4 induced cell damage in an in vitro assay on human hepatoma cell line (Huh7). The extract and isolated compounds (**25**–**33**) at 100 μg/mL prior to CCl_4 challenge protected against cell injury by decreasing the level of AST, ALT, MDA and increasing the activities of SOD [102]. The protective effects of *E. galalensis* methanolic extract, its fractions as well as the isolated compounds is at least partly due to their antioxidant activities as evidenced by the reduction in MDA level and the increase in SOD activity.

Lawsonia inermis

Lawsonia inermis (lythraceae) is a shrub or small tree cultivated in many regions as an ornamental and commercial dye crop [103]. It is mostly found in the tropic, sub-tropic, and semi-arid zones of Africa (tropical Savannah and tropical arid zones), South Asia and North Australia [104]. As a medicinal plant, the leaves, seed and bark of *L. inermis* have been used in folk remedy as astringent, hypotensive, sedative, and against a headache, jaundice, spleen enlargement, leprosy and other liver disease [105]. Its hepatoprotective activity was shown in a toxicity model by CCI_4 in rats. These research proved that animal pretreatment with a methanolic extract of *Lawsonia inermis* (100 and 200 mg/kg of weight) attenuated the increase in AST serum activity, alanine aminotransferase (ALT), alkaline phosphatase (ALP), total bilirubin (TB), and histological changes observed in the damage induced by CCl_4 [106, 107]. Previous reports have shown that *L. inermis* is rich in phenolic compounds such as phenolic acids, flavonoids, tannins, lignin, and others that possess antioxidant, anticarcinogenic, and antimutagenic effects as well as antiproliferative potentials [108], which may be responsible for its hepatoprotective activities.

Ficus chlamydocarpa

Ficus chlamydocarpa (Moraceae) is traditionally used in Cameroon for the management of different diseases including; filarial, diarrheal infections and tuberculosis [109]. Another ethnopharmacological survey has revealed that a decoction of the stem bark is used in West Cameroon folk medicine for the treatments of abdominal problems, arthritis, inflammatory conditions and jaundice, which are commonly considered symptomatic of liver-related diseases.

Its hepatoprotective effect was evaluated through the induction of acute hepatic damage in rats using CCl_4 [99]. In this, study the pre-treatment with 50–200 mg/kg of methanolic extract of *F. chlamydocarpa* stem bark prevented serum increase of hepatic enzyme markers and lactate dehydrogenase (LDH), enhanced hepatic reduced glutathione (GSH) level and decreased of hepatic malondialdehyde (MDA) during CCl_4 intoxication. Previous phytochemical studies on stem bark of *F. chlamydocarpa* revealed the presence of the following flavonoids; alpinumisoflavone (**115**), genistein (4′, 5, 7–trihydroxyisoflavone **116**) and luteolin (3′, 4′, 5, 7–tetrahydroxy flavones **117**) with significant DPPH radical scavenging activities with IC_{50} (μg/mL of 6, 5.7, 5.0 respecively [99].

Allanblackia gabonensis

Allanblackia gabonensis (Guttiferae) is commonly grown in tropical Africa including; Cameroon, Democratic Republic of Congo, etc. between around 500 and 1750 m above sea level [110]. The plant is used in traditional medicine to treat some inflammatory diseases. The aqueous suspension of the stem bark of *A. gabonensis* showed significant hepatho-nephroprotective activity against acetaminophen-induced liver and kidney disorders in rats. In this, study the pre-treatment with 100 and 200 mg/kg significantly reduced the serum level of MDA, increase in enzymatic antioxidant activities (SOD and CAT) and non enzymatic antioxidant (GSH) levels [111]. The stem bark of this plant has been known to elaborate the following compounds xanthones, benzophenone, flavonoide, and phytosterol [112]. In addition, *A. gabonensis* possess significant analgesic and anti-inflammatory activities [113] which may be contributing to its hepatoprotective activities.

Ficus exasperata

Ficus exasperata vahl (Moraceae) is a terrestrial plant that grows 20 m high and inhabits the evergreen and secondary rainforest of West Africa. The plant is commonly known as sand paper tree, it is also known locally as "anwerinwa" [114]. The ethanol extracts of the leaves of *F. exasperata* showed significant hepatoprotective activitie in acetaminophen-induced hepatotoxic rats [115]. The extract at 125–500 mg/kg significantly ameliorated toxin induced alterations in the liver ALT, AST, ALP and bilirubin levels. The histological evaluation showed a partial prevention of inflammation, necrosis and vacuolization induced by CCl_4 [115].

Erythrina senegalensis

Erythrina senegalensis DC (Fabaceae), locally known by the Bamun people in Cameroon as *'Megham njû'* is a thorny shrub or small tree, with a corky stem bark and bright red flowers, found in Sudanese savannah regions. Hepatoprotective effect of the ethanolic extract of *Erythrina senegalensis* stem bark was studied in vivo against CCl_4–induced induced liver damage as well as in vitro against rat liver slices intoxicated CCl_4. *E. senegalensis* extract at 100 mg/kg significantly attenuated hepatotoxin induced biochemical serum ALT, AST and lipid peroxidation in liver homogenate. Polyphenols including flavonoids have been characterized from this plants which could be implicated for its hepatoprotective potential [116].

Njayou et al. [117], evaluated the hepatoprotective effect of fifty four Cameroonian plants extracts against Fe (II)-Ascorbate induced microsomal lipid peroxidationin rat liver. Only 15 plants extract inhibiting oxidation phenomena with percentage inhibition of > 50 at 200 μg/mL were considered as possessing a high lipid oxidation inhibitory potential. In this respect, *Mangifera indica, Enantia chlorantha, Voacanga africana, Aspilia africana, Senna alata, Piliostigma thonningii, Piliostigma thonningii, Kalonchoe crenata, Alchornea laxiflora, Crotalaria lachnophora, Erythrina senegalensis, Khaya grandifoliola, Entada africana, Melinis minutiflora* and *Curcuma longa* were found to be active. Among these active plant species, some of them, namely *E. chlorantha* [118], *E. africana* [119] and *C. longa* [120], have been reported to be active against experimentally induced hepatitis. *M. indica* on its part has been shown to be very effective against lipid and protein oxidation in vitro and injury associated to hepatic ischemia reperfusion [121, 122]. The inhibitory effect against the free radical-mediated degradation of microsomal lipid peroxidation by plant extracts mentioned above may also be attributed to flavonoids and polyphenols as many of these phytoconstituents are known to be antioxidants [123]. The presence of flavonoids and polyphenols has been reported in all the above cited plant extracts [124, 125].

Aja et al., [2], documented the antioxidant activities of the ethanol leaf extracts of *C. citratus* and *H. spicigera* against *Plasmodium berghei* induced oxidative stress by significantly ($P < 0.05$) increasing the superoxide dismutase, reduced glutathione, catalase and peroxidase activities and decreasing the lipid peroxidation when compared with the controls. This study indicates the effectiveness of the use of *Cymbopogon citratus* and *Hyptis spicigera* in the management of oxidative stress caused by malaria [2].

Mulata et al. [126], evaluated the effect of hydroethanolic seed extract of *Calpurnia aurea* against highly active antiretroviral therapy (HAART) induced free radical reactions in the liver and liver cell damage in rats. The authors reported that the extract (300 mg/kg) reduced the HAART induced liver toxicity by decreasing the free radical reactions, ALP, ALT, AST release and increasing antioxidant profiles in treated rats.

A polyherbal formulation comprising of *Gongronema latifolia, Ocimum gratissimum* and *Vernonia amygdalina* demonstrated significant hepatoprotective activities by attenuating the increase in serum hepatic enzyme levels after CCl_4 treatment compared to the toxin control group and increasing the levels of serum CAT, GPx, GSH, GST, SOD, total protein and significantly ($p < 0.05$) decreasing lipid peroxidation compared to the toxin control group [127].

"Ata-Ofa" a polyherbal formulation consisting of twenty one (21) plant products, including, *Ginger officinalle, Tamarindus indica, Khaya senegalensis, Moringa oleifera, Nauclea latifolia, Camellia sinensis*, *Anacardium occidentale, Aframomum melegueta, Phyllantus amarus*, *Morinda lucida* and *Mangifera indica* was reported (at 5 mg/kg) for in vivo antioxidant, hepatoprotective and curative effects by its ability to ameliorate CCl_4 induced alterations in biochemical parameters and antioxidants enzymes in intoxicated rat [128].

Antioxidants and hepatoprotective activities of insect/mollusk and their secreations

Omalu et al. [129], evaluated the free radical scavenging activity of Nigeria Leech (*Aliolimnatis michaelseni*) saliva extract. Their results revealed that the extract excert significant DPPH free radical scavenging activity with IC_{50} value of 8.169 μg/mL initially and 8.67 μg/mL after starvation for 1 month. Omalu et al., [130], also documented the antioxidants potency of maggots of the blowfly (*Lucilia robineau*) excretion/saliva extract with DPPH free radical scavenging activity of (IC_{50} of 152.66 μg/mL) compared with 108.99 μg/mL of L-ascorbic.

Giant African Snail (*Achachatina maginata*) haemolymph has been reported for in vitro antioxidant activity with an IC_{50} value of 579.66 ± 2.69 μg/mL in DPPH radical scavenging assay and 310.75 ± 3.12 μg/mL in lipid peroxidation inhibitory assay. The haemolymph also excert ameliorative effects on CCL_4–induced elevations of the levels of AST, ALT, ALP, TBARS and it reversal effect on reduced concentration of catalase induced by CCL_4 intoxication. The total phenolics and flavonoids contents were reported to be 9.30 ± 0.11 mg/g GAE and 15.20 ± 0.59 mg/g catechin equivalent respectively [5].

Shittu et al. [131], reported the ameliorative effects of the methanol extracts of *Musca domestica* (400 mg/kg) against T. *brucei* induced alteration in antioxidants enzymes (SOD and CAT). Antioxidant screening of the extract against DPPH was positive, with IC_{50} and antioxidant activities index (AAI) of 174.38 mg/mL and 0.29 respectively. Since oxidative stress has been implicated in the etiology of African trypanosomiasis, these two findings suggest that the methanol extract of *Musca domestica* probably excert it anti-trypanosoma effect by free radical scavenging and thus could serve as a candidate for the development of new drugs for the treatment of trypanosomiasis. The methanol extracts of Nigeria bee propolis (600 mg/kg) has been reported for hepatocurative effect by ameliorating CCL_{4-}induced alterations in the serum and liver AST, ALT and ALP activities when administered orally to rats for 10 days [132].

Tanzania honey bee has been reported for DPPH radical scacvenging activity with IC_{50} 4.19, 12.93 and 18.03 mg/mL in stingless bee honeys, raw bees honey and processed bees honey respectively. Similarly, iron chelating activities were reported with IC_{50} value of 0.04, 0.057 and 0.158 mg/mL for stingless bee's honey, raw bee's honey and processed bee's honey respectively [133]. Previous phytochemical investigation of the Nigerian sweet and bitter honey revealed total flavonoids contents of 20.81 μg/mL and 18.92 μg/mL respectively [134].

Nyanzi et al., [135], reported the antioxidant activities of methanol extract from freeze-dried cells of probiotic *Lactobacillus* strains. At the extract concentration of 20 mg/mL the authors reported that *Lb. acidophilus*, *Lb. rhamnosus* and *Lb. casei* strains had DPPH scavenging activities of 77.9–86.1%, 45.7–86.4% and 36.9–45.8% respectively. This finding is an indication that Probiotic extracts can potentially be used as bio-preservatives and in reduction of oxidative stress.

Conclusion and future prospects

Meta-analysis of available scientific literature on antioxidants and hepatoprotective activity of African natural products to a great extent validate folkloric claims about the usefulness of these botanicals to treat liver diseases and other oxidative stress induced disorder. This review has documented the list of African natural products with potential antioxidants and hepatoprotectives effect. Many of these natural products displayed good antioxidants and hepatoprotective activities. This explains the effort of Africa research institutes in drug discovery from natural products. However, the variations in method of analsis, presentations of results, doses, durat ion as well as the geographical difference of the plants reviewed in this study has made it difficult to accurately point out plant/compounds with the best reported antioxidants and hepatoprotective activities. But our close analysis of the reports seem to suggest that *Combretum apiculatum, Telfaria occidentalis, Acalypha racemosa, Garcinia lucida, Xeoderris sthulmannii, Clausena anisata, Harpephyllum caffrum, Ceratotheca sesamoides, Camellia sinensis, Cyathea dregei, Harpephyllum caffrum, Aspalathus linearis* were the most active ROS-detoxifying plant extracts from African flora. The best ROS-detoxifying phytochemicals were moracin T, U, S and R (**84**–**87**), oleanolic acid (**54**), 5,7,4′–trihydroxy–3,8,3′,5′–tetramethoxyflavone (**89**), 5,7,3′–trihydroxy–3,8,4′,5′-trimethoxyflavone (88), luteolin (3′,4′, 5,7–tetrahydroxy flavone) (**117**) and genistein (4′,5,7–trihydroxyisoflavone) (**116**). It is hoped that pertinent scientist and stakeholders will look further into some of these plants and compounds for detailed authentification and subsequent commercialization. Although, most of studies reviewed are preliminary in nature, detailed isolation, characterization, mechanisms of actions of these of isolated compounds, safety studies, quality control as well as clinical trials on some of these herbs and their isolated compounds is far from satisfactory.

Additional file

Additional file 1: Structure of chemical compounds isolated from African plants with potential antioxidants properties. (DOCX 121 kb)

Authors' contributions

This work was carried out in collaboration between all authors. Author BL & OKS did the literature search. Author BL, OKS, FIO, EBB & MH carry out the data analysis and preparation of the manuscript. All authors read and approved the final manuscript.

Competing interests

The authors declare that they have no competing interests.

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