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Review

Antioxidant potential of African medicinal plants

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Cellular damage or oxidative injury arising from free radicals or reactive oxygen species (ROS) now appears the fundamental mechanism underlying a number of human neurodegenerative disorders, diabetes, inflammation, viral infections, autoimmune pathologies and digestive system disorders. Free radical are generated through normal metabolism of drugs, environmental chemicals and other xenobiotics as well as endogenous chemicals, especially stress hormones (adrenalin and noradrenalin). Accumulated evidence suggests that ROS can be scavenged through chemoprevention utilizing natural antioxidant compounds present in foods and medicinal plants. Africa is blessed with enormous biodiversity resources, but plagued with several diseases, including those with ROS as the etiological factor. In this review, research on the antioxidant potential of medicinal plants of African origin between 1965 and September, 2004 is considered.

Keywords: Medicinal plant, antioxidant activity, chemoprevention, neurodegenerative diseases, Africa.

INTRODUCTION

Considerable evidence have accumulated to implicate cellular damage arising from reactive oxygen species (ROS), at least in part, in the etiology and pathophysiology of human diseases such as neurodegenerative disorders (e.g. Alzeimer disease, Parkinson disease, multiple schlerosis, Down's syndrome), inflammation, viral infections, autoimmune pathologies, and digestive system disorders such as gastrointestinal inflammation and ulcer (Reppeto and Llesuy, 2002; Aruoma, 2003; Surh and Fergusson, 2003). In living systems, free-radicals are generated as part of the body's normal metabolic process, and the free radical chain reactions are usually produced in the mitochondrial respiratory chain, liver mixed function oxidases, by bacterial leucocytes, through xanthine oxidase activity, atmospheric pollutants, and from transitional metal catalysts, drugs and xenobiotics. In addition, chemical mobilization of fat stores under various conditions such as lactation, exercise, fever, infection and even fasting, can result in increased radical activity and damage, in particular, to the immune and nervous systems, while the stress hormones (adrenalin and noradrenalin) secreted by the adrenal glands under conditions of continuing and excessive emotional stress, are metabolised into simpler, albeit, free radical molecules.

Free radicals or oxidative injury now appears the fundamental mechanism underlying a number of human neurologic and other disorders. For instance in diabetes, increased oxidative stress which co-exist with reduction in the antioxidant status has been postulated: Oxygen free-radical can initiate peroxidation of lipids, which in turn stimulates glycation of protein, inactivation of enzymes and alteration in the structure and function of collagen basement and other membranes, and play a role in the long term complication of diabetes (Sabu and Kuttan, 2002; Boynes, 1991; Collier et al., 1990). Similarly, in carcinogenesis, reactive oxygen species are responsible for initiating the multistage carcinogenesis process starting with DNA damage and accumulation of genetic events in one or few cell lines which leads to progressively dysplastic cellular appearance, deregulated cell growth, and finally carcinoma (Tsao et al., 2004). Hence, therapy using free-radical scavengers (antioxidants) has potential to prevent, delay or ameliorate many of these disorders (Delanty and Dichter, 2000). Over the past two decades, an expanding body of evidence from epidemiological and laboratory studies have demonstrated that some edible plants as a whole, or their identified ingredients with antioxidant properties have substantial protective effects on human carcinogenesis (Surh and Fergusson, 2003; Park and Pezzuto, 2002; Wattenberg, 1996; Greenwald, 2002; IARC, 1996; Fujiki, 1999; Tsao et al., 2004; Kinghorn et al., 2004; Mehta and Pezzuto, 2002). Similar evidence also exist to demonstrate the chemopreventive capacities of ethnobotanicals and components of vegetable diets with free-radical scavenging potential on ulcers (Borreli and Izzo, 2000), diabetes (Sabu and Kuttan, 2002), memory and cognitive function (Howes and Houghton, 2003), Alzheimer's disease (Howes et al., 2003; Perry et al., 1998), age- related neurological dysfunction (Youdim and Joseph, 2001; Delanty and Dichter, 2000), cardiovascular and renal disorders (Anderson et al., 1999; Miller, 1998) and several other human ailments (Scartezzini and Speroni, 2000; Borek, 2001; Craig, 1999; Galvano et al., 2001; Lampe, 2003; Surh, 1999).

Besides, some medicinal plants have been shown to have both chemopreventive and/or therapeutic effects on breast cancer (Mantle et al., 2000) and skin cancer (F'guyer et al., 2003. A review of case control studies suggest that various types of ginseng (*Panax ginseng*) reputed to be the most highly recognized medicinal herb in the orient, could protect against tumours of the lip, oral cavity, pharnx, larynx, lung, esophagus, stomach, pancreas, ovary and colorectum (Surh and Ferguson, 2003; Yun, 2003; Zhu et al., 2004). Spices and herbs are recognized as sources of natural antioxidants that can protect from oxidative stress and thus play an important role in the chemoprevention of diseases that has their etiology and pathophyiology in reactive oxygen species. The medicinal properties of folk plants are mainly attributed to the presence of flavonoids, but may also be influenced by other organic and inorganic compounds such as coumarins, phenolic acids and antioxidant micronutrients, e.g., Cu, Mn, Zn (Repetto and Llesuy, 2002).

Africa is blessed with enormous biodiversity resources. This is not surprising, since Africa is located within the tropical and sub-tropical climate. It is known that plant accumulate antioxidant chemicals as secondary metabolites through evolution as a natural means of surviving in a hostile environment (Manach et al., 2004). Because of her tropical conditions, Africa has an unfair share of strong ultraviolet rays of the tropical sunlight, and a myriad of pathogenic microbes, including several species of bacteria, fungi and viruses, suggesting that African plants could accumulate chemopreventive substances more than plants from the northern hemisphere. Abegaz et al. (2002) have indeed observed that of all species of *Dorstenia* (*Moraceae*) analysed, only the African species, *Dorstenia mannii* Hook.f, a perennial herb growing in the tropical rain forest of Central Africa contained the antioxidants, mono-, di-, and triprenylated and also mono-, and digeranylated flavonoids.

Therefore there is need to assess how Africa fare in the utilization of her enormous biodiversity resources, with particular reference to the antioxidant components of medicinal plants found on the continent. Hence, this review aims to stimulate interest in this all important research area that will be of immense benefit to our people, who, though plagued with several ailments, and lack the technological and economic resources to combat them with orthodox medicine. Even in technologically and economically advanced countries like the USA, about 40% of the population use alternative remedies, including herbal medicines, for disease prevention and therapy (Eisenberg et al., 1998).

METHODOLOGY

In this review, Medicinal plants of African origin that have been studied for antioxidant potential, *in vivo* and or *in vitro* are considered on the basis of the geographical region of their origin. The literature considered are those available on the Medline covering the period, 1965 to September, 2004. The keywords combination for the search was: medicinal plant, antioxidant and Africa. Supplementary information was obtained by using another keywords combination: *plant,* antioxidant and Africa. Following the review, the entire information is summarized into Table 1.

WEST AFRICAN PLANTS

Reports have appeared on the antioxidant potential of West African plants harvested from Nigeria, Ghana, Mali and Niger Republic. The antioxidant potential of *Sacoglottis gabonensis* stem bark, a Nigerian beverage additive on 2,4 dinitrophenylhydrazine-induced membrane peroxidation *in vivo* has been reported (Maduka and Okoye, 2002). The authors concluded that the mechanism of antioxidant action of the extract was multifactorial/multi-system involving inhibition of catalase, enhancing the superoxide dismutase (SOD) capability of the liver and red blood cells, and sparing tissue depletion/utilization of vitamin C (ascorbic acid) and vitamin E (tocopherol).

Using streptozotocin-induced non-insulin dependent diabetis (NIDD) rat model, Ugochukwu and Babadu

Table 1. African medicinal plants studied for antioxidant activities.

Name of Plant	Country of Origin	Region	Part Studied	Type of Assay	Antioxidant Potential	Active Component(s)	Reference (s)
Sacoglottis gabonensis	Nigeria	West Africa	Stem Bark	*In vivo*	Good	Not identified	Maduka and Okoye, 2002
Mallotus oppositifolium	Nigeria	West Africa	Leaf	*In vivo*	Good	Flavonoid	Farombi et al., 2001
Gongronema latifolium	Nigeria	West Africa	Leaf	*In vivo*	Good	Not identified	Ugochukwu and Babady, 2002
Trichilia roka	Mali	West Africa	Root	*In vivo*	Good	Not identified	Germano et al., 2001
Cussona barteri	Mali	West Africa	Leaves	*In vivo*	Good	Not identified	Diallo et al., 2001
Glinus oppositifolius	Mali	West Africa	Leaves	*In vivo*	Good	Not identified	Diallo et al., 2001
Lannea vilutina	Mali	West Africa	Leaves	*In vivo*	Good	Not identified	Diallo et al., 2001
Tapinanthus globiferus	Niger	West Africa	Leaves	*In vitro*	Good	Not identified	Cook et al., 1998
Parinari macrophylla	Niger	West Africa	Fruit/shell	*In vitro*	poor	Not identified	Cook et al., 1998
Adansonia digitata	Niger	West Africa	Leaves	*In vitro*	poor	Not identified	Cook et al., 1998
Balanites aegyptiaca	Niger	West Africa	Fruits/seed	*In vitro*	Good	Not identified	Cook et al., 1998
Bombax costatum	Niger	West Africa	Fruit	*In vitro*	Good	Not identified	Cook et al., 1998
Boscia senegalensis	Niger	West Africa	leaf	*In vitro*	Good	Not identified	Cook et al., 1998
Entada africana	Niger	West Africa	Leaf	*In vitro*	Good	Not identified	Cook et al., 1998
Gynandropis gynandra	Niger	West Africa	Leaf	*In vitro*	Good	Not identified	Cook et al., 1998
Hypaene thebaica	Niger	West Africa	Fruit	*In vitro*	Poor	Not identified	Cook et al., 1998
Hypaene thebaica	Niger	West Africa	Shell	*In vitro*	Good	Not identified	Cook et al., 1998
Leptadenia hastata	Niger	West Africa	Leaf	*In vitro*	Good	Not identified	Cook et al., 1998
Sesbania pachycarpa	Niger	West Africa	Leaf	*In vitro*	Good	Not identified	Cook et al., 1998
Thonningia sanguinea	Ghana	West Africa	Not indicated	*In vivo/in vitro*	Good	Ellagitannins (thonningianins A(1) and B (2)	Gwamfi et al., 1999 Ohtani te al., 2000
Desmodium adscendens	Ghana	West Africa	Not indicated	*In vivo/in vitro*	Poor	Not identified	Gwamfi et al., 1999
Indigofera arrecta	Ghana	West Africa	Not indicated	*In vivo/in vitro*	Poor	Not identified	Gwamfi et al., 1999
Trema occidentalis	Ghana	West Africa	Not indicated	*In vivo/in vitro*	Poor	Not identified	Gwamfi et al., 1999
Caparis erythrocarpus	Ghana	West Africa	Not indicated	*In vivo/in vitro*	Poor	Not identified	Gwamfi et al., 1999
Dorstenia psilurus	Cameroun	Central Africa	Not indicated	*In vitro*	Good	Not identified	Kansci et al., 2003
Dorstenia ciliata	Cameroun	Central Africa	Not indicated	*In vitro*	Good	Not identified	Kansci et al., 2003
Dorstenia mannii	Cameroun	Central Africa	Leaf/twig	*In vitro*	Good	Not identified	Dufall et al., 2003
Sutherlandia frutescens	South Africa	South Africa	Not indicated	*In vitro*	Good	Not identified	Fernandes et al., 2004
Pelargonium reniforme	South Africa	South Africa	Not indicated	*In vitro*	Good	Not identified	Latt32&Kolodziej 2004
Olea europa (Africana)	South Africa	South Africa	Leaf	*In vivo*	Good	Not identified	omova et al., 2003
Myrothamnus flabellifolia	South Africa	South Africa	Not indicated	*In vivo*	Good	Ascorbate, B-carotene, alpha tocopherol.	Kranner et al., 2002
Rhoicissus digitata	South Africa	South Africa	Leaf/stem/root	*In vitro*	Poor	Not identified	Opoku et al., 2002
Rhoicissus rhomboidea	South Africa	South Africa	Leaf/stem/root	*In vitro*	Good	Not identified	Opoku et al., 2002
Rhoicissus tomentosa	South Africa	South Africa	Leaf/stem/root	*In vitro*	Poor	Not identified	Opoku et al., 2002
Rhoicissus tridentata	South Africa	South Africa	Leaf/stem/root	*In vitro*	Good	Not identified	Opoku et al., 2002
Eucalyptus Camaldulensis	Egypt	North Africa	Leaf	*In vitro*	Good	Gallic and ellagic acid	El-Ghorab et al., 200
Cleome arabica	Algeria	North Africa	Leaf	*In vitro*	Good	Not identified	Selloum et al., 1997
Burkea africana	Not specified	Africa	Stem bark	*In vitro*	Good	Proanthocyanidins, catechin, epicatechin & fisetinidol	Mathisen et al., 2002

(2002), demonstrated that aqueous and ethanolic extracts of *Gongonema latifolium* leaves harvested from eastern Nigeria significantly increased the activity of superoxide dismutase and the level of reduced glutathione peroxidase as well as the levels of glutathione peroxidase and glucose-6-phosphate, while decreasing lipid peroxidation. Based on these observations, these authors concluded that the diabetic activities of the plant could be mediated through its antioxidant properties. Methanol extract of leaves of another Nigerian plant*, Mallotus oppositifolium* harvested from Western Nigeria has been shown to possess antioxidant and anti-inflammatory activities in -carotene linoleate model system and the carrageen-induced rat paw oedema animal model (Farombi et al., 2001). Thin layer chromatographic analysis of this extract revealed the presence of four phenolic spots, two of which were flavonoids.

Germano et al. (2001) have reported the hepatoprotective properties of root decoction of *Trichilia roka* Chiov. (Meliaceae), a plant used in Mali folk medicine, against carbon tetrachloride-induced hepatotoxicity and correlated this effect to the polyphenol antioxidant component of the fraction. In another study involving the screening of 78 other extracts from 20 Malian medicinal plants belonging to 14 families, Diallo et al. (2001) demonstrated with DPPH spray that 20% of the plants, including *Cussonia barteri* (Araliaceae), *Glinus oppositofolius*, *Lannea velutina* (Anacardiaceae) possessed potent antioxidant activity.

Work on some Ghanaian medicinal plants revealed that *Thonningia sanguinea* possess free-radical scavenging capacity and strong hepatoprotective activity inhibiting hydrogen peroxide-induced lipid peroxidation, galactosamine-induced hepatitis and carbon tetrachloride-induced hepatotoxicity (Gyamfi et al., 1999). Four other plants examined, namely, *Desmodium adscendens*, *Indigofera arrecta*, *Trema occidentalis* and *Caparis erythrocarpus* possessed no such activities. Another report on *T. sanguinea* harvested from elsewhere in Africa confirmed its antioxidant potentials and free-radical scavenging activity (Ohtani et al., 2000). In fact these authors isolated two ellagitannins, thonningianins A (1) and thonningianins A (2) as the major antioxidant principle of this plant.

Using the Trolox assay, Cook et al. (1998) estimated the antioxidant activity of 17 wild edible plants of Niger Republic used for food and traditional medicine. They observed that *Balanites eagyptiaca fruit/seeds, Bombax costatum, Boscia senegalensis, Entada Africana, Gynandropsis gynandra, Hyphaene thebaica, Leptadenia hastate, sesbania pachcarpa and Tapinanthus globiferus* possessed strong antioxidant activity, while *Parinari macrophylla* had the lowest.

SOUTH AFRICAN PLANTS

Fernandes et al. (2004) analyzed the antioxidant potential of *Sutherlandia frutescens* subsp. Microphylla (family fabaceae/Leguminosa) – one of the best known multi-purpose medicinal plant used in the treatment of cancer, viral diseases and inflammatory conditions, etc in South Africa. Their result indicated that hot water extract of *S. frutescens* possess superoxide as well as hydrogen peroxide scavenging activities at low concentrations (10 g/ml). Similarly, analysis of methanol extracts of four other South African medicinal plants used by the Zulu traditional healers showed that Rhoicissus *rhomboidea* and *Rhoicissus tridentate* inhibited the activities of NAPPH free radicals, xanthione oxidase and also prevented production of thiobarbituric acid reactive substances and also free- radical mediated sugar damage. Related plants like *Rhoicissus digitata* and *Rhoicissus tomentosa* does not possess these inhibitory properties, except at very high concentrations.

Another South African plant, *Pelargonium reniforme*, used locally for treatment of liver disorders, was assessed for antioxidant properties by Latte and Kolodziej (2004) using the DPPH radical scavenging system and a luminol-dependent chemiluminescence assay. Their work indicated that, in both assays, the polyphenols tested showed higher radical scavenging activities than the reference antioxidant ascorbic acid (IC50 2.6 – 32.9 M vs 40.9 M in the DPPH test, and 2 – 25 times stronger effects in the chemiluminescence assay). Furthermore, they reported that the tannins of the plant possessed more antioxidant potential than the flavonoids. They ascribed the marked antioxidant activities of the hydrolysable tannins to the presence of galloyl and hexahydroxydiphenoyl groups, and carbonyl (ester) functionalities in oxidatively modified hexahydroxydiphenoyl moieties and for the flavonoids, the catechol (3',4' dihydroxy) element in the ring were important determinants with the O-glucosides being more effective than the flavone-based C-glucosyl: their activities were potentiated by introduction of a galloyl group.

Also from South Africa, Somova et al. (2003) have demonstrated the antioxidant potential of triterpenoids isolated from the leaves of *Olea europa*, subspecies*, africana* and wild African olive leaves, while Mowla et al. (2002) reported the identification of cDNA corresponding to 1-Cys peroxiredoxin, an evolutionarily conserved thiol specific antioxidant enzyme from *Xeropta viscosa* Baker, a resurrection plant belonging to the family, Velloziaceae which is indigenous to South Africa. The antioxidant status of another South African resurrection plant, *Myrothamnus flabellifolia*, a short woody shrub is reported to correlates with its revival (Kranner et al., 2002).

NORTH AFRICA

Reports on the antioxidant potential of North African medicinal plants are rather scanty.El-Ghorab et al. (2003) reported on the promising antioxidative activities of ethanol extract from the leaves of *Eucalyptus camaldulensis* var*. brevirostris* harvested form Egypt which contained gallic and ellagic acid as the major components. Similarly, Selloum et al. (1998) reported the antioxidant potency of *Cleome arabica* leaves of Algerian origin.

CENTRAL AFRICAN PLANTS

The only reports on antioxidant potential of medicinal plants from the central African countries come from Cameron, where Kansci et al. (2003) observed that two Camerounian plants, *Dorstenia psilurus* an *Dorstenia ciliata* used as both food ingredient and recipe in traditional medicine possessed strong anti-radical activity when evaluated with the DPPH test. They suggested that the anti-radical potency should be the basis for its therapeutic efficacy in traditional medicine.

Similarly, Duffall et al. (2003) demonstrated the antioxidant activity of prenylated flavonoids from *Dorstenia mannii*, a Central African plant harvested from Cameroun. They attributed the medicinal action of the plant to the high concentration of the potent antioxidant prenylated flavonoids which inhibited Cu^{2+}-mediated oxidation of human low density lipoprotein (LDL), scavenged the free radical 1,1-diphenyl-2-picrihydrazyl (DPPH), and was more potent than butylated toluene (BHT) , a common antioxidant used as a food additive.

MISCELLANEOUS AFRICAN PLANTS

The stem bark of *Burkea Africana*, a sub-saharan Africa medicinal plant has been shown to possess antioxidant and anti-radical scavenging activity (Mathisen et al., 2002). The antioxidant component identified by the authors include fisetinidol-(4- -8)-catechin-3-gallate and bis-fisetinidol-(4- -6, 4- -8)-catechin-3-gallate, and to a lesser extent, monomeric flavo-3-ols (catechin, epicatechin and fisetinidol).

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CONCLUSION

Considering the enormous biodiversity resources of the African continent, and the high incidence of diseases with oxidative damage as their etiological factor in the continent, a total of 38 medicinal plants investigated in 18 studies from 8 countries scattered around the continent, is by all standard, unacceptably low. Even for the few plants that were studied, the active principle responsible for the antioxidant properties were not identified (Table 1). Therefore, there is need for all stakeholders on the continent to strive towards taking advantage of our enormous biodiversity resources to free our people from diseases, abject poverty and stagnation.

DEDICATION

To my lovely daughter, Miss Ojonoka Erika Atawodi on the occasion of her 8th Birthday.

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