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Study of Non-Enzymatic Antioxidant Activity of Apocynaceous Plant Species, Available from Purulia District, West Bengal, India: A Review

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Abstract

Reactive oxygen species (ROS) are activated derivatives of oxygen, formed by incomplete reduction of molecular oxygen due to redox imbalance. ROS play a harmful role to cellular damage and pushes us towards severe oxidative stress-related diseases, like cancer, liver injury, lung damage, cardiovascular disorders, inflammation etc. Plants are natural source of antioxidant, the scavenger that remove injurious free radicals and combat detrimental diseases. The present study deals with the significance of Apocynaceae (Dogbane) family, with special reference to understanding of more effective and less toxic non enzymatic antioxidant type bioactive compounds which may be resistant to oxidative stress and improve healthcare system of human being. Many species of Apocynaceae having novel phytochemical compounds earned worldwide reputation as a source of life-saving drugs. In this review collection of detailed information, data collection and evaluation of natural antioxidant property, were done from various literature sources wherein data were generated by the methods like widely used assay, DPPH (1,1-diphenyl 2- picryl hydrazyl), ABTS etc. Phenols, carotenes, xanthophylls, sterols, different alkaloids, glycosides, saponins etc. exhibited potential non-enzymatic antioxidant capacity. In this comprehensive study, non-enzyme antioxidant profile of 29 plants species under Apocynaceae family from Purulia district of West Bengal is represented.

Key words: Non-enzymatic antioxidants, Reactive oxygen species, Oxidative stress, Apocynaceae

1. Introduction

Medicinal plants with their bioactive phytochemicals play protective role by defending free radicals generated after normal metabolic processes in the body with their antioxidant potential.

Normally believed that plant-based natural medications are pure, healthier, non-toxic and inexpensive than artificial synthetic drugs for human being in modern culture. Indian system of medicine like Ayurveda predominantly uses plants as source of drugs or formulation of drugs to cure various critical diseases because they contain bio-active constituents with therapeutic properties. Phytochemicals are synthesized as secondary metabolites which are found in minor amount in higher plants. The term “antioxidant” refers to any substance that delays, prevents or removes oxidative damage to a target molecule[1]. Medicinal plants possess natural antioxidants such as steroids, phenols, polyphenols, flavonoids, carotenoids, alkaloids, tannins, terpenoids, ascorbic acid (AA), reduced glutathione (GSH), other thiol compounds, alpha tocopherol, proline etc. Antioxidant plays significant role in removal of reactive oxygen species (ROS), thus fight against harmful infections and detrimental effects of cells in different stress conditions. They also prevent various pathological diseases and other life-threatening ailments such as cancer, cardiovascular and neurodegenerative diseases which are believed to be associated with oxidative stress[2]. In recent decades, interestingly natural antioxidants like flavonoids, anthocyanins, essential oils etc. not only cause health promotion but also used in cosmetics because they are nontoxic and eco-friendly than artificial antioxidants. Numerous natural antioxidants have already been isolated from different varieties of plant material such as leafy vegetables, fruits, seeds, cereals and algae[3].

Oxidative stress:

In the cellular environment presence of oxygen causes a constant oxidative threat to cellular biochemical processes and structures[4].Oxidative stress is induced due to free radicals generated during oxidative breakdown of our food to simpler forms [5].It is well established that redox imbalance or highly oxidizing metabolic activities are the key source of Reactive Oxygen Species (ROS). ROS leads to an increased membrane lipid peroxidation and cause injury to cell and also attack on cell protein, lipids and DNA[6]. This destructive situation leads to oxidative stress.

Chemistry of ROS:

Mitochondria, peroxisomes of all cells and chloroplast in photosynthetic cells are major organelles for producing ROS. During cellular respiration in mitochondria and photosynthesis in chloroplast, due to unwanted extreme rate of

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electron flow through Electron Transport Chain (ETC) and Z-scheme respectively, causing redox imbalance. Atmospheric molecular oxygen is relatively non-reactive. But, in adverse situation under redox imbalance conditions, at the end of electron flow chain electrons are partially accepted by last electron acceptor, the oxygen and this leads to formation of ROS. ROS both comprise free radical form, superoxide radical(O_2^-), hydroxy radical (OH), perhydroxy radical (HO_2-), alkoxy radical (RO^-), peroxy radical (ROO^-) and non-radical form hydrogen peroxide(H_2O_2), singlet and oxygen ($^1O_2$). Reactive oxygen species like OH, HO_2^-, H_2O_2, $^1O_2$, O_2^-, H_2O_2 etc play a key role for oxidative damage of cells. The univalent reduction of O_2^- produces hydrogen peroxide (H_2O_2), which is moderately reactive. Singlet oxygen ($^1O_2$) is an unusual ROS, not related to electron accept by oxygen. Other exclusive sources of ROS production within cells are causal agents for detoxification reactions catalysed by cytochrome p450 in cytoplasm and endoplasmic reticulum (ER). ROS are also generated at plasma membrane level or extracellularly in apoplast in plants. pH-dependent cell wall-peroxidases, germin-like oxalate oxidases and amine oxidases have been proposed as a source of H_2O_2 in apoplast of plant cells [7]. Thus, ROS are highly toxic, cause lipid peroxidation (LPO), protein oxidation, damage DNA, carbohydrates etc. and at last cell death resulted.

Antioxidants: The scavengers of ROS

A great deal of research has established that the induction of the cellular antioxidant machinery is important for protection against various cellular damages. The components of antioxidant defence system are enzymatic and non-enzymatic antioxidants. Enzymatic antioxidants include superoxide dismutase (SOD), catalase (CAT), ascorbate peroxidase (APX), monodehydro ascorbate reductase (MDHAR), dehydroascorbatereductase (DHAR), guaiacol peroxidase (GPOX), and glutathione S-transferases (GST). Non-enzymatic antioxidants are glutathione (GSH), ascorbic acid (vitamin C) (both water soluble), carotenoids, α-tocopherols (vitamin E, lipid soluble)[8]. Other antioxidant molecules like carotenoids (β-carotene), flavonoids, phenolics, polyphenols, proline etc. These are playing a key role in scavenging free radicals in cells by donating electron or hydrogen [9].

Apocynaceae:

Apocynaceae, the largest angiosperm family commonly known as the Dogbane (Gentianales), most of the species are characterised by producing white milky latex often having poisonous juice or exudates. The expanded family includes five sub-families of Apocynoideae, Asclepiadoideae, Periplocoideae, Rauvolfioideae and Secamonoideae[10]and this new largest comprises 375 genera and 5100 species[11]. Plants of family Apocynaceae are usually distributed in tropical and subtropical regions with herbs, shrubs, sub shrubs, vines, succulents, and trees [12]. About 44 genera and 145 species of Apocynaceae have been reported from China, among them 95% are found in the southern and south western regions of China and of which one genus with 38 species are endemic[13]. In India from different regions several indigenous communities use Apocynaceae plants for medicinal or other purposes like food, fodder, timber, ornamental, perfume, dyes, poison, etc.[14]. Apocynaceae is known as a medicinally important family and species are rich in toxic and medicinal secondary metabolites such as alkaloids, triterpenoids, flavonoids, glycosides, phenols, steroids, lactones, and sterols [15],[16],[17]. Many crucial drugs from this family like cardiac glycosides are highly effective in heart functioning[18] and thus, many apocynaceous plants are potent source of antioxidants.

However, a comprehensive review work on ethnomedicinal plants, particularly from Apocynaceae family species of Purulia district, West Bengal with their antioxidant activities is not available. Hence, the main objective of the present review is accumulation of detailed information and evaluate efficacy of Apocynaceae plant species with reference to their antioxidant properties, from Purulia district, West Bengal.

3.Methodology:

A total 29 species of the Apocynaceae family were selected for the present review with prime focus on preparation of non-enzymatic antioxidant profile. The species are available in several tribal regions of the Purulia district, West Bengal. By using search engines such as Google, Yahoo etc. 18 species of this family have already been reported time to time from different areas of Purulia district by several researchers. About eleven tribal communities throughout the Purulia district are using the whole plants or parts of the plants like root, leaf, bark, flowers etc for curing many health problems. Information on the ethno-medicinal plants and their antioxidant activities have been collated from various sources including journals, books, scientific databases, floras, eFloras, websites like PubMed, Embase, Google Scholar, Scopus, Science etc. Accepted scientific names, synonyms and antioxidant activities of the selected 29 species are illustrated at 'Results and Discussion' section along with references. Accepted botanical names and their synonyms have been confirmed from The Plant List.org (TPL, 2013).

Determination of Antioxidant Activities:

The antioxidant potential of the methanolic plant extract is determined on the basis of their scavenging activities of the stable 1,1-diphenyl 2-picrylhydrazyl (DPPH) free radical. DPPH method

is most widely used and easiest method to determine antioxidant activity (20). Due to the presence of free radical scavenger an odd electron gets combined with an antioxidant agent, DPPH radicals get concentrated to corresponding hydrazine, DPPH-H form, and the sample solution changes from deep violet to light yellow colour [19]. UV spectrophotometer is used for measuring of absorbance and ascorbic acid is used as a reference standard [20].
DPPH inhibitory effect is calculated according to the following formula:

$$\% \text{ inhibition} = \frac{(\text{Absorbance of control} - \text{Absorbance of test sample}) \times 100}{\text{Absorbance of control}}$$

The antioxidant activity of each sample is expressed in terms of IC50. (µg/ml) concentration required to inhibit DPPH radical formation by 50% [20]. Another test for antioxidant activity analysis are metal ion chelating, hydrogen peroxide scavenging, superoxide anion radical scavenging, and ferric thiocyanate reducing ability, are compared to standard antioxidants such as butylatedhydroxyanisole (BHA), butylatedhydroxy toluene (BHT), l- ascorbic acid and α-tocopherol[21].

4. Result and Discussion

Antioxidant capacity and diversity of antioxidant, compounds of 29 different species of Apocynaceae was studied and discussed (Table 1). Information and data from search engines and e-resources revealed that all 29 species possess more or less level of antioxidant property, due to presence of various bioactive compounds. Comparison of antioxidant capacity, based on DPPH assay of non-enzymatic antioxidants in **table 1**. Results showed that, out of 29 species, 13 species has high (H), 7 species moderate (M), 5 species low (L) antioxidant activity. A brief account of species-wise nonenzymatic antioxidants is given hereunder. **I.*Allamanda blanchetii* A.DC.:**
Flowers of purple allamanda has higher amounts of flavonoids, polyphenols, polysaccharide [22]. Two active compounds such as plumericinisoplumericin and 5,6-dimethoxycoumarin (unckalin) are detected from this plant. The floral extracts exhibited comparatively higher anti-oxidant property[22]than other plant parts and different extractions have free radical scavenging potential with IC50 values ranging from 40.50 to 119.21 mg/ml. The highest free radical scavenging activity was demonstrated by the carbon tetrachloride soluble fraction. A positive correlation was seen between total phenolic content and total antioxidant activity [23].
II.*Allamanda cathartica* L.:
Numerous phytochemical investigations of plants from the *A. cathartica* (also called golden trumpet or yellow allamanda) have shown the presence of hydrocarbons, alcohols, esters, ethers, aldehydes, ketones, fatty acids, phospholipids, volatile compounds, phenolic compounds, flavonoids, alkaloids, steroids, terpenes, lactones, and carbohydrates [24]. Flowers of this plant has higher amounts of flavonoids, polyphenols, polysaccharide [22]. In DPPH assay, as compared to standard antioxidant ascorbic acid, methanolic extract of this plant showed mild antioxidant activity [25]. The floral extracts display comparatively higher anti-oxidant property [22].
III.*Allamanda schottii* Pohl:
This plant is commonly known as bush allamanda. The active components, in order of elution on Sigel, are: isoplumericin, plumericin, scoparone, allamandin, scopoletin, pinoresinol, and allamcin[26]. Phytochemical screening result showed the presence of saponin, terpenoids, flavonoid, tannin and alkaloid with antioxidant activity [27].
IV.*Alstonia scholaris* (L.) R.Br.:
*Alstonia scholaris*is popularly known as "Saptaparni" or "Devil's tree". When cut, the outer blaze is cream to yellow with abundant, milky latex. Qualitative phytochemical screening revealed the presence of alkaloids, glycosides, flavonoids, saponins, triterpenoids, tannin, gums and mucilage as well as oils and fats in bark, stem and leaf extracts. Quantitative tests revealed that glycosides, alkaloids, gums and mucilage are present in higher quantity in bark but not in leaf and stem[21], [28]. In DPPH method, ethanolic leaf extract (1mg/mL) shows 63% of inhibition as compared to standard antioxidant ascorbic acid [21]. Both aqueous as well as methanol extracts from bark showed potent total antioxidant activity. Particularly at higher concentrations (200, 250 and 300 µg/ml), the antioxidant activity of aqueous extract was higher than that of standard Ascorbic acid [28].
V.*Calotropis gigantea* (L.) Dryand.:
Calotropis gigantea, the crown flower locally known as akanda, with waxy flowers having lavender colour. Preliminary phytochemical screening showed the presence of alkaloids, sterols, triterpenes, saponins, flavonoids, tannins, carbohydrates, cardiac glycosides and amino acids [29]. Ethanolic extract of leaves (1mg/mL) showed 67.90% [30] and methanolic extract of leaves 400µg/mL concentration showed maximum DPPH radical scavenging activity showing 85.17% of inhibition as compared to standard antioxidant ascorbic acid[29]. In comparison to that of ascorbic acid, the free radical scavenging activity exhibited by the extract was concentration dependent. This activity of the extract is mainly due to the presence of flavonoids and terpenoids[31].
VI.*Calotropis procera*(Aiton) W.T. Aiton:
Commonly known as 'apple of sodom' or rubber bush, this plant is characterised by presence of

poisonous milky sap. Phytochemical analyses of its latex revealed that it possesses antioxidants, namely terpenes, phenolic compounds and cardenolides, flavonoids, saponins, glycosides, tannins, phytosterols, acetogenins. Latex also contains enzymatic antioxidants, namely superoxide dismutase (SOD), catalase and glutathione [32]. Ethanolic leave extracts show highest free-radical scavenging activity, 84.23 % inhibition of DPPH radical [33]. In another report, methanolic leaf extract (10mg/ml) showed75.00 % inhibition as compared to ascorbic acid [34]. Methanol extracts of the leaves of exhibit strong antioxidant activity, while the aqueous extract showed mild antioxidant activity [35].

VII.*Carissa carandas* L.:

Common name 'Bengal currant' or 'Christ's thorn', having berry like fruits commonly used as a condiment in Indian pickles and spices. The fruit extract was orange-pink, translucent, and used in toner formulation[36]. Its fruits contain a high amount of antioxidant substances such as anthocyanin and vitamin C. Phenolics in ripe fruit, for example, isoamyl alcohol, benzyl acetate, lupeol, oxalic acid, tartaric acid, citric acid, malic acid, malonic acid, and glycolic acids, also exhibited antioxidant activity [36]. The inhibition concentration (IC50) of *Carissa carandas* was found to be 27.45±0.43µg/ml. The therapeutic value of a plant mainly depends upon its antioxidative property. Certain compounds like ascorbic acid, phenolics, carotenoids, tocopherol etc. can enhance antioxidant activity. Phenolic compounds and ascorbic acid contribute greatly to the antioxidant activity of a fruit[37]. By using DPPH assay, the lyophilized fruit extract exhibited antioxidant capacities with the inhibitory concentration (IC50) value of 633.42 ± 0.64 µg/ml. [36]. Methanolic extract of leaves was found to exhibit significant dose-dependent DPPH radical scavenging, total antioxidant activity (IC50 value= 73.12µg/ml).

VIII.*Carissa spinarum* L:

*Carissa spinarum*is known as 'conkerberry' or 'bush plum'. The phytochemical screening of extract showed the presence of various phytoconstituents like alkaloids, glycosides, tannins, protein, phenols and flavonoids [38]. In DPPH assay methanolic extract showed stronger antioxidant activity, 56.314±0.639% inhibition as compared to ascorbic acid [38].

IX.*Catharanthus roseus* (L.) G.Don:

Catharanthus roseus (L.) G. Don was previously known as *Vincarosea*(L.) and commonly known as Madagascar periwinkle. This is an ornamental shrub that grows up to30–100 cm in height. By using eutectic solvent solution, *Catharanthus roseus* plant parts, particularly flower petals, showed higher total phenolic content, than root and stem, and leaves have the lowest total phenolic content [19]. Several other reports revealed that plant has various compounds, like terpenoidalindole alkaloids, vinca alkaloids, flavonol glycosides, anthocynidin glycosides and simple phenolics. By DPPH method and using eutectic solvent solution, *Catharanthus roseus* root, stem, leaves, and flower petal was found to contain differential antioxidant activities. The per-centage inhibition of *Catharanthus roseus* plant parts, flower petal, root, stem, and leaves, were detected 73.13 68.64, 64.87, and 61.16%, respectively as compared to ascorbic acid, the standard antioxidant. Flower petal showed highest antioxidant activity. It is concluded that to this plant has strong antioxidant activity it would be an amazing source of beneficial antioxidants that can be helpful for the treatment of diseases caused by free-radical oxidative stress[19].

X.*Catharanthus pusillus* (Murray) G. Don:

Commonly known as the tiny periwinkle and local name sadabahar, marchiara. Terponoid indole alkaloids are predominant in this plant. This species seems to constitute a precious source of the monomerics, vindoline and catharanthine, intermediates in the synthesis of the two important antitumor dimerics vincristine and vinblastine [40].

XI.*Cryptolepis dubia* (Burm.f.) M.R.Almeida .:

Local names are Dudhia, dudhlalar. having activities of enzymatic antioxidant like SOD, CAT, LP, GSH and GPX [41],—but non-enzymatic antioxidant activity yet not reported.

XII.*Gymnema sylvestre*(Retz.) R. Br. ex Schult:

Vernacular name is merasingi and hindi name is 'gurmar' means sugar destroyer. Leaves reduce sensitivity to sweet substances after chewing. Leaves contain lupeol, β-amyrin, stigmasterol, pentriacontane, hentricontane, α and β chlorophyll, resin, tartaric acid, gymnemic acid, anthraquinone derivatives, alkaloids, betaine choline and trimethylamine. Antisweet constituent of the leaves has been found to be a mixture of triterpenesaponins. The sugar residues are glucuronic acid and galacturonic acid while ferulic and angelic acids have been attached as the carboxylic acid. Methanolic leaf extract revealed the presence of some active ingredients such as alkaloids, cardiac glycosides, tannins, saponins, anthroquinones, phenols and flavonoids [39]. Methanolic extract of the leaves showed good DPPH scavenging activity. At higher concentrations its radical quenching ability was identical to the standard ascorbic acid. Ethanolic leaf extract showed highest DPPH radical scavenging activity with 83.41±0.13% at 120 µg/ml concentration (which is nearly close to the value of Ascorbic acid a standard antioxidant) [39]. The activity found for methanolic extract at its highest concentration of 6 µg was 82.5% [40].

XIII.*Hemidesmus indicus* (L.) R. Br. ex Schult:

This plant has different local names like Huringonal, anantamul, marangonol sing dhubi, having prostrate or semi erect shrub habit. The phytochemical screening of the ethanolic extract (yield, 9.2%) of root was dark brown in colour and sticky in nature indicating positive results for having flavonoids, terpenoids, tannins, coumarins, glycosides, polyphenols and coumarins. Alkaloids are not found in the extract i.e., negative results for alkaloids, anthraquinones, lactones/ester, protein/ amino acids, and saponins [44, 45]. The methanolic extract of *H. indicus* root bark exhibited different levels of antioxidant activity in all the models studied. It showed a concentration dependent antiradical activity by inhibiting DPPH radical with an EC50 value of 18.87 µg/ml [41].

XIV.*Holarrhena pubescens Wall.ex G.Don:*

The vernacular name is Kurchi, tuar, indrajob and presence of flavonoides, phenolic compounds suggested that they possess a number of common antioxidants [42]. In several reports, extract of bark has compounds like non-alkaloidal constituents kurchinin, kurchinicin, holarrheno and alkaloids holamine, kurchamine, holaphyllidine, holaromine, mitiphylline, holadysenterine[43]. The methanolic and water extract showed strong antioxidant activity with inhibition of more than 90% DPPH free radicals at the concentration of 100µg/mL [42].

XV.*Holostemma annularis* K.Schum:

Commonly known as jivanthi, this plant yields terpenoid sugar and other highly valued secondary metabolites, which have antioxidant property. Plant extracts exhibited significant dose-dependent DPPH radical scavenging activity, with a 50% inhibition (IC50) at a concentration of 265.95, 151.51and 68.18µg/ml respectively. The IC50 value of the hexane and ethyl acetate extract was found to be lesser than the standards [49].

XVI.*Ichnocarpus frutescens* (L.) W.T. Aiton*:*

Commonly known as 'black creeper', with several vernacular names like Pirihore, onol sing, chotodudhi, dudhilata, shyamalata, dugdhalata, sayalata, perilata. Phytochemical analyses revealed the presence of flavonoids, polyphenols, anthocyanins and simple phenolic acids. Various solvent extracts of the plant have been reported to be potent free radical scavengers and inhibitors of lipid peroxidation [44]. The percentage inhibition of 40 µg/ml concentration of methanolic extract in DPPH radical scavenging model was found as 86.7% [45].

XVII.*Nerium indicum* Mill.:

Local name is 'raktakarabi'. All the extracts have been found to contain significant amount of total flavonoid and phenolic compounds. Both of these compounds have good antioxidant potential and their effects on health and disease prevention are considerable. Flavonoids are polyphenolic plant secondary metabolite characterized by a common benzopyrone ring which functions primarily as antioxidants and also have cardio protective role[46]. The methanolic extracts of leaf, stem and root of showed excellent dose-dependent scavenging activity of DPPH radical. The IC50 values of the leaf, stem and root extracts and standard ascorbic acid were 217.15 ± 18.39 ìg/ml, 63.56 ± 1.63 ìg/ml, 166.18 ± 6.84 ìg/ml and 5.29 ± 0.28 ìg/ml respectively. At 100 ìg/ml, the percentage of inhibition of the leaf, stem and root extracts were 33.14%, 64.16% and 38.03% whereas at 45 ìg/ml the standard ascorbic acid shows 27.93% inhibition[46].

XVIII.*Nerium oleander* L.:

Historically considered as poisonous plant having a local name karabi. Various compounds have been reported in connection with these biological activities, such as cardenolides (oleanderin, neriantin, adynerin, deacetyloleanerin, neriifolin), triterpenoidalsaponins, oleanderol, rutin, dambonitol in leaves; odorosides (A, B, D, F, G, H, K) in barks; triterpene, steroidal cardenolide, volatile oil, stearic acid, oleic acid in roots; and gitoxigenin, uzarigenin, strospeside, odoroside H in flowers [47]. Methanolic extract contained highest amounts of phenolic compounds and exhibited the maximum antioxidant activity. The *in vitro* DPPH assay showed high scavenging property of methanolic extract 78.52±0.37, may be due to hydroxyl groups existing in the phenolic compounds, chemical structure that can provide the necessary component as a radical scavenger [20].

XIX.*Pergulariadaemia* (Forsk.) Chiov.:

The trellis vine and local name is latabakanda. The phytosterols, saponins, phenols, alkaloids, tannins, flavonoids and triterpenes found in the extract may be responsible for the observed anti-hyperglycaemia and antioxidant activities [48]. In the DPPH radical scavenging assay, the extract showed a concentration dependent radical scavenging effect. In this assay, the lower the EC50 values the higher the ability to scavenge for oxygen radicals. In comparison to ascorbic acid and BHT, the extract had a lower scavenging effect. The EC50 values were 2.608, 0.149 and 0.699mg/mL for the extract, ascorbic acid and BHT, respectively [48].

XX.*Plumeria acutifolia* Poir.:

Plumeria acutifolia is an ornamental plant, with long, oval and pointed leaves. Plant used in the traditional medicine and known to have a variety of constituents as alkaloids, flavonoids, and iridoids[49]. The antioxidant activity was concentration dependent; ethyl acetate fraction showed the most predominant effect, with an IC50 of 197.1 µg/ml and inhibition with 82.81%. Five compounds were identified as narcissinquercitrin, sweroside, gaertneroside and plumieride[49].

XXI.*Plumeria obtusa* L.:

Singapore graveyard flower, leaves are ovate or teardrop shaped. Various phytochemicals like alkaloids, flavonoids, terpenoids, glycosides and

sterols are present, which show antioxidant activity. Methanolic extract of leaves has antioxidant inhibitory effect, 38.12±0.641 as compared to ascorbic acid [50].

XXII.*Plumeria rubra* L.:

Common name fringipani and local names are Lalgorur, gulach, Plant has antioxidant and hypolipidemic activity due to presence of flavone glycoside compounds[51]. More than 110 chemical constituents have been isolated from *P. rubra* including iridoids, terpenoids, flavonoids and flavonoid glycosides, alkaloids, glycosides, fatty acid esters, carbohydrates, animo acids, lignan, coumarin, volatile oils, etc. The important chemical constituents responsible for pharmacological activities of the plant are fulvoplumierin, plumieride, rubrinol, lupeol, oleanolic acid, stigmasterol, taraxasteryl acetate, plumieride-p-*E*-coumarate, rubranonoside, rubrajalellol, plumericin, isoplumericin, etc. The plant possesses a wide range of pharmacological activities present namely antibacterial, antiviral, anti-inflammatory, antipyretic, antidiabetic, hepatoprotective, anticancer, anthelmintic, antifertility and many other activities [52].. Highest antioxidant activity was found in *P. rubra* flowers[51]. Plant latexes (58±2.9%) also possess good antioxidant activity [53].

XXIII.*Rauvolfia serpentina*(L.) Benth. exKurz:

This plant is commonly known as "quinine tree" with local name 'Chotachand', 'sarpagandha'. *Rauvolfia* is important from a medicinal point of view because of the presence of N-containing indole alkaloids, which are localised in roots [54]. Nutrients and phytochemical characterisation included determination of tocopherols by HPLC-fluorescence, phenolics, flavonoids, carotenoids, ascorbic acid and pigment composition by spectrophotometric techniques. *Rauvolfia serpentina* exhibited the highest total phenolic content [55]. DPPH assay showed a percentage inhibition of 19, 27.5, 38, 47.9, and 55 for cultivated and 34.99, 62.5, 76.09, 81.94, and 84.64 for wild at 0.1, 0.2, 0.3, 0.4, and 0.5 µg/ml concentrations, respectively. The DPPH radical scavenging activities of the species of *Rauvolfia* leaf extracts increased with increasing concentrations [60]. At 100 g/mL, the highest DPPH radical scavenging activity (93.1 ± 0.06%) was observed in *R. serpentina* than R. *tetraphylla*[55].

XXIV.*Rauwolfia tetraphylla* Linn:

Commonly known as 'devil-pepper' and vernacular names are Borachadar, nagmani.

Several, steroids, triterpenoids, steroidal glycosides, flavonoids, saponins, catechin, phenolics and alkaloids have been reported which show potent antioxidant activity[56].Plants produce a great number of secondary metabolites like alkaloids, terpenes and polyphenolic compounds, many of which, are known to possess therapeutic applications [57]. *Rauvolfia tetraphylla has* highest flavonoid content among the five species of this genus [55].

XXV.*Tabernaemontana divaricata*(L.)R.Br. ex Roem.&Schult:

Also called crape jasmine or pinwheel flower, which exudes milky latex and its local name 'tagar'. In various assays particularly DPPH, the plant showed antioxidant activity. Several known and yet unknown oxidants are supposedly present in this plant [58]. Flavonoids and some other phytochemicals are found in higher concentrations[59]. The major classes of alkaloids are present within the genus, like monoterpene indole, bisindole alkaloids. Other compounds include terpenes, lactones, steroids, phenolics and flavonoids each of which related to antioxidant property[60].

XXVI.*Telosma pallida* (Roxb.) W. G. Craib:

This plant is called Telosma vine. Antioxidant capacity of methanolic extract of leaves and stem was found highest as IC50 values were 253.12±1.02, 158.43±0.48 respectively [61]. Antioxidant power may be due to the presence of phenolics, flavonoids and some other chemicals like alkaloids, glycosides, saponins, sterols and tannin [61].

XXVII.*Thevetia peruviana*:

Common name yellow oleander, local name 'kolke' with enormous milky latex. Various flavonoids and phenolic compounds were detected in the collected latex, namely nirigin, rutin, quercetin, kaempferol, luteolin, hesperdin, catechin[62]. Methanolic extract contained highest amounts of phenolic compounds and exhibited the maximum antioxidant activity. The *in vitro* DPPH assay showed high scavenging property of methanolic extract 69.79±0.12, and this may be due to hydroxyl groups existing in the phenolic compounds-[20].

XXVIII.*Tylophora fasciculate* Buch.-Ham. ex Wight:

Vernacular name is 'ishermul'. In phytochemical studies the presence of alkaloids, flavonoids, phenols, saponins, steroids, tannins and terpenoids was confirmed by qualitative analysis and potent antibacterial activity of the plant extracts [63] was established. The active constituent phenanthroindolizidine alkaloid, tylophorine and huge content of phenolics have been [64]. The % DPPH scavenging activity increases with the increasing concentration. The concentration of the plant extract of *Tylophora indica* needed for 50% inhibition (IC50) was found to be 199.58µg/ml, whereas 194.58 µg/ml needed for ascorbic acid [64].

XXIX.*Vallaris solanaceae*(Roth) Kuntze:

The plant is woody climber and local name is 'ramsar'. The seed of this planthas several compounds like glycosides of vallaroside, solanoside, vallarosolanoside, 16-diacetyl-16-anhydro-acoschimperoside P, mono-O-acetyl-

acoschimperoside P, mono-O-acetyl-vallaroside and mono-O-acetyl- solanoside[65]. Leaf extract showed various compounds, such as carbohydrates, flavonoids, saponins, phenols, tannins, glycosides, steroids [66]. In DPPH assay, ethanolic extract showed 53.75% inhibition [67].

Phenols, carotene, xanthophyll, sterols, different alkaloids, glycosides, saponins etc. are exclusively important bioactive components with diverse biological functions including antioxidant capacity. Due to presence of their OH groups, act as non-enzymatic radical scavengers with tremendous effect.

Table 1: Comparison of antioxidant capacity based on DPPH assay among 29 species.

Sl. NO.	Accepted botanical names	Synonyms (TPL, 2013)	Activity
1.	*Allamanda blanchetii* A.DC	*Allamanda violacea* Gardner	**M**
2.	*Allamanda cathartica* L.	*Allamanda cathartica* var. *grandiflora* L.H.Bailey& Raffill	**L**
3.	*Allamanda schottii* Pohl	*Allamanda schottii* Hook.	**YNR**
4.	*Alstonia scholaris* (L.) R.Br.	*Echites scholaris* L.	**H**
5.	*Calotropis gigantea* (L.)Dryand.	*Calotropis gigantea* (L.) R. Br. ex Schult.,	**H**
6.	*Calotropis procera*(Aiton) W.T. Aiton	*Calotropis heterophylla* Wall.ex Wight	**H**
7.	*Carissa carandas* L.	*Carissa carandas* var. *congesta* (Wight) Bedd.	**L**
8.	*Carissa spinarum*L.	*Carissa abyssinica*R. Br.	**M**
9.	*Catharanthus roseus* (L.) G.Don	*Catharanthus roseus* var. *roseus*	**H**
10.	*Catharanthus pusillus*(Murray) G. Don	*Lochnera pusilla* (Murray) K.Schum.,	**YNR**
11.	*Cryptolepis dubia* (Burm.f.)M.R.Almeida.	*Cryptolepis buchananii* Roem. &Schult.	**YNR**
12.	*Gymnema sylvestre*(Retz.) R. Br. ex Schult	*Gymnema sylvestre* var. *affine* (Decne.) Tsiang,	**H**
13.	*Hemidesmus indicus* (L.) R. Br. ex Schult.	*Periploca indica* L.	**L**
14.	*Holarrhena pubescens* Wall.exG.Don	*Holarrhena antidysenterica* (L.) Wall.exA.,	**H**
15.	*Holostemma annularis* K.Schum	*Holostemma ada-kodien* Schult.	**M**
16.	*Ichnocarpus frutescens* (L.) W.T. Aiton	*Apocynum frutescens* L.	**H**
17.	*Nerium indicum* Mill.	*Nerium indicum* subsp. *kotschyi* (Boiss.) Rech.f.	**H**
18.	*Nerium oleander* L.	*Nerium oleander* subsp. *kurdicum* Rech.f.	**H**
19.	*Pergularia daemia*(Forsk.) Chiov.	*Pergularia daemia* var. *daemia*,	**L**
20.	*Plumeria acutifolia Poir*	*Plumeria acutifolia* var. *gasparrinii* A.DC.	**H**
21.	*Plumeria obtusa* L.	*Plumeria obtusa* var. *laevis* Griseb.	**L**
22.	*Plumeria rubra* L.	*Plumeria rubra* f. *acuminata* (W.T.Aiton) Woodson,s	**M**
23.	*Rauvolfia serpentina* (L.) Benth. ex Kurz	*Rauvolfiaobversa*(Miq.)Baill	**H**
s24.	*Rauvolfia tetraphylla* L.	*Rauvolfia hirsuta* Jacq.	**YNR**
25.	*Tabernaemontana divaricata*(L.)R.Br. ex Roem.&Schult	*Tabernaemontana coronaria* (Jacq.)Willd.,*Vinca alba* Noronha	**M**
26.	T*elosma pallida* (Roxb.) W. G. Craib	*Pergularia pallida* (Roxb.) Wight &Arn.	**H**
27.	*Thevetia peruviana*	*Thevetia peruviana* f. *aurantiaca* H.St.John	**H**
28.	*Tylophora fasciculata* Buch.-Ham. ex Wight	*Tylophora indica*	**M**
29.	*Vallaris solanaceae*(Roth) Kuntze	*Vallaris anceps (Dunn &R.S.Williams) Wall. Ex C.E.C.Fisch*	**M**

Abbreviations like H,M,L and YNR indicate the magnitude of inhibition

H= High (more than 60% inhibition), M= Moderate (more than 40% inhibition), L= Low (less than 40%), YNR= Yet Not Reported

4. Conclusion

Due to oxidative stress, always our body is facing several outrageous diseases like cancer, ulcer, liver injury, cardiovascular disease etc. The above result showed that plant extract of most of the species of Apocynaceae family are important agents with tremendous effect for removal of oxidative radicals i.e., ROS, which are responsible for imposing oxidative stress in our body. Among these 29 selected species *Catharanthus sp, Rauvolfia sp, Gymnema sylvestre, Holarhhena pubescens, Alstonia scholaris, Nerium sp and Calotropis sp* are strong enough as potential source for natural antioxidants.

The results and information revealed that the Apocynaceae plant species are potent and generating highly effective source of ROS scavengers to combat oxidative stress related deadly diseases. Majority of the ethnic and tribal peoples from Purulia district, West Bengal completely depend on the plant-based medicine for their regular healthcare. So, this comprehensive review ascertains the standard of plant-based herbal formulation of drugs which could be of great value for management of human healthcare, particularly for resource poor tribal communities of Purulia district.

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