Studieds on Some Medicinal Plants Obtained from A Dry Tropical Forest with Emphasis on Their Antioxidant Properties
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ABSTRACT
Antioxidants are derivatives of vitamin C or beta-carotene that prevent reactions stimulated by oxygen, peroxides, or free radicals, thus and reduces the oxidative stress. They have found their way into many uses in treating several human diseases and reduces the risk of developing diseases like cancer. In view of these properties, the present study was focussed in identifying several plants possessing antioxidative properties and which were also conserved in the ex-situ park of CSIR – Central Institute of Mining and Fuel Research, Dhanbad, India. Fifteen medicinal plants including herbs, shrubs and grasses are reported in this paper, and a collective insight has been presented about their antioxidan properties and the present state of their pharmacological applications. The specific chemical constituents abundant in the leaves, roots, stems, seeds and fruits of each of these plants have also been dealt with. To report a few antioxidant pharmacological preparations from Ayurvedic literature are Vimang, Maharishi Amrit Kalash (MAK4, MAK5), Maharishi Ayurved (MA631, MA47), MA Raja’s Cup, MA Student Rasayana and MA Ladies Rasayana. This review has been attempted to enhance the importance of the plants which are generally being neglected, so that it can be used by the local people in rural areas for their cultivation and it will also pave the pathway for their subsequent future use in medicinal and research industry for drug formulation.
Keywords: Free Radicals; Antioxidants; Pharmacological Value; Vitamin C; Ageing; Herbs

1. Introduction
Oxidative stress is the result of free radicals generated from lipid oxidation products which harm healthy cells, contributing to aging and diseases like liver cirrhosis, atherosclerosis, cancer, and diabetes[1-4]. These free radicals if scavenged can help prevent such diseases. Antioxidants or derivatives of vitamin C are beta-carotene compounds that can scavenge these free radicals[5]. They act by delaying or inhibiting the oxidative chain reaction during oxidation of lipids[6] and deactivate the free radicals already generated, often before they attack targets cells[7]. Usually the antioxidants which are available in the market are found in the form of costly medicines. Many medicinal plants on the other hand possess natural antioxidants[8] and have been exploited from ancient times in ayurveda for human benefits[9]. These antioxidants are usually classified as flavonoids, anthocyanins, carotenoids, dietary glutathione and vitamins[10-13].

Various studies have been reported in literature concerning research works on many plant extracts for a significant antioxidant activity[14-16]. Phytochemical analysis of rasayana from plants showed that a large numbers of compounds including tannic acid, flavonoids, tocopherol, curcumin, ascorbate, carotenoids, polyphenols, etc. have shown effective antioxidant properties[17-19]. Govind[20] stated that on the use of medicinal plants with high level of antioxidant constituents can be an effective therapeutic approach for treating hepatic damages. Shikhar et al.[21] has reviewed six plants such as Lantana camara, Glycyrhiza glabra, Vaccinium oxyccocos, Cinnamomum zeylanicum, Saraca indica and Acacia arabica for their antioxidant properties. Based on phytochemical analysis they revealed that a large number

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of compounds including flavonoids along with phenolics also show antioxidant properties. Another seven medicinal plants like Ocimum sanctum, Camellia sinensis, Withania somnifera, Glycyrrhiza glabra, Curcuma longa, Zingiber officinale, Me-lia azadarach were also reported for their antioxidant potential[22]. Kusuma et al.[23] studied the antioxidant properties of some medicinal plants used by the Bantian tribe from Indonesia for medicinal use. Antioxidant activity is mostly assayed by DPPH (diphenyl picryl hydrazyl) radical scavenging activity mechanism. The most extensive antioxidant activities against DPPH were displayed by the ethanol extracts of Ficus variegata stem bark, Lecosyke quadrinervia root and Clausena excavate leaves exhibiting 91%, 91% and 86% inhibition of the radicals, respectively[23]. Similarly plants such as Emblica officinalis, Curcuma longa, Mangifera indica, Momordica charantia, Santalum album, Swertia chirata, Withania somnifera were also reviewed for their antioxidant properties, phytochemical and pharmacological aspects[24]. Ferreira et al.[25] analysed ten Portuguese plants for inhibitory activity of the enzyme acetyl cholinesterase as per their antioxidant activity. The ethanolic extract of Sanguisorba minor showed the best inhibition of AChE and subsequently showed a very good antioxidant activity. A decoction of Menthae aveolens was also very effective in the inhibition of AChE and as a scavenger of radicals. Antioxidant properties of Laurus nobilis, Menthae aveolens, Hypericumun dulatum, Melissa officinalis and Sanguisorba minor can help in preventing or alleviating patients suffering from AIDS as they showed both inhibitory activity on AChE. These herbs have also been used for a long time as a source of food, and condiments in Portugal but recent studies have indicated that they also have a scientific value which suggests their applications in new avenues[25]. Seven Korean medicinal plants were also studies for their free radical scavenging capacities and antioxidant activities. They observed that the root bark of Morus alba and the leaf of Saururus chinensis showed stronger SC50 or ID50 values. Their experimental result shows a protective effect on DNA damage caused by hydroxyl radicals produced from UV-induced photolysis of hydrogen peroxide[26]. Whole plant of Torilis leptophylla was studied for antioxidant properties in which the phytochemical screening such as total phenolic (TPC) and total flavonoid contents (TFC) showed radical scavenging activity. They suggested that methanolic extract of T. leptophylla may be useful in defence against CCl4-induced liver damage in male Sprague-Dawley rat possibly due to its antioxidant properties and it can be the potent source of natural antioxidants in food as well in pharmaceutical formulations[27]. Pourmorad et al.[28] showed antioxidant activity of Mellilotus officinalis plant extract and it was 4 times greater than the synthetic antioxidant called butylated hydroxy toluene (BHT). The extract of M. officinalis, showed highest amount of flavonoid and phenolic compounds, and exhibited antioxidant activity due to the hydroxyl groups existing in the phenolic compounds[29]. Thus, from various experimental studies it has been revealed that such plants can be good sources of natural antioxidants that can be further harnessed for treating different ailments.

In the state of Jharkhand various such medical plants including herbs shrubs and grasses having antioxidant property and are dominant species along the roadsides, arable and fallow lands. There is need to conserve these species at any cost. Earlier in one of our studies we had carried an ethnobotanical study to identify medicinal importance of some selected dominant species in the native forest of Jharkhand and preserved all of them under ex-situ conservation Park for socio-economic development of the tribals[29]. In the study, a total of 41 medicinal plants had been selected and documented for their therapeutic use against various types of diseases frequently occurring in tribal people in mining areas of the coal capital of India[29]. We also reviewed 23 different types of medicinal plants, herbs and shrubs dominating the Jharkhand state and which can be sustainably exploited to cure various ailments in local people who lack modern medicine facility[29–30]. In this regard, firstly, there is a necessity for developing an awareness regarding the antioxidants which are naturally available, their method of use and cultivation. This would make the use of antioxidants cost-effective and pave the pathway for future research and medicinal industry for formulating new drugs. Thus, the aim of the study is to enhance the importance of the plants which are generally being neglected, so that it can be used for earning a livelihood in the long term.

2. Survey study done in CSIR-CIMFR
2.1 Study area
The ex-situ conservation park (23° 48’ 57.20’’ N and 86° 25’ 41.71’’ E) is located at CSIR-CIMFR, Dhanbad, Jharkhand, India. The institute is located in the town of Dhanbad, known as coal capital of India. It is strategically situated in the Damodar basin of eastern part of the country which is endowed with rich coal deposits and hosts several large mineral based industries. The area experiences tropical climate and is characterized by very hot summer and cold winters. The temperature in the cold weather months (November to February) varies from lowest minimum of 8.3°C to the highest maximum of 34.4°C. During summer months March to June it varies from the lowest minimum of 13.3°C to the highest maximum of 47.0°C. During the remaining months, July to October, the rainy season persist in which the temperature varies from the lowest minimum 15°C to 36°C. Relative humidity (RH) is high in the rainy days being about 94% in June and low in the month of May which is about 36%. Thunder storms usually occur in the month of May and June accompanied by a temporary fall by some degrees. The area receives annual rainfall of about 1100–1200 mm.

2.2 Vegetation of the study area

The dry deciduous forest was dominated by tree species such as Palash (Butea monosperma) Lamb. Taub, Asan (Terminalia tomentosa Wight & Arn), Sal (Shorea robusta Gaertn) and Shishum (Dalbergia sissoo) Rujuta. The species such as Sidha (Lagerstromia parviflora Roxb.), Gamhar (Gmelina arborea Roxb. ex Sm), Sirish (Albizia lebbeck L. Benth), Bahera (Terminalia bellerica Gaertn. Roxb.), Bel (Aegle marmelos Correa), Semal (Bombax malabaricum DC), Khair (Acacia catechu L. f. wild), Mahua (Madhuca indica G.F. Gmel) were also found scattered in the forests. However, Salai is (Boswellia serrata) Roxb. ex Colebr) one of the common species in dry mixed deciduous forests in other parts of Jharkhand but was almost absent here except a few individuals. Good quality of bamboo forests was also found mixed with these trees. The species with high medicinal value from the forests were conserved in our ex-situ conservation park.

2.3 Data collection methods

The study was carried out at the ex-situ conservation Park which was established in the year 2003 by the Ministry of Environment and Forest (MoEF), Government of India. All plant specimens were collected during the adulthood stage with the help of gardeners, and local well-knowledge persons and identify the plants on the basis of their habitat. The local names of the plants were obtained from the local habitants. The specimens were photographed, pressed and dried in the field. Samples were also taken for scientific identification and preparations of herbarium as per standard procedures[31]. The species were identified by the Botanical Survey of India; Kolkata. The socio-interaction was carried out to know its therapeutic uses and a door to door survey was done. On the basis of the various therapeutic uses of selected medicinal plants, their antioxidant properties were identified.

3. Antioxidant properties of the selected dominant plants

The collected data on ethno-medicinal uses as well as antioxidant properties of the selected herbs, shrubs grasses and plants is presented in Table 1. The columns include the botanical name, plant type, family, local name, parts used, and the chemical constituents used as antioxidants. The photographs of the individual plants taken during the field study have been shown in Figure 1. Namely the plants include 8 trees, 4 herbs, 2 climbers and 1 grasses. Their scientific names are Alstonia scholaris L. R. Br., Andrographis paniculata Burm. f. Wall. ex Nees, Carcum coticum Linn., Cissus quadrangularis L., Cymbopogon citratus L. DC. Ex Nees. Stapf., Mangifera indica Linn., Mimusops elengi Linn., Ocimum sanctum Linn., Pterospermum acerfolium L., Wild Santalum album Linn., Saraca asoca Roxb. Wild., Terminalia arjuna Roxb. Wright & Arn., Terminalia bellerica Gaertn. Roxb., Tinospora cordifolia Thumb. Miers .. Withania somnifera L. Dunal. The literature revealed that the antioxidant property of the plants were observed in the roots, leaves, stem, fruits, bark, flowers, seeds, latex as well as in whole plants in some of the species. Chemically the antioxidants extracted from the plants were alkaloids, terpenoids, diterpenoids, diterpene, flavonoids, polyphenols, glycosides, lactones, glycosides, saponins, steroids etc. These plants were also found to be abundant in the natural forests and ex-situ Conservation Park as they are native plants and adapted to the local climate. In this aspect, policies and strategies should be framed out conjointly my the Government and Research Institutes to cultivate these highly
important medicinal plants on the vast acres of degraded lands to address various environmentally important topics like soil conservation, soil fertility, carbon sequestration, and switching to green medicine compared to chemical developed synthetic drugs in laboratories.

<table>
<thead>
<tr>
<th>Sl. no</th>
<th>Botanical name</th>
<th>Plant type</th>
<th>Family</th>
<th>Local name</th>
<th>Parts used</th>
<th>Chemical constituents</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td><em>Alstonia scholaris</em> (L.) R.Br.</td>
<td>T</td>
<td>Apocynaceae</td>
<td>Chhatim</td>
<td>stem barks, flower, latex</td>
<td>Alkaloids (alstonidine, alstonine, chlorogenic acid, chlorogenine, ditaic, echitamine, echitanin, β-sitosterol), terpenoids (lupeol, linoleate, lupeol), flavonoids</td>
</tr>
<tr>
<td>2.</td>
<td><em>Andrographis paniculata</em> Burm.f. Wall, ex Nees</td>
<td>H</td>
<td>Acanthacea</td>
<td>Kalmegh</td>
<td>Leaves, roots, whole plants</td>
<td>Diterpenoids, diterpene, flavonoids, polyphenols, glycosides, lactones</td>
</tr>
<tr>
<td>4.</td>
<td><em>Cissus quadrangularis</em> L.</td>
<td>C</td>
<td>Vitaceae</td>
<td>Hadjod</td>
<td>Stem</td>
<td>Triterpenes, α- and β-amyrins, β-sitosterol, keto-steroids, phenols, carotene, vitamin C flavonoids, quercetin, kaempferol</td>
</tr>
<tr>
<td>5.</td>
<td><em>Cymbopogon citratus</em> L. DC. Ex. Nees. Stapf.</td>
<td>G</td>
<td>Poaceae</td>
<td>Lemon grass</td>
<td>Leaves, stem</td>
<td>Tannins, sterols, terpenoids, phenols, ketone, flavonoids, alkaloids, saponin, (α-sistosterol), terpenes, flavonoids, chlorogenic acid, p-coumaric acid</td>
</tr>
<tr>
<td>6.</td>
<td><em>Mangifera indica</em> Linn.</td>
<td>T</td>
<td>Anacardiaceae</td>
<td>Aam</td>
<td>Leaves, fruits, barks, seeds</td>
<td>Flavonoid, phenolic acid, β-carotene &amp; Vitamin C</td>
</tr>
<tr>
<td>7.</td>
<td><em>Mimusopus elengi</em> Linn.</td>
<td>T</td>
<td>Sapotaceae</td>
<td>Bakul</td>
<td>Bark, seed, leaf, fruit</td>
<td>Alkaloids, saponins, quercitol, hentriacontane, β-carotene, quercetin</td>
</tr>
<tr>
<td>8.</td>
<td><em>Ocimum sanctum</em> Linn.</td>
<td>H</td>
<td>Lamiaceae</td>
<td>Tulsi</td>
<td>Leaves, seeds</td>
<td>Saponins, flavonoids, triterpenoids, phenolic compounds, vitamin C</td>
</tr>
<tr>
<td>9.</td>
<td><em>Pterospermum acerifolium</em> L. Wild.</td>
<td>T</td>
<td>Sterculiaceae</td>
<td>Kanak champa</td>
<td>Leaves, bark, flowers</td>
<td>Flavonoids, tannins, cardiac glycosides, saponin glycosides, terpenoids, anthraquinones, alkaloids</td>
</tr>
<tr>
<td>10.</td>
<td><em>Santalum album</em> Linn.</td>
<td>T</td>
<td>Santalaceae</td>
<td>Safed chandan</td>
<td>Bark</td>
<td>Gallic acid (polyphenol), α-tocopherol, quercetin</td>
</tr>
<tr>
<td>No.</td>
<td>Species</td>
<td>Family</td>
<td>Mode of Preparation</td>
<td>Secondary Metabolites</td>
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<tr>
<td>11</td>
<td><em>Saraca asoca</em> Roxb. Willd.</td>
<td>Caesalpinaceae</td>
<td>Ashok</td>
<td>Bark, leaves, flowers, seeds Ascorbic acid, catechin, flavonoids, lignin glycosides, β-sitosterol, polyphenolics</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td><em>Terminalia arjuna</em> Roxb. Wright &amp; Arn.</td>
<td>Combretaceae</td>
<td>Arjun</td>
<td>Barks, stems, leaves Tannins, triterpenoidsaponin (arjunic acid, arjunolic acid, arjungenin, arjunglycosides) flavonoids (arjunone, arjunolone, luteolin), gallic acid, ellagic acid</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td><em>Terminalia bellirica</em> Gaertn. Roxb.</td>
<td>Combretaceae</td>
<td>Bahera</td>
<td>Fruits Glucoside, gallic acid, ethyl Gallate, chebulinic acid</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td><em>Tinospora cordifolia</em> Thunb. Miers.</td>
<td>Menispermaceae</td>
<td>Giloe</td>
<td>Root, stem, leaves, whole plant Alkaloids, diterpenoid lactones, glycosides, steroids, sesquiterpenoid, phenolics, aliphatic compounds, polysaccharides</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td><em>Withania somnifera</em> L. Dunal.</td>
<td>Solanaceae</td>
<td>Ashwagandha</td>
<td>Roots, leaves Steroidal lactones, alkaloids, flavonoids, cuseohygrine, analyhygrine, tropine, anaferine, glycosides, enolide</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: H: herb; S: shrub; T: tree; C: creeper; G: grass

Table 1. Description of plants observed in the study for antioxidant properties
In view of the suggestion of sustainable forestry on degraded lands by global researchers some plants have been discussed below as per the extensive work on their antioxidant properties for their future recommendation to include them in species list for establishing man-made forests tracts on barren lands. This will not only open new avenues to the drug development industry but will also add to the socio-economic status of the local people due to their value-added properties.

### 3.1 Mangifera indica

Several authors have reported *M. indica* as a potent source of antioxidants[32-36]. Chukwuemeka *et al.*[37] had experimentally studied the antioxidant potential from extract *M. indica*. Their results on phytochemical screening and FTIR spectra revealed the presence of bioactive molecules including flavonoids and phenols. Bushra *et al.*[38] investigated the antioxidant activity of leaves, peels, stem bark, and kernel of mango varieties Langra and Chonsa. Total phenolic (TPC) and total flavonoid contents (TFCs) in segments of Langra ranged from 63.9 to 116.8 mg GAE/g DW and 45.6 to 90.9 mg CE/g DW, respectively, and that of Chonsa were 69.24 to 122.60 mg GAE/g DW and 48.43 to 92.55 mg CE/g DW, respectively. The 2, 2-diphenyl-1-picrylhydrazyl (DPPH) scavenging activity and linoleic inhibition capacity in segments of Langra ranged from 53% to 61% and 40% to 47%, respectively, whereas for Chonsa was 56.4% to 66% and 48.1% to 49.0%, respectively. Lai *et al.*[39] analysed the ethanolic and aqueous extracts of *M. indica*. The standardised ethanolic extracts of the *M. indica* leaf show free radical scavenging activity of 0.17 mg/ml and a total phenolic content of 590 mg/g of extract. It proves that the aqueous and ethanolic extracts of *M. indica* leaf can protect ageing cells from oxidant-induced cell death. Similarly Ribeiro *et al.*[40] has analyzed the phenolic compounds and antioxidant activities of four mango varieties cultivated in Brazil. A total of 12 flavonoids and xanthones were identified in the pulps, peels and seed kernels of the fruit with larger amounts antioxidant activity.

### 3.2 Alstonia scholaris

Molly *et al.*[41] had investigated the antioxidant activity from the extracts of leaf and bark of *A. scholaris*. The
antioxidant assays revealed the presence of tannins, proteins, phenols and steroids in the extracts. Jagetia and Balig[42] had evaluated the cytotoxic activity of A. scholaris R. Br. The highest cell killing activity was observed from the extracts prepared from the summer collections and the fractions containing the alkaloids were highly effective. Recently, in vitro radical scavenging and antioxidant activity was reported in crude alcoholic extracts of stem bark, leaves, flower and fruit[43-46]. James et al[47] reported that the methanolic extracts of the flowers possessed higher antioxidant activity than its fruit, while the radical scavenging and antioxidant potential of the leaves was ascribed to the phenolic and flavonoid contents[44,45].

3.3 Andrographis paniculata

Zhang and Tan[48] investigated the ethanolic extracts of the aerial parts of A. paniculata for anti-hyperglycaemic and antioxidant effects and found that it not only possesses an anti-hyperglycaemic property, but also reduces oxidative stress in mice models. Research on the effectivity of antioxidants as well as an anti-cancerous drug Doxorubicin (DOX), in liver lymphoma indicated that the aqueous extracts of the plant is more effective than DOX with respect to its effect on catalase, superoxide dismutase, glutathione S transferase, lactate dehydrogenase activities[50]. Similarly Sheeja et al[51] concluded that the methanolic extract of A. paniculata was found to prevent the formation of oxygen derived free radicals such as superoxide by 32%, hydroxyl radicals by 80%, lipid peroxidation by 80%, and nitric oxide by 43%.

4. Pharmacological use of the antioxidants derived from some of the above plants

In the present scenario various antioxidant chemical formulations from the plants are available in the market in different forms and are also being used for various medicinal purposes. Such pharmacological use/market products have been tabulated in Table 2. Descriptively M. indica has been extensively used to obtain a product known as “Vimang” which is commercially used for its antioxidant properties. Moreover various research on cancer and the need to find a cure for killing cancer cells have prompted the researchers to use the antioxidant formulations from A. scholaris and A. paniculata. To report some more antioxidant pharmacological preparations from Ayurvedic literature are Maharishi Amrit Kalash (MAK4, MAK5), Maharishi Ayurved (MA631, MA47), MA Raja’s Cup, MA Student Rasayana and MA Ladies Rasayana.

<table>
<thead>
<tr>
<th>Plants</th>
<th>Chemical composition</th>
<th>Pharmacological use/market product</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>M. indica</td>
<td>Polyphenols, terpenoids, steroids, phenolic esters, flavan-3-ols, xanthone (mangiferin)</td>
<td>Vimang</td>
<td>[52]</td>
</tr>
<tr>
<td>A. scholaris</td>
<td>Cytotoxicity chemicals</td>
<td>Kills cancerous cells</td>
<td>[42]</td>
</tr>
<tr>
<td>A. paniculata</td>
<td>Carcinogen Metabolizing Enzymes</td>
<td>Has potential against chemotoxicity, carcinogenicity</td>
<td>[53]</td>
</tr>
</tbody>
</table>

Table 2. Showing the present pharmacological use/market product from the antioxidant chemicals derived

5. Conclusion

Damage caused by free radicals is responsible for development of many chronic health problems such as many cardiovascular, inflammatory diseases, cataract and cancer. Antioxidants prevent free radical induced tissue damage by preventing the formation of radicals, scavenging them, or by promoting their decomposition. Chemically the antioxidants are ascorbic acid, catechin, flavonoids, lignin glycosides, polyphenolics, alkaloids, terpenoids, tannins and carotene. Most importantly these antioxidants find their way to prevention of cancer and ageing. However the synthetic drugs and the therapies used for treating cancer or any other disease witness a myriad of side-effects. Thus, there has been an upcoming surge of shifting towards green medicine and their consumption on a daily basis/upon early diagnosis of susceptibility to a disease, as a prevention strategy for future development of the disease. In this aspect plant derived natural antioxidants resources are the only alternative which will also boost the internal antioxidating capability of a living organism. Still further detailed investigation studies are needed to justify their use as a natural
source of antioxidants and develop commercial medicines out of them.

**Author Contributions**

The first author has conceived the idea of the paper. He has carried out field surveys and the socio-interaction with people to know the plant’s therapeutic use. He also framed out and wrote the manuscript with the support of the co-author and corresponding author. The second author has gone through the full manuscript and framed out the logical contents of the paper to make it more informative. She also framed out the tables, drafted the manuscript and designed the figures. All authors have jointly discussed the findings and usefulness of the manuscript.

**Conflict of interest**

The authors declare no conflict of interest.

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