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PHARMACOLOGICAL AND MEDICINAL ACTIVITIES OF RESURRECTION PLANTS

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Abstract

Resurrection plants are special kinds of plants in that they can survive almost complete desiccation from their vegetative parts. They do so by shutting down their metabolic systems to tolerate dehydration and the plants are obviously lifeless. In the recent past, invaluable bioactive compounds from resurrection plants have attracted much attention cognizance of their potential application in medicine. Some of these

metabolites are reported to have antibacterial, anticancer, antifungal, and antiviral biological effectiveness. In this review article, particular emphases are made on pharmacological and medicinal applications of some resurrection plants.

Key words: Desiccation, Medicinal Plants Metabolite, Resurrection Plant and Pharmacology.

Introduction:

Drought stress affects plant growth, development, and yield in contrast to the normal water supply required for regular growth. Drought stress tolerance is the ability of a plant to thrive with an economic value under limiting water supply [1]. Different plant species exposed to drought stress at a different level of growth shows tolerance to stress depending on the period of exposure through the induction of various biochemical, physiological or morphological factors. Changes that occur in plants during the stress period are influenced by a range of physiological and molecular interactions developed to adapt (withstand) drought stress [2, 3]. Resurrection plants are a group of plants that has the potential to tolerate and withstand extreme dehydration of their vegetative tissues when exposed to severe drought stress, and still resume their normal physiological and metabolic activities following rehydration [4]. They are special kinds of plants in that they can survive almost complete desiccation from their vegetative parts. They so by shutting down their metabolic systems to tolerate dehydration and the plants are obviously lifeless [1]. To adapt to severe dehydration, resurrection plants have developed special molecular responses to withstand desiccation-induced injury. Dinakar and Bartels summarized these responses to include, over-expression of dehydration associated genes (dsp-22) generation of protective metabolites, as well as rapid rearrangement of transcriptome and metabolome upon exposure to drought stress [5]. Resurrection plant species constitute more than 1300 species of bryophytes, pteridophytes, and about 300 angiosperms [6]. Over the years, essential genes and metabolites of resurrection plants have attracted much attention cognizance of their potential application in biomedical sciences. A polyphenol-rich extract of the South African resurrection plant Myrothamnus flabellifolia was shown to inhibit viral (M-MLV and HIV-1) reverse transcriptases. Dell'Acqua and Schweikert reported the use of Haberlea rhodopensis extract (glycoside myconoside), to strongly stimulate antioxidant skin defense and extracellular matrix protein synthesis.

Amentoflavone, a bioactive compound from Selaginella tamariscina, has also shown strong anticancer/pro-apoptotic, antibacterial, and antifungal activities [7, 8, 9, 10, 11].

In this review article, particular emphases are made on pharmacological and medicinal applications of some resurrection plants.

Metabolites of Resurrection Plants:

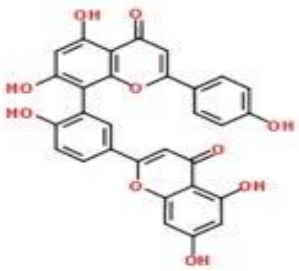
Metabolomic approaches such as gas chromatography-mass spectrometry (GC–MS), liquid chromatography (LC)–MS, capillary electrophoresis (CE)–MS, and nuclear magnetic resonance (NMR) spectroscopy are common techniques used in plant metabolomics studies. These approaches give quantitative details of metabolic molecules present in plants. The primary metabolites of resurrection plants are central to their physiology. Some of the desiccation-induced metabolites include amino acids, peptides, nucleotide derivatives, polyamines, antioxidants, and defence compounds. In the case of stress-induced dehydration, the primary metabolites act as osmoprotectants for this condition. An exhaustive metabolome profiling of some resurrection species such as Haberlea rhodopensis, Stapfianus sporobolus, and Lepidophylla selaginella has been carried out [12, 13, 14]. Plants protection against stress also occurs through the metabolism of sugar. In plants like Lepidophylla selaginella the presence of sugar is more abundant than it is found in some plants like Moellendorffii selaginella that are sensitive to desiccation [15, 16]. The presence of different sugars such as melibiose, trehalose, raffinose and sucrose are high in H. rhodopensis as compared to other resurrection species [17]. During dehydration condition in most of the resurrection species, the accumulation of sucrose is observed [18, 19, 20]. Another abundant sugar which acts as osmoreceptors and is present in resurrection species is raffinose. Galactinol and raffinose play a protective role against cellular damage caused due to oxidative stress [21]. Acidic and alcoholic sugars present in resurrection species, when combined with other sugar, protect these species from reactive oxygen species (ROS) which cause damage by alleviating the dehydration consequences and stabilized the protein and macro-molecules. The level of glycerate, erythronate and threonate are more in H. rhodopensis as compared to T. halophila and A. thaliana for the alleviation of dehydration condition. Different resurrection species used amino acid and dicarboxylic acid.

The metabolism of lipid also changes during dehydration. Most of the lipids present in L. selaginella accumulate during dehydration and they play a significant role in the stabilization and hydration of membrane. In stressed-free plants the presence of poly-unsaturated fats is abundant. The role of lipid is also crucial and like sugar, they prevent plants from damage and act as a signalling molecule and a good energy source. In Resurrection plants, secondary metabolites are also present. They perform a different function related to their physiology. Resurrection species not only used secondary metabolites for protection against dehydration but it is equally effective against other stresses like herbivore attack and ultraviolet light. Some examples of these secondary metabolites include luteolin, apigenin, anastatins b and a, di-caffeoylquinic acid, caffeoyl, alcohol dehydrodiconiferyl, di-hydroxybenzoic acid 3,4, kaempferol, quercetin, luteolin and silybins [22, 23, 24].

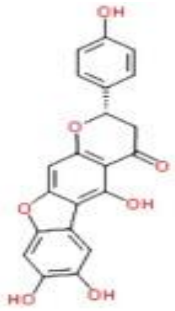
Medical Applications of Resurrection Plants:

Resurrection plant species	Pure component or their extract	Biologically effectiveness
Anastatica hierochuntica	A and b anastatin	It gives protection from galactosamine, d which induced hepatotoxicity.
	A isosilybins and B, luteolin, quercetin, (+)-balanophonin	It causes the melanogenesis inhibition in b16murine 4a5 melanoma cells.
Haberlea rhodopensis	Myconoside-enriched fraction	Increases skin elasticity in humans (3%the extract of haberlea cream) and protect human fibroblast dermal against hydrogen peroxide damage by stimulating the synthesis of elastin.
	Ethanol–water (70:30, v/v) extract	Dose-dependent reduction of chromosomal aberrations which caused by γ-radiation in rabbit blood lymphocytes (120 mg kg^{-1} body weight)
Myrothamnus flabelifolia	Tri 3,4,5 O-galloylquinic acid	It inhibits HIV and reverse transcriptase also inhibition occurs in murine Moloney leukemia virus.
	Acetone-water (70:30, v/v) extract	Activity against herpex simplex type 1 virus (Herpes Simplex Virus-1; IC_{50} 0.4 μg mL^{-1})
Moschatus myrothamnus	Essential oil (steam distillation for 3 h)	It shows anti-fungal activity against candidas albicans & anti-neoplastic activity by inhibiting the breast cancer cells.

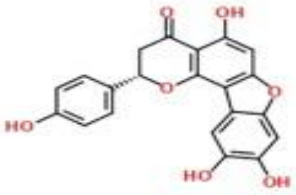
Resurrection plant species	Pure component or their extract	Biologically effectiveness
Polypodium polypodioides	Water extract (decoction or infusion)	It acts as diuretic agent & shows number of ethno-pharmacological uses.
Bryopteris	The Water-extract	Promotes the growth of mouse macrophage (BMC2) and Spodoptera frugiperda Sf9 cells Protects Sf9 cells from Ultra voilet-induced damage and hydrogen peroxide induced apoptosis (1–10% extracts) Reduces the methyl isocyanate and induced apoptosis epithelial cells of human kidney (HEK-293) and epithelial cells of human colon (FHC) reduced the incidents of dimethyl benzopyrene which induced lung carcinogenesis and benz[a]anthracene-mediated skin papillomagenesis in Swiss albino mice
Lepidophylla s	Methanol water (10:90, v/v) extract	It shows Activity against Helicobacter pylori (strains 43505 and 25), with MIC_{50} 200 and 400 μg mL^{-1}, respectively
Tamariscin s	Water extract	in human leukemia cells it induces the apoptosis (HL-60; cytotoxicity observed at 400 μg mL^{-1})
	Ethanol–water (50:50, v/v) extracts	Antimetastatic activity in osteo-sarcoma cells (50 μg mL^{-1})
	Amento-flavone	It shows anti-bacterial effect against staphylococcus aureus and apoptotic and anti-proliferative effect against cervical cancer and these cells are siha and caski.
	Isocryptomerin	It shows resistant against staphylococcus aureus and shows anti-microbial characteristic against candidas albicans.
Recurvata tillandsia	Cycloart-23-ene-3,25-diol-enriched extract	It shows anti-neoplastic activity in case of prostate cancer and also inhibits different kinases which associated with these types of cancer [4].



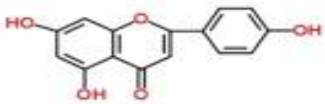
amentoflavone



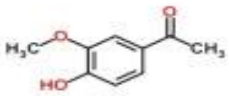
anastatin A



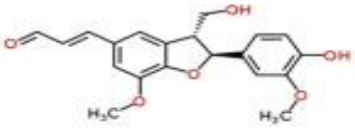
anastatin B



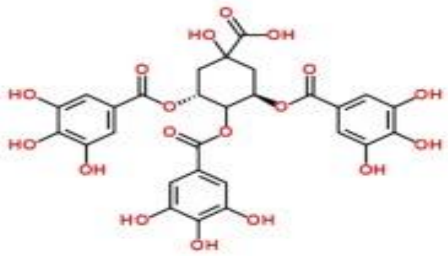
apigenin



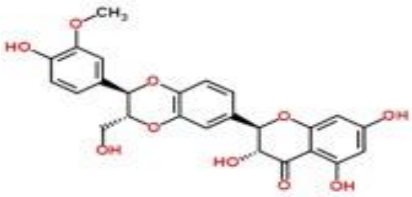
apocynin



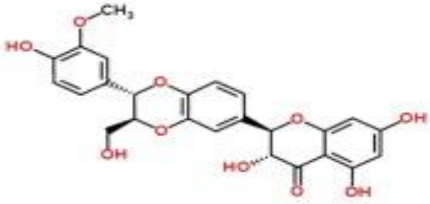
balanophotin



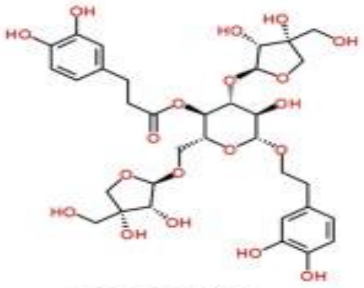
3,4,5-tri-*O*-galloylquinic acid



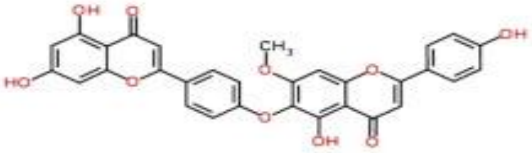
isosilybin A



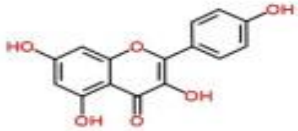
isosilybin B



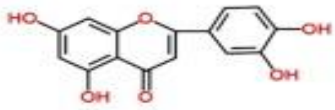
myconoside



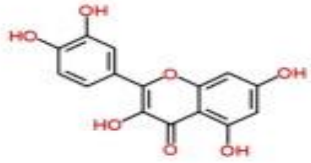
isocryptomerin



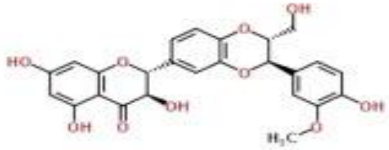
kaempferol



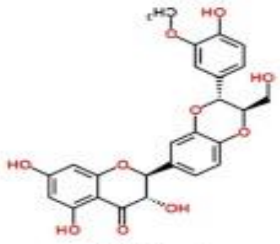
luteolin



quercetin



silybin A



silybin B

Hierochuntica l. anastatica:

This resurrection plant is mostly cultivated and distributed in different parts of Asia and Africa. The extract obtained from this plant contains different component like terpenes, glucosinolates, and flavonoids. Other secondary component include glucoiberin, b and a isosilybins, quercetin, isovitexin, b and a silybins, luteolin, 7 glucoside kaempferol, isovitexin, glucoiberin, dihyfroxy-benzoic acid 4-3, glucocheirolin, apigenin, di-caffeoyl quinic acid and caffeoyl. All these compounds present in this species are effective and show different activity, but some are more important which shows significant potential for medicinal purpose and these includes quercetin, luteolin, apigenin [25, 26]. Quercetin is an important anti-oxidant component and their presence observed in different plant because it is an effective dietary flavonoids. Quercetin has the potential to treat cancerous cells by the inhibition of their growth [27], and in human it prevents platelet aggregation when ingested, it is also effective against cardiovascular disease (CVD) [28]. Another important component derived from this plant is silybin which shows hepatoprotective effect, anti-oxidant effect and some extract show anti-cancer activity. Anastatin B is an important flavonoids component derived from the hierochuntica anastatica and this also shows hepatoprotective effect by decreasing the galactosamine d cytotoxicity. Other components of this plant like tyrosinase is effectively used in cosmetics and medicine because it can produce melanin. The extract of hierochuntica also shows anti-microbial properties [29]. Their effectiveness is observed more for gram positive bacteria than gram negative bacteria [30]. In preventing birth pain the extract of hierochuntica shows effective results. Hierochuntica also shows antiepileptic activity, emmenagogue, hepatoprotective and analgesic properties [31].

Flabellifolia myrothamnus:

It is an important shrub which is mostly cultivated in South Africa; it is an important resurrection species which contain different secondary metabolites and shows significant medicinal activities [32]. In African medicine the use of this plant is a common practice. It used for the treatment of health related issue like myrothamnus flabellifolia effective for chest problem, used as ointments for the cure of wounds, effective for cough, mastitis, scurvy, gingivitis, halitosis, abdominal pain, hemorrhoids, backaches, influenza and kidney problem [33].

Rhodopensis harberlea:

The presence of this plant is mostly found in Europe, it belongs to gesneriaceae family and good dicot perennial resurrection plant [34]. This plant draw more significance attention of researchers because of their anti-oxidant effect which are observed in the extract of this plant [35]. Their extract contains important component like caffeoyl which possess different medicinal activities. The extract of haberlea is used against ultraviolet induced oxidation. Extract from this plant are best used for the protection of skin to enhance the elasticity of skin owing to its antiaging properties. Due to this action their used in cosmetics is also effective [36].

Moschatus myrothamnus:

It is an important resurrection dicot shrub. The chemical composition of this plant includes beta pinene, pinocarvone, beta selinene, pinocarveol trans, and acetate perillyl. For the cure of asthma leaves which are in dried form is most effective; for vomiting and cough infusion of leaves is very effective. The oil of this plant is very effective because it inhibits the chances of breast cancer and also shows anti-fungal properties [37].

Ulgare polypodium:

It is an important desiccation plant that is abundant with phenolic compound that mostly accumulate during rehydration and desiccation [38]. Another component of this plant is phytoecdy steroids reported to have shown a significant activity against lymphoma T cells [39].

Selaginella bryopteris

The plant contain sugars, phenolic compounds, and polyols for protection against stress. These metabolites possesses chemo-preventive and anti-carcinogenic properties. Regulatory protein assessment of this plant reveals its potential in 7,12-dimethyl benz (a) anthracene-mediated skin papilloma agenesis and benzopyrene-induced lung carcinogenesis resulting in unperturbed cell-cycle regulation, inhibition of DNA fragmentation, maintenance of intracellular antioxidant defence, prevention of stress-induced senescence, anti-inflammatory activity, and genoprotective effects against methyl isocyanate carcinogenicity [40].

Other resurrection plants:

Recurvata tillandsia a resurrection plant rich in metabolites and show different medicinal activities. The extract of this plant is very effective against different problem. Another important plant is Polypodioides pleopeltis which mostly cultivated in Eastern and Latin America. This plant contains different chemical component like cycloartane, hopane, terpenoids, serratane polypodane and malabaricane. This plant and their component is effective for the treatment of liver infection, cystitis, renal stone and diuretic. Their decoction is effective for the treatment of dizziness, bleeding gums, hypertension, fever, bronchitis and headache. Lepidophylla selaginella is also important resurrection plant which contains number of secondary and primary metabolites, effective for the cure of soreness of throat and cold. Their methanolic extract is effective for the treatment of gastric cancer. One important component is jericine which is obtained from the aqueous extract of this plant and is effectively used in cosmetic for antiaging purpose. Another important resurrection plant which shows anti-cancer, anti-bacterial and anti-inflammatory effect is Tamariscina selaginella. The extract of this plant is effective for the cure of leukemia in human [40].

Conclusion:

Many plants found in different geographical location posses pharmacological properties which are used as medicines [41,42,43]. There resurrection species are unique group of plants with invaluable properties that has a wide pharmacological and medicinal potentials that has not been fully harnessed in drug development. In the event where whole extracts from these special plants are used, there is need for further analyses of the individual bioactive compounds and their mode of action. Furthermore, the possibilities of their use to develop economic plants that can tolerate and withstand drought stress should be considered.

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