

## **REVIEW**

# **Comprehensive review on treatment of HIV**

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**Abstract:** HIV or AIDS is a major threat for humanity in the world especially in developing countries. The causative factor of the syndrome is HIV, which infects and destroys one of the cellular components of the immune system, the T cells, causing deficiency in the immunological surveillance and ultimately leading to AIDS. According to WHO, around 35 million people were living with HIV in 2013 and since the start of epidemic 39 million people have died due to AIDS. Center for disease control and prevention estimated in 2014 that 1,201,100 people aged 13 and above were suffering from HIV infection Worldwide. The most effective approach is the highly active antiretroviral therapy (HAART) containing the combined use of drugs having different mechanisms of action. However, complete eradication of HIV from the body does not occur by HAART, but it lead to long term toxicity occurs and emerges as drug resistant. Despite the recent development of various new antiretroviral compounds, there is still a need to develop need to search for new alternatives which are equally efficient and less expensive as compared to the contemporary treatment available. This review provides an overview and a summary of herbal medicines for HIV infection and summarized the efficacy and medicinal use of different plants used in the treatment of HIV infection. The objective of this review is to enlighten the recent advances in the exploration of medicinal plants used for treatment of HIV/AIDS.

**Keywords:** AIDS, medicinal plants, efficacy, literature review.

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## **INTRODUCTION**

AIDS is an infectious disease caused by a transmissible infectious agent called human immunodeficiency virus. Studies indicate that AIDS virus has been found in high concentrations only in blood and semen. Other body fluids like saliva and tears also show the presence of the virus but evidence of spread of infection through these fluids is lacking. The first case of AIDS was recorded in USA in 1981. The virus of AIDS was discovered by Prof. Luc Montagnier and his colleagues at the Pasteur institute in Paris and they had given the name as lymphadenopathy associated virus (Papadopoulos *et al.*, 2004). Soon afterwards Dr Robert Gallo and his associates at the national cancer institute Bethesda USA confirmed the presence of new virus isolated form of AIDS and called it human T lymphocytes III (Gallo, 1997). Later on the present term-human immunodeficiency virus was adopted by international committee in taxonomy of virus for the agent responsible for AIDS. AIDS has dramatically increased in developing countries over the past few decades. The most effective approach is the highly active

antiretroviral therapy (HAART) containing the combined use of drugs having different mechanisms of action. Morbidity and mortality of patients with AIDS has markedly decreased due to this approach. This approach contains antiretroviral drugs such as protease inhibitors, reverse transcriptase inhibitors and a recently introduced fusion inhibitors (Palella *et al.*, 2006). However, complete eradication of HIV from the body does not occur by HAART, long term toxicity occurs and eventually drug resistant HIV emerges (Nadembega *et al.*, 2006). Therefore there is a need to search for new alternatives, which are equally efficient and less expensive as compared to the contemporary treatment available. Various medicines are being used in HIV treatment. Herbal medicines are gaining popularity due to less side effects and better efficacy that is evident from *in vitro* and *in vivo* studies conducted on herbal medicines (table 1). Various chemical constituents or compounds obtained from medicinal plants have proven their efficacy and safety in the treatment of HIV and related disorders. Major pathogens in HIV infections (Parveen *et al.*, 1994).

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### **Bacteria**

Bacteria include penicillium marfenii, mycobacterium avium intracellulare, mycobacterium tuberculosis, nocardia, rochalimaea quintana, rhodococcus equi, salmonella spp, moraxella catarrhalis, haemophilus influenza and streptococcus pneumonia

### **Viruses**

Viruses include human papilloma virus, papovirus, cytomegalovirus, varicella virus and herpes simplex.

### **Fungi and yeast**

Fungi and yeast include coccidioides immitis, histoplasma capsulatum, cryptococcus neoformans and candida spp.

### **Protozoa**

Protozoa include microsporidia spp, isopora belli, cryptosporidium parvum, toxoplasma gondii, pneumocystis carinii.

### **Risk factors**

Followings are the important factors increasing the risk of HIV infection such sexually transmitted infections, menstruation, non-circumcised, increased number of sexual partners, sharing needles, prostitutes and intravenous use (Narain *et al.*, 1994).

### **Signs and symptoms**

Major clinical features are fever, fatigue, erythematous maculopapular rash mainly over trunk, opportunistic infections such as oropharyngeal candidiasis, pneumocystis carinii pneumonia, neurological presentation manifesting as aseptic meningitis, encephalitis, myelitis, polyneuritis, mucosal ulceration (mouth, genital), headache, arthralgia, myalgia and pharyngitis with cervical lymphadenitis (Portillo *et al.*, 2007)

### **Pathology**

HIV is a retrovirus, which characteristically targets the cells, which have CD4 protein on their surface, so it attacks macrophages and T helper cells. These cells are concerned with cell mediated immunity. Due to this attack the number of CD4 carrying cells is reduced. Increasing immune suppression is recognized by decreasing CD4 lymphocytes count. If CD4 count falls below 500 it is an indication of active disease. A count below 200 is of poor prognostic value. The HIV actually goes inside the white blood cells and lies quietly. After about 5-10 years, the HIV virus enters the cell to start making viral proteins or proviral DNA by reverse transcriptase enzyme. This then enters the nucleus of CD4 lymphocytes and gets integrated into cell DNA, thus hijacking the human cell, which is converted into a factory and starts manufacturing new HIV particles. These enter new CD4 cells and destroy them and ultimately CD4 cell count decreases to less than 200/mm. These results in the formation of huge number of viral particles inside the white cells and

eventually the cells burst releasing the thousands of new viruses in the blood, which infect new white blood cells. This cycle goes on and on, and eventually the immune system of the body is overwhelmed and is no longer capable of fighting the infection. The immune system if patient is weakened that they develops different opportunistic diseases like tuberculosis, pneumonia, persistent diarrhea, fever, skin infection ultimately leading to death of patient (Levy, 1993).

### **Medicinal plants having anti-HIV activity**

#### ***Tuberaria lignosa***

Family: Cistaceae, Parts used: Aerial parts. Chemical constituents: It contains phenolic compounds, ellagitannins, flavonoids, sugar and ascorbic acid. Medicinal uses: It is used in viral infection and malaria. Pharmacological activity: It is antiviral and anti-malarial. Study: Bedoya *et al.*, has reported that extracts of *Tuberaria lignosa* exhibits anti-HIV activity in an *in vitro* MTT assay. A study was conducted to screen medicinal plants for their anti-HIV activity. *Tuberaria lignosa* was found effective in HIV (Bedoya *et al.*, 2001). Further extract was fractionated and constituents were isolated and their anti-HIV activity was tested *in vitro*. The compound isolated was ellagitannin enriched fraction that was isolated first time in this plant. Martino *et al* reported that ellagitannin is HIV-1 reverse transcriptase inhibitor (Martino *et al.*, 2004). This ellagitannin enriched fraction showed anti-HIV activity in MT-2 infected cells. Ellagitannin enriched fraction was effective with an IC<sub>50</sub> value of 2.33µg/ml. ellagitannin enriched fraction exhibited anti-HIV activity that is mediated by CD4 down-regulation and CD4 is the main receptor for entry of HIV. Ellagitannin enriched fraction does not affect the CXCR4 and CCR5 receptors. This study indicates that ellagitannin-enriched fraction is able to inhibit R5 and X4 infections. Furthermore, it also inhibits NL4.3-Luc replication at dose of 12,5mg/ml concentration (Bedoya *et al.*, 2010).

#### ***Calendula officinalis***

Family: Asteraceae, Parts used: Flowers and leaves. Chemical constituents: It contains triterpenoid esters, resins, essential oil, carotenoids, lutein, saponin, flavoxanthin, beta-carotene, auroxanthin and zeaxanthin. Medicinal uses: It is used in wounds, scalds, burns, bruises, eczema, varicose veins, gastritis, duodenal ulcers, colitis, indigestion, constipation, gallbladder problems, thrush and dysmenorrhea. Pharmacological activity: It is anti-inflammatory, astringent, antiseptic, antifungal, cholagogue and emmenagogue. Study: A study conducted in 1978 indicated that chloroform extract of *Calendula officinalis* has HIV replication inhibitory activity in acutely infected lymphocytic MOLT-4 cells *in vitro* with IC<sub>50</sub> of 0.4mg/ml (May and Willuhn, 1978). Kalvatchev *et al* has reported the anti-HIV activity of extracts from *Calendula officinalis* flowers. Flowers of this plant were

used for experiment. Extract was tested for its efficacy to inhibit replication of human immunodeficiency virus type 1 (HIV-1). Organic and aqueous extract was used for study. Both were non-toxic to human lymphocytic Molt-4 cells. Potent antiviral activity was exhibited by organic extract in an *in vitro* MTT/tetrazolium-based assay. When organic extract was administered at dose of 500microgram/ ml, uninfected Molt-4 cells were protected from infection for up to 24 hours from fusion and subsequent death. This study indicated that organic extract from *Calendula officinalis* flowers has anti-HIV-1 reverse transcription (RT) activity (Kalvatchev *et al*, 1997). *Calendula officinalis* is topically used in exfoliative cheilitis that is associated with candida infection in HIV positive patients (Lucia *et al*, 2009).

#### ***Palicourea condensate***

Family: Rubiaceae, Part used: Leaves. Medicinal uses: It is used in tumors and HIV. Pharmacologic activity: It is uterotonic and cytotoxic. Study: Bokesch *et al*, has reported a novel anti-HIV macrocyclic peptide from *Palicourea condensate*. This macrocyclic peptide contains thirty-seven amino acids. This peptide was isolated from organic extract of this plant. Palicourein is further evaluated for its efficacy to inhibit HIV. It was found that it is able to inhibit the *in vitro* cytopathic effects of HIV-1RF infection of CEM-SS cells. Although the mechanism of action is not yet understood, however, the plausibly suggesting reverse transcriptase as a potential mechanism of action. It was active at EC50 value of 0.1 microM and an IC<sub>50</sub> value of 1.5 microM (Bokesch *et al*, 2001).

#### ***Ancistrocladus korupensis***

Family: Ancistrocladaceae. Parts used: Leaves. Chemical constituents: It contains naphthylisoquinoline alkaloid dimer and michellamine B. Medicinal uses: It is used in AIDS, measles and dysentery. Pharmacological activity: It is antimalarial and anti-HIV. Study: Boyd *et al*, has reported the anti-HIV michellamines from *Ancistrocladus korupensis*. Michellamine B from this plant inhibits HIV induced cell killing and viral replication in a variety of human cell lines. This compound was found active against clinical strains of HIV-1 (G910-6) and A17. It was also effective against HIV-2. (Boyd *et al*, 1994).

#### ***Kadsura lancilimba***

Family: Schizandraceae, Parts used: Stems and roots. Chemical constituents: It contains triterpene and lancilactone. Medicinal uses: It is used in HIV. Pharmacological activity: It is anti-HIV. Study: Chen *et al* has reported the novel anti-HIV lancilactone C and related triterpenes from *Kadsura lancilimba*. Root and stem of this plant is used to treat HIV and other associate disorders. Lancilactone C and related triterpenes are found in *Kadsura lancilimba*. These triterpenes were isolated from root and stem of this plant. Mass and NMR

spectrum data was used to determine the structures and stereochemistry. Lancilactone inhibited replication of HIV. EC50 value of this triterpene was 1.4 microg/mL (Chen *et al*, 1999).

#### ***Symplocos setchuensis***

Family: Symplocaceae, Parts used: Bark. Study: Ishida *et al* has reported the anti-AIDS agents, anti-HIV activity of harman, an anti-HIV principle from *Symplocos setchuensis* and its derivatives. A study conducted by Ishida *et al* (2001), *Symplocos setchuensis* has two compounds named Matairesinol (1) and harman (5). These compounds were found active against replication of HIV in H9 lymphocyte cells. Further anti-HIV activity of 28 derivatives of 5 showed that compound 19 has anti-HIV activity. EC<sub>50</sub> of this compound was 0.037 micM and therapeutic index values was 210 micM (Ishida *et al*, 2001). There is significant difference when compared to EC50 of *Symplocos setchuensis* to EC50 of contemporary medicine. EC50 of *Symplocos setchuensis* is different from EC50 reported by Wei *et al*, 2014; in which, EC50 of romidepsin, vorinostat and panobinostat was 4.5Nm, 3.950 and 10nM respectively (Wei *et al*, 2014). EC50 of *Symplocos setchuensis* is also different from EC50 reported by Pirounaki *et al* in which EC50 of zidovudine, nevirapine and indinavir was 0.14 microM, 0.33 microM and 0.02 microM respectively (Pirounaki *et al*, 2000). Keeping in view the all discussed findings, it is suggested that *Symplocos setchuensis* can be used for treatment of HIV infection as an alternative drug.

#### ***Acer okamotoanum***

Family: Sapindaceae, Parts used: Leaves. Chemical constituents: It contains flavones glycoside gallate and quercetin. Medicinal uses: It is used in HIV. Pharmacological activity: It has anti-HIV activity. Study: Kim *et al* has reported a new flavonol glycoside gallate ester from *Acer okamotoanum* and its inhibitory activity against human immunodeficiency virus-1 (HIV-1) integrase. Ethyl acetate extract of this plant was prepared that was further fractionated. New compounds i.e. phenolic compounds and flavonol glycosides were identified from this plant. Spectrometric methods were used to determine the structure of the new compound. The most active compounds were Quercetin 3-O-(2"-galloyl)-alpha-L-arabinopyranoside (6) and 1. Significant anti-HIV integrase activity was exhibited by these compounds (Kim *et al*, 1998). Flavan-3-ol inhibits HIV and its efficacy is better than flavonones and flavones (Gerdin and Srenso, 1983). HIV infection and replication is inhibited by baicalin, a flavonoid found in *Scutellaria baicalensis* and other flavonoids such as hinokiflavone and robustaflavone also inhibit HIV-1 reverse transcriptase (Cushnie and Lamb, 2005). Another study indicated that flavones o glycoside inhibit HIV reverse transcriptase and prevent entry of HIV-1 into cells

possessing chemokines coreceptors and expressing CD4 (Li *et al*, 2000). HIV-1 protease is inhibited by flavonoids such as robinetin and demethylated gardenin A (Cushnie and Lamb, 2005). Another study showed that flavonoids apigenin, acacetin and chrysin inhibit activation of HIV-1 via inhibition of viral transcription (Critchfield *et al*, 1996).

#### ***Fraxinus sieboldiana***

Family: Oleaceae, Parts used: Bark. Chemical constituents: It contains calceolarioside, hydroxycoumarins, phenylethanoid glycosides, lignin and esculetin. Medicinal uses: It is used in cardiovascular disorders, HIV and colon cancer. Pharmacological activity: It is anti-oxidant and anti-HIV. Study: Kim *et al* has reported the HIV gp41-binding phenolic components from *Fraxinus sieboldiana*. *Fraxinus sieboldiana* contain phenylethanoid glycosides and hydroxycoumarins. These compounds were isolated using chromatographic fractionation. Three phenylethanoid glycosides, four hydroxycoumarins and one lignin were identified and isolated. Isolation was done by using n-butyl alcohol fraction. Esculetin and calceolarioside B exhibited moderate binding affinity on HIV gp41 (Kim *et al*, 2002). Hydroxycoumarin has HIV-1 protease inhibitor activity (Kirkiacharian *et al.*, 2002). Therefore *Fraxinus sieboldiana* could assist in the prevention and/or treatment of HIV.

#### ***Celastrus hindsii***

Family: Celastraceae, Parts used: Leaves. Chemical constituents: It contains maytenfolone and celasdin-B. Medicinal uses: It is used in tumor and HIV. Pharmacological activity: It has anti-HIV activity. Study: Kuo *et al* has reported the antitumour and anti-HIV triterpenoids from *Celastrus hindsii*. *Celastrus hindsii* contains triterpene compounds. Various compounds were isolated from this plant and one compound named Maytenfolone-A was further evaluated for its efficacy. Cytotoxicity against hepatoma and nasopharynx carcinoma was demonstrated. ED<sub>50</sub> of compound was 2.3 microgram/ml against hepatoma. ED<sub>50</sub> of compound was 308 micrograms/ml against nasopharynx carcinoma. Celasdin-B was able to inhibit anti-HIV replication activity in H9 lymphocyte cells. EC<sub>50</sub> was 0.8microgram ml-1 (Kuo *et al*, 1997).

#### ***Rhus succedanea***

Family: Anacardiaceae, Part used: Drupes. Chemical constituents: It contains morelloflavone, bioflavonoid, obustaflavone, hinokiflavone, agathisflavone and amentoflavone. Medicinal uses: It is used in cancer, degenerative disorders and viral infections. Pharmacological activity: It is anti-oxidant, cytotoxic and anti-HIV. Study: Lin *et al* reported the *in vitro* anti-HIV activity of bioflavonoid isolated from *Rhus succedanea* and *Garcinia multiflora*. Various compounds were

isolated from this plant and were tested for anti-HIV RT activity. Study indicated that robustaflavone and hinokiflavone have similar activity against HIV-1 reverse transcriptase (RT). Amentoflavone, agathisflavone, morelloflavonem GB-1a and GB-2a exhibited moderate activity against HIV-1 RT. Anti-HIV activity was also observed by Morelloflavone. Other compounds were very weak or have no activity against HIV-1 in human lymphocytes (Lin *et al*, 1997).

#### ***Ancistrocladus abbreviatus***

Family: Ancistrocladaceae, Chemical constituents: It contains naphthylisoquinoline. Study: Manfredi *et al* reported that novel alkaloids from the tropical plant *Ancistrocladus abbreviatus* inhibit cell killing by HIV-1 and HIV-2 (Manfredi *et al*, 1991).

#### ***Crataegus pinnatifida***

Family: Rosaceae, Parts used: Fruit and leaves. Chemical constituents: It contains sorbitol, diethylamine hydrochloride, rhamnosylvitexin, hyperin, quercetin and malic acid. Medicinal uses: It is used in skin cancer. Pharmacological activity: It is anti-thrombotic. Study: Min *et al* reported the inhibitory effect of triterpenes from *Crataegus pinatifida* on HIV-1 protease. Concentraion of extract was 100 micrograms/ml. Furthermore two new compounds were isolated from this plant. Structure of these compounds was similar to uvaol and ursolic acid. This similarity was found on spectral data. These two compounds were active anti-HIV-1 protease. IC<sub>50</sub> value of uvaol was 5.5 and IC<sub>50</sub> of ursolic acid was 8.0 microM (Min *et al*, 1999).

#### ***Punica granatum***

Family: Lythraceae, Parts used: Flowers, seeds, pericarb, bark and juice. Chemical constituents: It contains isopelletierine, pectin, fiber, vitamin C, sulphur, potassium, magnesium and carbohydrates. Medicinal uses: It is used in carcinoma of prostate, diabetes mellitus, lymphoma and rhinovirus infection. Pharmacological activity: It is hypoglycemic, anti-cancer and anti-viral agent. Study: Neurath *et al* reported that *Punica granatum* provides an HIV-1 entry inhibitor and candidate topical microbicide. In a study, inhibitory activity of fruit juice was investigated against HIV-1 IIIB. CD4 and CXCR4 were used as cell receptors. This study indicated that possibility of producing an anti-HIV-1 microbicide from *Punica granatum* (Neurath *et al*, 2004).

#### ***Garcinia speciosa***

Family: Garcinia speciosa, Parts used: Bark. Chemical constituents: It contains digeranyl benzophenone, triterpenes, lanostanes and friedolanostane. Medicinal uses: It is used in helicobacter pylori infection and hyperlipidemia. Pharmacological activity: It is antihelicobacter, antiobesity and anti-HIV. Study: Rukachaisirikul reported the anti-HIV-1 protostane

**Table 1:** Medicinal plants having anti-HIV activity

Plant	Family	Part used	Functions	Mechanism of action	IC50/ LD50 /EC50/	References
<i>Euphorbia hirta</i> L	Euphorbiaceae	Leaves, stem and flowers	Anti-HIV, gastroprotective, antimalarial	Reverse transcriptase inhibitor	IC50 (9±4.6 µg/ml) and, Therapeutic index (19)	Gyuris et al, 2009
<i>Ganoderma lucidum</i>	Ganodermataceae	Spores	Anti-HIV, immunosuppressant	Anti-HIV-1 protease	LD50 (0.05 microM)	El-Mekkawy et al, 1998
<i>Xanthoceras sorbifolia</i>	Sapindaceae	Wood	Anti-HIV	Inhibits HIV reverse transcriptase and integrase	EC50 (1.7 mg/ml) and IC50 (21.8 mg/ml)	Kashiwada, 1998
<i>Maprounea africana</i> Muell.	Euphorbiaceae	Roots	Anti-HIV	Reverse transcriptase inhibitor	IC50 (3.7 mM)	Pengsuparp et al., 1994
<i>Arnebia euchroma</i>	Boraginaceae	Roots	Anti-HIV, anti-inflammatory, antimicrobial	Inhibits HIV replication	EC50 (2.6 micrograms/ml)	Kashiwada et al, 1995
<i>Phyllanthus niruri</i>	Phyllanthaceae	Whole plant	Anti-HIV	Inhibits HIV replication	EC50 (20.98 microgmL)	Ogata et al. 1992

triterpenes and digeranylbenzophenone from trunk bark and stems of *Garcinia speciosa*. Garciosaterpenes, digeranylbenzophenone and garciasaphenone are found in this plant. Garciosaterpenes and garciasaphenone found effective in inhibiting the HIV-1 reverse transcriptase. This study showed the anti-HIV-1 activities of this plant (Rukachaisirikul, 2003).

#### ***Pinus parviflora***

Family: Pinaceae, Parts used: Cones. Chemical constituents: It contains uronic acid, glucose, galactose and mannose. Medicinal uses: It is used in tumor and bacterial infections. Pharmacological activity: It is anti-microbial and anti-tumor. Study: Tamura et al reported that soluble factor induced by an extract from *Pinus parviflora* can inhibit the replication of human immunodeficiency virus *in vitro*. This extract (PC6) was obtained from cones of *Pinus parviflora*. This extract induces the he human T-cell line CEM that in turn causes formation of pepsin-sensitive soluble factor. Replication of the type 1 human immunodeficiency virus (HIV-1) is inhibited. Study showed that PC6 induces anti-HIV-1 factor induced (Tamura et al, 1991).

#### ***Eclipta prostrata***

Family: Asteraceae, Parts used: Leaves, roots and aerial parts. Chemical constituents: It contains ascorbic acid, oleanolic acid, ursolic acid, alpha amyrrin, benzoic acid, lacceroic acid, stearic acid, daucosterol, alkaloids and saponins. Medicinal uses: It is used in snakebite, jaundice, bacterial infection, asthma, tuberculosis, anemia, skin disorders, itching, hyperlipidemia and obesity. Pharmacological activity: It is antibacterial, hepatoprotective and antiasthmatic. Study: Tewtrakul et al

reported the HIV-1 protease and HIV-1 integrase inhibitory substances from *Eclipta prostrata*. Six compounds were isolated from this plant. A compound namely Wedelolactone was found most active against HIV-1 integrase. Another compound namely terthiophene was found inactive. This study validates the use of this drug in HIV patients (Tewtrakul et al, 2007).

#### ***Euphorbia hirta* L.**

Family: Euphorbiaceae. Parts used: Stems, roots, latex and seeds. Chemical constituents: It contains phytosterol, alkanes, flavonoids, polyphenols, tannins and triterpenes. Medicinal uses: It is used in colic, dysentery, cough, bronchial infection, asthma, eczema and warts. Pharmacological activity: It is antispasmodic, antibacterial and antiasthmatic. Study: Gyuris et al reported activity of extracts of *Euphorbia hirta* L. against HIV-1, HIV-2 and SIVmac251 (Gyuris et al, 2009).

#### ***Geum japonicum***

Family: Rosaceae, Parts used: Whole plant. Chemical constituents: It contains triterpenoid compounds such as 19 $\alpha$ -hydroxyasiatic acid. Medicinal uses: It is used in diarrhea, heart problems and cancerous diseases. Pharmacological activity: It is cardioprotective and antiviral. Study: Xu et al has reported the anti-HIV triterpene acids from *Geum japonicum*. Methanolic extract of this plant was used for experimental study. HIV-1 protease was inhibited by the use of methanol extract from the whole plant of *Geum japonicum*. Various compounds were isolated from these plants that were further investigated for their Ant-HIV activity. This plant contains tormentic acid and other associated 4 compounds. A new triterpene acid from this plant was isolated. All

compounds were tested. Ursolic acid and maslinic acid was found potent anti-HIV-1 protease (Xu *et al*, 1996).

### ***Prunella vulgaris***

Family: Lamiaceae, Part used: Whole herb. Chemical constituents: It contains cellulose, sugar, tannin and volatile oil. Medicinal uses: It is used in sore throat, hemorrhoids, wounds and headache. Pharmacological activity: It is astringent and wound healer. Study: Yao *et al* has reported the mechanism of inhibition of HIV-1 infection *in vitro* by purified extract of *Prunella vulgaris*. Crude extract of this plant was used for study. Cytotoxic and anti-HIV activity was tested in several tissue culture lines. HIV replication was inhibited significantly by use of *Prunella vulgaris* extract. Low toxicity effect was observed by use of this plant extract. Furthermore, active constituents were isolated from this plant. HIV replication was inhibited by the purified extract. Extract was active at different dose levels 6, 30 and 12.5 micrograms/ml. HIV replication was not prevented when extract was administered to uninfected cells prior to infection. Infectiveness was dramatically reduced when HIV-1 was pre-incubated with the purified extract. Transmission of HIV-1 from cell to cell was blocked by the purified extract. Syncytium synthesis was prevented by this extract. HIV-1 and purified gp 120 was not able to bind to CD4 in presence of extract. When analyzed on PCR, there was absence of HIV-1 proviral DNA in cells that were exposed to virus in the presence of the extract. This study indicated that extract of this plant is able to prevent HIV infection of susceptible cells by a mechanism that blocks attachment of virus to the CD4 receptor (Yao *et al*, 1992).

### ***Rosa damascena***

Family: Rosaceae, Parts used: Flower buds, stamens and aqua of flowers. Chemical constituents: It contains quercitannic acid, volatile oil, malic acid, tartaric acid, gallic acid, quercitrin and tannic acid. Medicinal uses: It is used in burning sensation, leprosy, intestinal affections, inflammations, chronic fever, stomatitis, toothache and headache. Pharmacological activity: It is astringent, anti-inflammatory, appetizer, expectorant, cardiogenic and aphrodisiac. Study: A study was conducted to investigate the *in vitro* efficacy of *Rosa damascena* to treat HIV. In this study, various compounds were purified from the methanol extract of *Rosa damascena* and were evaluated on C8166 human T lymphoblastoid cells infected with HIV-1MN and H9 human T-cell lymphoma cells chronically infected with HIV-1IIIIB. Kaempferol and other related compounds exhibited significant activity against HIV infection of C8166 cells. Quercetin 2 was effective against HIV. *Rosa damascena* has anti-HIV activity due to the synergistic effects of different compounds acting additively against different stages of virus replication. Mahmood *et al* reported the anti-HIV activity and mechanisms of action of pure compounds isolated from *Rosa damascena* (Mahmood *et al*, 1996).

### ***Smilax glabra***

Family: Smilacaceae, Parts used: Root. Chemical constituents: It contains smiglabrol and smig lactone. Medicinal uses: It is used in diabetes mellitus, inflammation and cancer. Pharmacological activity: It is anti-proliferative, anti-viral, immunomodulant and antihyperglycemic. Study: It has been studied that smilaxin from *Smilax glabra* rhizomes attenuate the activity of HIV-1 reverse transcriptase with an IC<sub>50</sub> of 5.6µM (Chu, 2006)

### ***Withania somnifera***

Family: Solanaceae, Parts used: Root bark, berry, flower, fruit, leaves, seeds, tubers and root. Chemical constituents: It contains tannin, withaferine A, withanine and somniferin. Medicinal uses: It is used in rheumatism, lumbar pain, ulcers, chest pain, loss of memory, syphilis, inflammation, bronchitis, tumor and eye sores. Pharmacological activity: It is anti-inflammatory, antihyperuricemic, antigout, aphrodisiac, alterative, anthelmintic, hypnotic, diuretic, deobstruent, narcotic, nervine tonic and emmenagogue. Study: In one study, *Ocimum sanctum* Linn., *Withania somnifera* Dunal, *Tinospora cordifolia* were screened for anti-HIV activity. All plants caused interference with the gp120/CD4 interaction. *Ocimum sanctum* and *Tinospora cordifolia* inhibited reverse transcriptase of virus and contributed to the overall anti-viral activity *in vitro* (Anuya *et al*, 2010)

### ***Soya bean***

Family: Fabaceae, Parts used: Seeds Chemical constituents: It contains oleic acid, linolic acid, linolenic acid, stearic acid and palmitic acid. Medicinal uses: It is used in arthritis, infertility, edema and jaundice. Pharmacological activity: It is anti-diabetic and memory enhancer. Mechanism: Xiu *et al* reported the antitumor and HIV-1 reverse transcriptase inhibitor activity of a Hemagglutinin and a Protease Inhibitor from Mini-Black Soybean (Xiu *et al*, 2011).

## **CONCLUSION**

A variety of medicinal compounds obtained from various medicinal plants have been utilized to cure, prevent or ameliorate HIV/AIDS infections. The clinical trials conducted on different components of medicinal plant origin have shown their effectiveness to combat the HIV malaise and have shown no adverse effects. The synthetic drugs used for the treatment of HIV are costly and exhibit side effects or adverse drug reaction as well as possibility of drug resistance. Medicinal plant chemical constituents could be viable option to explore these promising naturally derived anti-HIV compounds so that the results and experiences with many of the anti-HIV natural products will inspire and motivate even more researchers to explore alternative way of treatment of HIV. It is suggested to conduct further studies on these plants to

prove their mechanism of action exhibiting promising results would lead to open new era for treatment of HIV.

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