Abstract: Since the beginning of the epidemic, human immunodeficiency virus (HIV) has infected around 70 million people worldwide, most of whom reside in sub-Saharan Africa. There have been very promising developments in the treatment of HIV with anti-retroviral drug cocktails. However, drug resistance to anti-HIV drugs is emerging, and many people infected with HIV have adverse reactions or do not have ready access to currently available HIV chemotherapies. Thus, there is a need to discover new anti-HIV agents to supplement our current arsenal of anti-HIV drugs and to provide therapeutic options for populations with limited resources or access to currently efficacious chemotherapies. Plant-derived natural products continue to serve as a reservoir for the discovery of new medicines, including anti-HIV agents. This review presents a survey of plants that have shown anti-HIV activity, both in vitro and in vivo.

Keywords: acquired immune deficiency syndrome; phytochemistry; pharmacognosy; antiviral; drug discovery
1. Introduction

The World Health Organisation estimates that over 75 million people globally have been infected with the human immunodeficiency virus (HIV), of which approximately 37 million are still alive and living with the infection [1,2]. It is currently estimated that ~26 million of these patients reside in Africa; 3.3 million in the Americas; 3.5 million in Southeast Asia; 2.4 million in Europe; 360,000 in the eastern Mediterranean; and 1.5 million in the western Pacific [2]. Data from 2016 indicates that there were approximately two million new cases of HIV infections, and as many as one million deaths due to the disease [2]. Importantly, these annual numbers are much reduced, as the numbers of newly infected patients has declined by 35% since 2000, and the mortality rate has also declined by almost 50%. The decline in HIV infections is thought to be due to increased use of condoms, a reduction in the prevalence of sexually transmitted infection, and the increased use of effective therapies, such as the three-drug therapy anti-retroviral therapy (ART). The number of HIV patients now receiving antiretroviral therapy has increased from ~685,000 in 2000 to 20.9 million in 2017 [2].

While HIV is a significant cause of morbidity and mortality worldwide, the sub-Sahara region of Africa is burdened with the largest number of HIV cases [2]. Of the 37 million cases of HIV, the sub-Saharan Africa is home to ~70%, although it has only 21% of the world’s population. In fact, African men and women worldwide are more affected by this disease than any other race [2,3]. Only ten countries in southern and eastern Africa, including South Africa (25%), Nigeria (13%), Mozambique (6%), Uganda (6%), Tanzania (6%), Zambia (4%), Zimbabwe (6%), Kenya (6%), Malawi (4%) and Ethiopia (3%), account for approximately 80% of HIV patients [2,3]; In most countries, the prevalence of HIV is the highest in specific groups including men who have sex with men, intravenous drug users, people in prisons and other confined settings, sex workers and transgender individuals. However, unlike other countries, the primary HIV transmission mode in sub-Saharan Africa is through heterosexual sex, with a concomitant epidemic in children through vertical transmission [3]. As a consequence, African women are disproportionately affected and make up ~58% of the total number of people living with HIV, have the highest number of children living with HIV and the highest number of AIDS related deaths [2].

New data from coding complete genome analyses of US serum samples from 1978 to 1979 revealed that the US HIV-1 epidemic that occurred in the 1970s was extensively genetically diverse [4]. Bayesian phylogenetic analyses of HIV-1 genomes suggest that the US epidemic emerged from a preexisting Caribbean epidemic with the place of the ancestral US virus being New York City [4]. The analysis of gag, pol and env RNA sequences placed the US sequences in a monophyletic clade nested within Caribbean subtype B sequences from Haiti, and other Caribbean countries, as well as Haitian immigrants in the US [4]. The data further suggested that the US clade emerged from the early growth phase of the Caribbean epidemic (1969–1973), which began after the introduction of the subtype B lineage from Africa about 1967 [4]. The Centers for Disease Control eventually made the connections between homosexual men with AIDS and Kaposi’s syndrome and sexual transmission of an infectious agent [5,6].

1.1. Pathophysiology

The HIV virus is a retrovirus that is able to integrate a DNA copy of the viral genome into the DNA of the host cells. The virus enters the cell through receptors that are expressed on the surface of T lymphocytes (activated T lymphocytes are preferred targets), monocytes, macrophages and dendritic cells [1,7]. To gain entry to the host cell, HIV-1 binds to the chemokine receptor 5 or the CXC chemokine receptor 4 through interactions with the envelope proteins. After fusion and uncoating, single stranded RNA is reverse transcribed into HIV DNA, and then integrated into the host DNA. HIV DNA is transcribed to viral mRNA and exported to the cytoplasm where it is translated to viral Gag, Gag-Pol, and Nef polyproteins, which are then cleaved later during virion assembly and maturation at the cell surface or after release of the new viral particles. Current therapies inhibit many of the steps
in this process, such as entry inhibitors, reverse transcriptase inhibitors, integrase strand transfer inhibitors and protease inhibitors [1,7].

1.2. Diagnosis

Detection of the HIV virus in the blood is usually measured as viral RNA load and infection is associated with an acute symptomatic period that includes fever, general malaise, lymphadenopathy, rash, myalgias, however serious consequences such as meningitis have also been reported [7,8]. During the period of acute infection, the plasma levels of HIV RNA are at their highest and the severity of symptoms is associated with the level of viral load. It has been suggested that viral characteristics and viral load determine both the replication and pathogenesis. Thus, the clinical outcomes and disease progression are dependent not only on the host, but also on the viral genotype [7]. HIV is difficult to completely eradicate as it establishes a quiescent or latent infection within the memory CD4+ T cells, which have a stem-cell-like capacity for self-renewal. Once the HIV DNA is integrated into the host chromatin, the virus can repeatedly initiate replication as long as that cell exists. While ART can prevent new cells from becoming infected, it cannot eliminate infection once the DNA has successfully integrated into the target cell. The lymph nodes harbor the virus because of limited antiretroviral drug penetration, and limited host clearance mechanisms, and serves as a source of virus recrudescence in individuals who stop or interrupt their therapy. It has been suggested that ART therapy may be needed for several decades before the viral reservoir might decay to negligible levels.

1.3. Current Treatments for HIV/AIDS

Although HIV was recognized early in the 1980s, there is still no cure or an effective vaccine for HIV infection, but there have been some significant advances in treatment, control, and prevention [9]. The introduction of anti-retroviral agents and highly active antiretroviral therapy (HAART) in 1996 significantly reduced the morbidity and mortality of HIV/AIDS. Antiretroviral therapy is currently recommended for all adults with HIV. Recommendations for initial regimens include two nucleoside reverse transcriptase inhibitors (NRTIs; abacavir with lamivudine or tenofovir disoproxil fumarate with emtricitabine) and an integrase strand transfer inhibitor, such as dolutegravir, elvitegravir, or raltegravir; a nonnucleoside reverse transcriptase inhibitor (efavirenz or rilpivirine) or a boosted protease inhibitor (darunavir or atazanavir) [10]. Alternative regimens are also available. Protease inhibitor monotherapy is generally not recommended, but NRTI-sparing approaches may be considered. Suspected treatment failure warrants rapid confirmation, performance of resistance testing while the patient is receiving the failing regimen, and evaluation of reasons for failure before consideration of switching therapy. Alterations in therapeutic regimens due to adverse effects, convenience, or to reduce costs should be carefully considered so as not to jeopardize antiretroviral potency. Research continues into HIV vaccines and antimicrobial agents, however other major advances in HIV prevention has been voluntary male medical circumcision [11,12], as well as antiretrovirals for the prevention of mother to child transmission [13–16].

The reduction in the morbidity and mortality of the disease has changed it from a fatal disease to a chronic, manageable condition [2,3,11,12]. Interestingly, the increased survival rate has resulted in an aging HIV/AIDS population, which has presented a whole new set of issues including a higher prevalence of chronic diseases in this population, such as cardiovascular and pulmonary diseases, malignancies and even a unique set of comorbidities, which are now designated as HIV-associated non-AIDS (HANA) conditions.

Antiretroviral agents remain the cornerstone of HIV treatment and prevention [17]. It is currently recommended that all HIV-infected patients with detectable virus, regardless of their CD4 cell count, should be treated with anti-retroviral therapy (ART) soon after diagnosis to prevent disease progression, improve clinical outcomes including reducing AIDS-associated events, non-AIDS-related events, and all-cause mortality, as well as to decrease transmission [17]. These recommendations are supported by large randomized controlled clinical trials it is recommended that all HIV-infected individuals
with detectable plasma virus receive treatment with recommended initial regimens consisting of an integrase strand transfer inhibitors (InSTI) plus two nucleoside reverse transcriptase inhibitors (NRTIs). When used effectively, the anti-retroviral agents suppress HIV and prevent new HIV infections. It has been suggested that with these treatment regimens, that survival rates among HIV-infected adults can approach those of uninfected adults [17].

1.4. New Drug Therapies for HIV

A recent review of HIV therapies with new mechanisms of action in phase 2 clinical trials has reported on drugs with new mechanisms of action, including histone deacetylase (HDAC) inhibitors, gene therapies, broadly neutralizing anti-HIV antibodies, immune modulation, and drugs with new mechanisms to block HIV entry [18]. The new therapies are being developed for both as add-on therapy to existing combination antiretroviral therapy and as agents to be used during treatment interruption. The current drugs in development have had varying degrees of success in the early trials. Each of these new drugs may potentially fill a void in current antiretroviral therapy (ART) therapies, which will ultimately lead to improved outcomes in HIV-infected individuals.

1.5. Natural Products and Herbal Medicines for HIV

Although effective, ART is not without serious adverse events, which is especially evident in persons undergoing long-term treatment. In addition, the current therapies are limited by emergence of multidrug resistance [19], and new drugs and novel targets are needed to overcome the issues of HIV reservoirs in the body in order to have the complete eradication of HIV and AIDS. Latently infected cells remain a primary barrier to eradication of HIV-1. Over the last ten years the molecular mechanism by which HIV latency persists has led to the discovery of a number of drugs that are able to selectively reactivate latent proviruses without inducing polyclonal T cell activation [20]. Interestingly, histone deacetylase (HDAC) inhibitors, including vorinostat are able to induce HIV transcription from latently infected cells. Vorinostat has been shown to increase the susceptibility of CD4+ T cells to infection by HIV in a dose- and time-dependent manner, does not enhance viral fusion with cells, but increases reverse transcription, nuclear import, and integration, and enhances viral production in a spreading-infection assay. HDAC inhibitors, particularly vorinostat, are currently being investigated clinically as part of a “shock-and-kill” strategy to purge latent reservoirs of HIV [20].

Since new drugs will be needed for the management of HIV, the World Health Organization (WHO) has suggested the that ethnomedicines and other natural products should be systematically tested against HIV as they may yield effective and more affordable therapeutic agents (World Health Organization [21,22]. Interestingly, a significant amount of work in this area was performed in the 1990s, particularly investigations of natural products with activities against HIV-1 reverse transcriptase, HIV-1 and -2 proteases and integrases (extensively reviewed by Kurapati et al. [23]). The natural products calanolides (coumarins), ursolic and betulinic acids (triterpenes), baicalin (flavonoid), polycitine A (alkaloid), lithospermic acid (phenolic compound) have been proposed as promising candidates for anti-HIV agents [23]. However, most of these studies are in vitro, and too few investigations have been performed in vivo or in human studies. In terms of clinical data, a meta-analysis assessed 12 clinical trials involving 881 patients with AIDS to determine the efficacy of traditional Chinese medicines (TCM). The results showed that TCM interventions were associated with significantly reduced plasma viral load compared with placebo. This study further suggested that TCM interventions were significantly more effective than placebo for reducing plasma viral load and increasing CD4+ T lymphocyte count in patients with AIDS. However, when compared with conventional Western medicine, TCM interventions were significantly less effective in reducing viral load, but were associated with improved symptoms in a larger number of patients, with fewer adverse events [24]. Thus, there is significant potential for natural products and traditional medicines for the management of HIV infections and symptoms but in vivo and human studies are lacking.
2. Traditional Knowledge on Plants Used against HIV

Medicinal plants can be a promising alternative for various diseases and conditions [25–46]. The 717 species belonging to 151 families are reported in this article. The taxonomy of the plant species plays a significant role in the proper identification. The website, http://www.theplantlist.org and http://www.tropicos.org/Home.aspx were considered as the authentic sources of information in resolving the ambiguity of the names related to plants. A list of plant species with inhibition studies is summarized in Table 1. A majority of the inhibition studies are carried out on the crude extracts of the plant material by various solvents, while limited literature is available on the isolated natural products for different inhibition studies. Table 2 lists all the names which are reported in this article and their synonyms are reported in the literature.

The Food and Drug Administration (FDA or USFDA) classifies antiretroviral drugs for HIV infection into the following categories:

1. Multi-class Combination Products,
2. Nucleoside Reverse Transcriptase Inhibitors (NRTIs),
3. Nonnucleoside Reverse Transcriptase Inhibitors (NNRTIs),
4. Protease Inhibitors (PIs),
5. Fusion Inhibitors,
6. Entry Inhibitors—CCR5 co-receptor antagonist and
7. HIV integrase strand transfer inhibitors.

For better understanding, 1st, 5th and 6th types are not explicitly mentioned in this article. 2nd and 3rd classes are categorized into HIV-reverse transcription (HIV-RT), 4th type as HIV-protease (HIV-PR) and 7th type as HIV-integrase (HIV-IN). Painter et al. [47] Konvalinka et al. [48] and Blanco et al. [49] have reviewed the roles of HIV-RT, HIV-PR and HIV-IN, respectively. Also, Matthée et al. [50] have discussed the natural inhibitors of HIV-RT.

Of these 717 species, HIV-RT, HIV-PR, and HIV-IN are reported for 206, 254 and 43 species, respectively. Apart from these three inhibitor studies, researchers have also evaluated 390 species for other enzyme inhibition studies which are grouped under anti-HIV activities.
Table 1. List of plant species exhibiting different human immunodeficiency virus (HIV)-inhibition activities.

| Family       | Plant                                      | Plant Part | HIV-RT | HIV-PR | HIV-IN | Anti-HIV       |
|--------------|--------------------------------------------|------------|--------|--------|--------|----------------|
| Acanthaceae  | *Andrographis paniculata* (Burm. f.) Wall. ex Nees | Aerial part | Crude  |        |        | Crude [51,52] |
| Acanthaceae  | *Avicennia marina var. rumphiana* (Hallier f.) Bakh. | Seed       |        |        |        | Iridoid glycoside [53] |
| Acanthaceae  | *Avicennia officinalis* L.                   | Leaf       | Crude  |        |        | Crude [54]    |
| Acanthaceae  | *Justicia adhatoda* L.                      |            |        |        |        | Crude [56]    |
| Acanthaceae  | *Justicia gendarussa* Burm.f.                | Aerial part | Crude  |        |        | Crude [57]    |
| Acanthaceae  | *Rhinacanthus nasutus* (L.) Kurz             | Aerial part | Crude  |        |        | Crude [58]    |
| Acanthaceae  | *Strobilanthes casia* (Nees) Kuntze         |            |        |        |        | Crude [59]    |
| Acoraceae    | *Acorus calamus* L.                         | Rhizome    | Crude  |        |        | Crude [58]    |
| Adoxaceae    | *Sambucus ebulus* L.                        | Whole plant | Crude  |        |        | Crude [61]    |
| Adoxaceae    | *Sambucus nigra* L.                         | Whole plant | Crude  |        |        | Crude [62,63] |
| Adoxaceae    | *Sambucus racemosa* L.                      | Leaf, Fruit | Crude  |        |        | Crude [62,64] |
| Adoxaceae    | *Sambucus williamsii* Hance                  | Roots, Fruits |        |        |        | Crude [65,66] |
| Adoxaceae    | *Viburnum opulus* L.                        | Leaf, Fruit | Crude  |        |        | Crude [62]    |
| Aizoaceae    | *Sceletium tortuosum* (L.) N.E. Br.         |            | Crude  |        |        | Crude [67]    |
| Alismataceae | *Alisma plantago-aquatica* L.               | Rhizome    |        |        |        | Crude [66]    |
| Amaranthaceae| *Achyranthes bidentata* Blume              |            |        |        |        | Crude [66,69] |
| Amaranthaceae| *Achyranthes japonica* (Miq.) Nakai         | Root       |        |        |        | Crude [66]    |
| Amaranthaceae| *Aerva lanata* (L.) Juss. ex Schult.        | Root       | Phytoterosols [70] |        |        |                |
| Amaranthaceae| *Alternanthera brasiliensis* (L.) Kuntze    |            |        |        |        | Crude [71]    |
| Amaranthaceae| *Alternanthera philoxeroides* (Mart.) Griseb. | Aerial part |        |        |        | Crude [72,73] |
| Amaryllidaceae| *Allium sativum* L.                          | Bulb       | Crude  |        |        | Crude [58]    |
| Amaryllidaceae| *Crinum amabile* Donn ex Ker Gawl.         | Bulb       | Crude  |        |        | Crude [74]    |
| Amaryllidaceae| *Crinum macowanii* Baker                    | Bulb       | Crude  |        |        | Crude [75]    |
| Amaryllidaceae| *Hymenarthus albiflos* Jacq.            |            |        |        |        | Crude [76]    |
| Amaryllidaceae| *Leucojum vernum* L.                        | Bulb       | Alkaloids [77] |        |        |                |
| Amaryllidaceae| *Pamianthe peruviana* Anonymous             | Bulb       | Crude  |        |        | Crude [74]    |
| Amaryllidaceae| *Tulbagha alliacea* Anonymous              | Bulb       |        |        |        | Crude [78]    |
| Amaryllidaceae| *Tulbagha violacea* Harv.                  | Bulb       | Crude  |        |        | Crude [75]    |
| Anacardiaceae| *Lannea edulis* (Sond.) Engl.              | Bulb       |        |        |        | Crude [79]    |
| Anacardiaceae| *Mangifera indica* L.                      | Stem bark  |        |        |        | Crude [80]    |
| Anacardiaceae| *Rhus chinesis* Mill.                      | Leaf, Root, Stem, Bark, Fruit |        |        |        | Read phyto [81] |
| Family          | Plant                          | Plant Part | HIV-RT                     | HIV-PR       | HIV-IN                     | Anti-HIV                                      |
|-----------------|-------------------------------|------------|----------------------------|--------------|----------------------------|-----------------------------------------------|
| Anacardiaceae   | *Schinus molle* L.            | Leaf       | Crude [82]                 |              |                            |                                               |
| Anacardiaceae   | *Spondias pinnata* (L. f.) Kurz | Fruit     | Crude [58]                 |              |                            |                                               |
| Anacardiaceae   | *Toxicodendron ascinmunatum* (DC.) C.Y. Wu & T.L. Ming | Gall       | Crude [85]                 |              |                            |                                               |
| Anacrostocladaeae | *Ancistrocladus korupensis* D.W. Thomas & Gereau | Root       | Naphthylisoquinoline alkaloids [84] | Crude [85]   | Naphthylisoquinoline alkaloids [86] |                                               |
| Annonaceae      | *Annona glabra* L.            | Fruit      | Alkaloids [87]             |              |                            |                                               |
| Annonaceae      | *Annona senegalensis* Pers.   | Leaf       | Crude [80]                 |              |                            |                                               |
| Annonaceae      | *Annona squamosa* L.          | Fruit      | Diterpenoids [86]          |              |                            |                                               |
| Annonaceae      | *Dasymachalon rostratum* Merr. & Chun | Stem    | Phenypropanoid derivatives [89] |              |                            |                                               |
| Annonaceae      | *Dasymachalon sootepense* Craib | Leaf      | Alkaloids, Flavonoid [90]  |              |                            |                                               |
| Annonaceae      | *Polyalthia suberosa* (Roxb.) Thwaites | Stem bark | Crude [57]                 |              |                            | Triterpene [91] and 2-substituted furans [92] |
| Annonaceae      | *Xylopia frutescens* Aubl.    | Bark       | Crude [93]                 |              |                            |                                               |
| Apiaceae        | *Aepidea amatymbica* Eckl. & Zeyh. |          |                            |              |                            | Rosmarinic acid [94]                          |
| Apiaceae        | *Ammi vinage* (L.) Lam.        | Fruit      | Crude [95]                 |              |                            |                                               |
| Apiaceae        | *Anethum graveolens* L.       | Seed       | Crude [83]                 |              |                            |                                               |
| Apiaceae        | *Angelica dahurica* (Fisch.) Benth. & Hook. f. | Root     | Crude [66]                 |              |                            |                                               |
| Apiaceae        | *Angelica gigaserrata* Maxim. | Aerial part | Crude [96]                 |              |                            |                                               |
| Apiaceae        | *Apium graveolens* L.         | Fruit      | Crude [83]                 |              |                            |                                               |
| Apiaceae        | *Cryptotaenia japonica* Hassk. | Aerial part | Crude [96]                 |              |                            |                                               |
| Apiaceae        | *Foeniculum vulgare* Mill     | Fruit      | Crude [66]                 |              |                            |                                               |
| Apiaceae        | *Lomatium suksdorff* (H. Watson) J.M. Coulth. & Rose | Fruit | Coumarins [97] |              |                            |                                               |
| Apiaceae        | *Malus sieversii* Gillet & Hook. | Leaf, Stem | Crude [82]                 |              |                            |                                               |
| Apiaceae        | *Ridolfia segetum* (L.) Moris |          |                            |              |                            | Essential oils [98]                           |
| Apiaceae        | *Saposnkoavia divaricata* (Turcz.) Schischk. |          |                            |              |                            |                                               |
| Apiaceae        | *Toreia japonica* (Houtt.) DC. | Seed       | Crude [96]                 |              |                            |                                               |
| Apocynaceae     | *Aristolochia rusa* (L.) R. Br. | Stem bark | Crude [56]                 |              |                            |                                               |
| Apocynaceae     | *Carissa bispinosa* Desf. ex Brenan | Roots      | Crude [99]                 |              |                            |                                               |
| Apocynaceae     | *Catharanthus roseus* (L.) G. Don | Leaf       | Crude [56]                 |              |                            |                                               |
| Apocynaceae     | *Cynanchum atratum* Bunge     | Root       | Crude [66]                 |              |                            |                                               |
| Apocynaceae     | *Cynanchum paniculatum* (Bunge) Kitag. | Root     | Crude [66]                 |              |                            |                                               |
| Family          | Plant                  | Plant Part | HIV-RT   | HIV-PR  | HIV-IN | Anti-HIV  |
|-----------------|------------------------|------------|----------|---------|--------|-----------|
| Apocynaceae     | Gymnema sylvestre (Retz.) R. Br. ex Schult. | Crude [99] |          |         |        |           |
| Apocynaceae     | Hemidesmus indicus (L.) R. Br. ex Schult. |            |         |         |        |           |
| Apocynaceae     | Hoodia gordonii (Masson) Sweet ex Decne. | Crude [101] |         |         |        |           |
| Apocynaceae     | Paraemia laricigata (Juss.) Moldenke | Bark |         | Crude [101] |        |           |
| Apocynaceae     | Rauwolfia serpentina (L.) Benth. ex Kurz | Crude [100] | Crude [101] |        |        |           |
| Apocynaceae     | Sesamum indicum | Root |          | Crude [56] |        |           |
| Apocynaceae     | Tabernaemontana stapfiana Britten |            |         |        |        |           |
| Araceae         | Alocasia odora (Roxb.) K. Koch | Rhizome | Crude [68] |         |        |           |
| Araliaceae      | Acanthopanax koreanum Nakai | Stem bark | Crude [66] |         |        |           |
| Araliaceae      | Eleutheroococcus sessiliflorus (Rupr. & Maxim.) S.Y. Hu | Crude [66] | Crude [66] |        |        |           |
| Araliaceae      | Kalopanax pictus (Thunb.) Nakai | Stem bark | Crude [66] |         |        |           |
| Araliaceae      | Panax ginseng C.A. Mey. | Root | Triterpenoids [103] |     | Saponin [104] | |
| Araliaceae      | Panax notoginseng (Burkill) F.H. Chen ex C.H. Chow | Crude [60,83] | Crude [105] |        |        |           |
| Araliaceae      | Panax zingiberensis C.Y. Wu & K.M. Feng | Rhizome |                   | Zingibroside [106] | | |
| Areaceae        | Areca catechu L. | Seed | Crude [60,83] |         |        |           |
| Areaceae        | Attalea tessmannii Burret | Seed | Crude [82] |         |        |           |
| Aristolochiaceae| Aristolochia bracteolate Lam. | Fruit | Crude [74] |         |        |           |
| Aristolochiaceae| Aristolochia contorta Bunge | Fruit | Crude [95] |         |        |           |
| Aristolochiaceae| Aristolochia manshurianum Kom. | Stem | Ossoperezonone [107] | | | |
| Aristolochiaceae| Asarum sieboldii Miq. | Root | Crude [66] |         |        |           |
| Asparagaceae    | Anemarrhena asphodeloides Bunge | Rhizome | Crude [66] |         |        |           |
| Asparagaceae    | Asperagus cochinchinensis (Loutr.) Merr. | Root | Crude [66] |         |        |           |
| Asparagaceae    | Asparagus racemosus Willd. | Root | Crude [56] |         |        |           |
| Asparagaceae    | Dactylis glomerata (Loutr.) S.C. Chen | Aerial part | Crude [58] |         |        |           |
| Asteraceae      | Acanthoserum hispidum DC. | Aerial part | Crude [74] |         |        |           |
| Asteraceae      | Achyranthes alata (Kunth) DC. | Flower, Stem | Crude [82] |         |        |           |
| Asteraceae      | Achyranthes flaccida (Weinm.) DC. | Flower | Crude [108] |         |        |           |
| Asteraceae      | Achyranthes sativoides (Lam.) DC. | Flower | Crude [82] |         |        |           |
| Asteraceae      | Ainsliaea acerifolia Sch. Bip. | Whole plant | Crude [82] |         |        |           |
| Asteraceae      | Ambrosia artemisiifolia L. | Whole plant | Crude [82] |         |        |           |
| Asteraceae      | Ambrosia maritima L. | Aerial part | Crude [56] |         |        |           |
| Asteraceae      | Ambrosia persimilis All. | Leaf, stem | Crude [82] |         |        |           |
| Family        | Plant                          | Plant Part | HIV-RT | HIV-PR | HIV-IN | Anti-HIV                      |
|--------------|--------------------------------|------------|--------|--------|--------|-------------------------------|
| Asteraceae   | Anvillea garcinii (Burm. f.) DC.| Aerial part|        |        |        | Germacranolides [109]         |
| Asteraceae   | Arctium lappa L.                | Aerial part|        | Crude  | Crude  | [60]                          |
| Asteraceae   | Artemisia absinthium L.         | Leaf       |        |        |        | Crude [105]                   |
| Asteraceae   | Artemisia annua L.              | Aerial part|        |        |        | Crude [82]                    |
| Asteraceae   | Artemisia capillaris Thunb.     | Aerial part, Seed | Crude |        |        | [68]                          |
| Asteraceae   | Artemisia princeps Pamp.        | Leaf       |        |        |        | Crude [66,96]                 |
| Asteraceae   | Artemisia verlotorum Lamotte    |            |        |        |        | Crude [110]                   |
| Asteraceae   | Aspilia pluriseta Schweinf. ex Schweinf. | Aerial part |        |        |        | Crude [111]                   |
| Asteraceae   | Aster tataricus L. f.           | Root       |        | Crude  |        | [68]                          |
| Asteraceae   | Atractylodes japonica Koedz.    | Root       |        | Crude  |        | [66]                          |
| Asteraceae   | Atractylodes lancea (Thunb.) DC.| Rhizome    |        |        |        | Crude [112]                   |
| Asteraceae   | Atractylodes ovata (Thunb.) DC. | Rhizome    |        | Crude  |        | [68]                          |
| Asteraceae   | Baccharis genistemoides (Lam.) Pers. | Leaf, stem |        | Crude  |        | [82]                          |
| Asteraceae   | Baccharis latifolia (Ruiz & Pav.) Pers. | Leaf, stem |        | Crude  |        | [82]                          |
| Asteraceae   | Baccharis trimera (Less.) DC.    | Leaf, stem |        | Crude  |        | [82]                          |
| Asteraceae   | Baccharis trinervis Pers.       | Aerial part|        |        |        | Crude [95]                    |
| Asteraceae   | Bidens pilosa L.                | Aerial part|        | Crude  |        | [95]                          |
| Asteraceae   | Blumea balsamifera (L.) DC.     |            |        |        |        | Crude [113]                   |
| Asteraceae   | Broussonetia Bunge Kitam.       | Aerial part|        |        |        | Crude [113]                   |
| Asteraceae   | Calopogon acuminatus L.         | Leaf       |        |        |        | Crude [62]                    |
| Asteraceae   | Carthamus tinctorius L.         | Flower     |        |        |        | Crude [66]                    |
| Asteraceae   | Centaurea punctata Cass.        | Leaf       |        | Crude  |        | [114]                         |
| Asteraceae   | Chrysanthemum indicum L.        | Capitulum  |        | Crude  |        | [60]                          |
| Asteraceae   | Chrysanthemum morifolium Ramat. | Capitulum  | Flavonoids [116]| Crude | [105] | [60,68]                        |
| Asteraceae   | Cirsium japonicum DC.           |            |        |        |        | Flavonoid [117]               |
| Asteraceae   | Cirsium prostratum (L.) L.      | Whole plant|        |        |        | Crude [117,118]               |
| Asteraceae   | Elephantopus scaber L.          | Leaf       |        | Crude  |        | [68]                          |
| Asteraceae   | Espartium lindleyanum DC.       | Aerial part|        |        |        | Crude [96]                    |
| Family       | Plant                              | Plant Part       | HIV-RT | HIV-PR | HIV-IN | Anti-HIV |
|--------------|------------------------------------|------------------|--------|--------|--------|----------|
| Asteraceae   | Francoeuria crispa (Forssk.) Cass. | Leaf, stem       | Crude  |        |        | [121]    |
| Asteraceae   | Franseria artemiosioides Willd.    |                  | Crude  |        |        | [82]     |
| Asteraceae   | Gamochaeta simplicialis (Willd. ex Spreng.) Cabrera |      | Crude  |        |        | [122]    |
| Asteraceae   | Geigeria alata (DC.) Oliv. & Hiern | Leaf, stem       | Crude  |        |        | [108]    |
| Asteraceae   | Gynura pseudochina (L.) DC.        | Leaf             | Crude  |        |        | [121]    |
| Asteraceae   | Gynura pseudochina (L.) DC.        | Leaf             | Crude  |        |        | [57]     |
| Asteraceae   | Helianthus tuberosus L.            | Whole plant      | Crude  |        |        | [96]     |
| Asteraceae   | Helichrysum acutatum DC.           | Aerial part      | Crude  |        |        | [123]    |
| Asteraceae   | Helichrysum alliosides Less.       | Aerial part      | Crude  |        |        | [123]    |
| Asteraceae   | Helichrysum anomalum Less.         | Aerial part      | Crude  |        |        | [123]    |
| Asteraceae   | Helichrysum appendiculatum (L. f.) Less. | Aerial part | Crude  |        |        | [123]    |
| Asteraceae   | Helichrysum auroritum Sch. Bip.    | Aerial part      | Crude  |        |        | [123]    |
| Asteraceae   | Helichrysum cephaloideum DC.       | Aerial part      | Crude  |        |        | [123]    |
| Asteraceae   | Helichrysum chinosphaerum DC.      | Aerial part      | Crude  |        |        | [123]    |
| Asteraceae   | Helichrysum conferum N.E. Br.      | Aerial part      | Crude  |        |        | [123]    |
| Asteraceae   | Helichrysum cymosum (L.) D. Don ex G. Don | Aerial part | Crude  |        |        | [123]    |
| Asteraceae   | Helichrysum difficile Hilliard     | Aerial part      | Crude  |        |        | [123]    |
| Asteraceae   | Helichrysum drakensbergense Killick | Aerial part | Crude  |        |        | [123]    |
| Asteraceae   | Helichrysum herbaceum (Andrews) Sweet | Aerial part | Crude  |        |        | [123]    |
| Asteraceae   | Helichrysum melanacme DC.          | Aerial part      | Crude  |        |        | [123]    |
| Asteraceae   | Helichrysum micostifillum DC.      | Aerial part      | Crude  |        |        | [123]    |
| Asteraceae   | Helichrysum natalitium DC.         | Aerial part      | Crude  |        |        | [123]    |
| Asteraceae   | Helichrysum nudifolium (L.) Less.  | Aerial part      | Crude  |        |        | [123]    |
| Asteraceae   | Helichrysum odoratissimum (L.) Sweet | Aerial part | Crude  |        |        | [123]    |
| Asteraceae   | Helichrysum oreophilum Dunster     | Aerial part      | Crude  |        |        | [123]    |
| Asteraceae   | Helichrysum oxyphyllum DC.         | Aerial part      | Crude  |        |        | [123]    |
| Asteraceae   | Helichrysum pallidium DC.          | Aerial part      | Crude  |        |        | [123]    |
| Asteraceae   | Helichrysum panduratum O. Hoffm.   | Aerial part      | Crude  |        |        | [123]    |
| Asteraceae   | Helichrysum pannosum DC.           | Aerial part      | Crude  |        |        | [123]    |
| Asteraceae   | Helichrysum pilosifolium (L. f.) Less. | Aerial part | Crude  |        |        | [123]    |
| Asteraceae   | Helichrysum populifolium DC.       | Aerial part      | Crude  |        |        | [123]    |
Table 1. Cont.

| Family     | Plant                              | Plant Part | HIV-RT | HIV-PR | HIV-IN | Anti-HIV |
|------------|------------------------------------|------------|--------|--------|--------|----------|
| Asteraceae | Helichrysum rugulosum Less.        | Aerial part| Crude  |        |        | [123]    |
| Asteraceae | Helichrysum splendidum (Thunb.) Less. | Aerial part| Crude  |        |        | [123]    |
| Asteraceae | Helichrysum subulatum Burtt Davy   | Aerial part| Crude  |        |        | [123]    |
| Asteraceae | Helichrysum sutherlandii Harv.     | Aerial part| Crude  |        |        | [123]    |
| Asteraceae | Helichrysum umbaculigerum Less.    | Aerial part| Crude  |        |        | [123]    |
| Asteraceae | Helichrysum vernum Füllard         | Aerial part| Crude  |        |        | [123]    |
| Asteraceae | Hieracium pilosella L.             | Whole plant| Crude  |        |        | [61]     |
| Asteraceae | Hieracium umbellatum L.            | Whole plant| Crude  |        |        | [96]     |
| Asteraceae | Inula britannica L.                | Flower     | Crude  |        |        | [66]     |
| Asteraceae | Inula helenium L.                  | Root       | Crude  |        |        | [66]     |
| Asteraceae | Ixeris tamagawaensis (Makino) Kitam. | Aerial part| Crude  |        |        | [124]    |
| Asteraceae | Lactuca raddiana Maxim.            | Whole plant| Crude  |        |        | [96]     |
| Asteraceae | Miyamagunysa koraiensis (Nakai) Kitam. | Root | Crude  |        |        | [96]     |
| Asteraceae | Matutia acuminata Ruiz & Pav.      | Leaf       | Crude  |        |        | [82]     |
| Asteraceae | Perzizia multiora (Bonpl.) Less.   | Leaf       | Crude  |        |        | [82]     |
| Asteraceae | Pilosella officinarum FW. Schultz & Sch. Bip. | Whole plant| Crude  |        |        | [61]     |
| Asteraceae | Psidias dentata (Cass.) DC.         |            | Coumarin |        |        | [125]    |
| Asteraceae | Senotolina oblongfolia Boss.       | Whole plant| Crude  |        |        | [61]     |
| Asteraceae | Serratula coronata L.              | Leaf       | Crude  |        |        | [96]     |
| Asteraceae | Scrobicula pisunata (Lam.) Kuntze ex Thell. | Leaf | Crude  |        |        | [82]     |
| Asteraceae | Senecio comans Sch. Bip.           | Leaf       | Crude  |        |        | [82]     |
| Asteraceae | Senecio matthesii Wedd.            | Leaf       | Crude  |        |        | [82]     |
| Asteraceae | Senecio rizomatus Rusby            | Leaf       | Crude  |        |        | [82]     |
| Asteraceae | Senecio sasandens Buch.-Ham. ex D. Don | Whole plant| Crude  |        |        | [60]     |
| Asteraceae | Serratula coronate L.              | Aerial part| Crude  |        |        | [96]     |
| Asteraceae | Sigebeckia glabrescens (Makino) Makino | Whole plant| Crude  |        |        | [66]     |
| Asteraceae | Sonchus aleraceus L.               | Leaf       | Crude  |        |        | [82]     |
| Asteraceae | Symphyotrichum undulatum (L.) G.L.Nesom | Aerial part|        |        |        | [126]    |
| Asteraceae | Tagetes riganez M. Ferraro         | Leaf       | Crude  |        |        | [82]     |
| Asteraceae | Tanacetum microphyllum DC.          | Whole plant| Crude  |        |        | [61]     |
| Asteraceae | Taraxacum mongolicum Hand.-Mazz.   | Whole plant| Crude  |        |        | [68]     |
| Family       | Plant                     | Plant Part | HIV-RT | HIV-PR | HIV-IN | Anti-HIV |
|--------------|---------------------------|------------|--------|--------|--------|----------|
| Asteraceae   | Xanthium spinosum L.       | Flower     | Crude  | [82]   |        |          |
| Berberidaceae| Berberis holstii Engl.     | Root and Leaf | Crude  | [127]  |        |          |
| Berberidaceae| Epimedium grandiflorum C. Morren | Aerial part | Crude  | [21,72] |        |          |
| Berberidaceae| Epimedium sagittatum (Siebold & Zucc.) Maxim. | Leaf | Crude  | [68]   |        |          |
| Berberidaceae| Nandina domestica Thunb.   | Leaf       | Crude  | [68]   |        |          |
| Betulaceae   | Alnus firma Siebold & Zucc. | Leaf       | Triterpenoids [126] |        |        |          |
| Betulaceae   | Alnus incana (L.) Moench  | Leaf       | Crude  | [62]   |        |          |
| Bignoniaceae | Kigelia africana (Lam.) Benth. | Fruit | Crude  | [105]  |        |          |
| Bignoniaceae | Spathodea campanulata P. Beauv. | Stem bark | Crude  | [129]  |        |          |
| Bignoniaceae | Tecomella undulata (Sm.) Seem. | Leaf | Crude  | [130]  |        |          |
| Blechnaceae  | Blechnum spicant (L.) Sm.  | Leaf       | Crude  | [62]   |        |          |
| Blechnaceae  | Brainea insignis (Hook.) J. Sm. | Rhizome | Crude  | [68]   |        |          |
| Blechnaceae  | Woodwardia orientalis Sw.   | Rhizome   | Crude  | [68]   |        |          |
| Blechnaceae  | Woodwardia unigemmata (Makino) Nakai | Rhizome | Crude  | [60]   | Crude  | [105]    |
| Boraginaceae | Brachyacanthes parviflora Maxim. ex Oliv. | Leaf | Crude  | [96]   |        |          |
| Boraginaceae | Cordia spinosae L.         | Leaf       | Crude  | [93]   | Crude  | [93]     |
| Boraginaceae | Lithospermum erythroborzii Siebold & Zucc. | Root | Crude  | [60,68] | Crude  | [105]    |
| Boraginaceae | Lobostemon trigonae H. Baue | Root       | Crude  | [132]  |        |          |
| Brassicaceae | Brassica juncea (L.) Cerns. | Semen     | Crude  | [133]  |        |          |
| Brassicaceae | Brassica oleracea L.       | Crude     | [134]  |        |        |          |
| Brassicaceae | Brassica rapa L.           | Crude     | [134]  |        |        |          |
| Brassicaceae | Capsella bursa-pastoris (L.) Medik. | Whole plant | Crude  | [82]   |        |          |
| Brassicaceae | Lepidium arvensefolium Turcz. | Leaf | Crude  | [82]   |        |          |
| Brassicaceae | Raphanus raphanistrum L.  | Crude     | Inhibition [66] |        |        |          |
| Cactaceae    | Pilosus hiso (Kunth) DC.   | Whole plant | Crude  | [53]   |        |          |
| Calophyllaceae| Marilia pluricostata Standl. & L.O. Williams | Phenylcoumarins [135] |        |        |        |          |
| Campanulaceae| Adenophora triflora (Thunb.) A. DC. | Root | Crude  | [66]   |        |          |
| Campanulaceae| Platycodon grandiflorus (Jacq.) A. DC. | Root | Crude  | [68]   |        |          |
| Cannabinaceae| Cannabis sativa L.         | Fruit     | Crude  | [68]   |        |          |
| Cannabinaceae| Humulus lupulus L.         |           |        |        |        | Flavonoid [136] |
| Family         | Plant                           | Plant Part     | HIV-RT | HIV-PR | HIV-IN | Anti-HIV       |
|---------------|---------------------------------|----------------|--------|--------|--------|----------------|
| Cannaceae     | Canna indica L.                 | Rhizome        | Crude  | [57]   |        |                |
| Canellaceae   | Warburgia ugandensis Sprague    | Crude          | [102]  |        |        |                |
| Capparaceae   | Buscia senegalensis (Pers.) Lam. ex Poir. | Leaf     | Crude  | [74]   |        |                |
| Capparaceae   | Capparis decidua (Forsik.) Edgew. | Stem     | Crude  | [74]   |        |                |
| Capparaceae   | Crateva religiosa G. Forst.     | Bark           | Crude  | [83]   |        |                |
| Caprifoliaceae| Loniceria japonica Thunb.       | Flower bud     | Crude  | [135]  | Crude  |                |
| Caprifoliaceae| Patrinia scabiosifolia Link     | Root           | Crude  | [96]   |        |                |
| Caprifoliaceae| Patrinia villosa (Thunb.) Dufr. | Root           | Crude  | [68,96]|        |                |
| Caprifoliaceae| Valeriana coarctata Ruiz & Pav. | Leaf           |        |        |        |                |
| Caprifoliaceae| Valeriana micropterina Wedd.    |                |        |        |        |                |
| Caprifoliaceae| Valeriana thalictroides Graebn.| Root           |        |        |        |                |
| Caryophyllaceae| Wightella suberosa L.H. Bailey  | Stem           | Crude  | [96]   |        |                |
| Caryophyllaceae| Drymaria cordata (L.) Willd. ex Schult. | Leaf     |        |        |        |                |
| Caryophyllaceae| Drymaria diandra Blume          |                | Alkaloid [138]|        |        |                |
| Caryophyllaceae| Silene soulenensis Nakai        | Aerial part    | Crude  | [96]   |        |                |
| Celastraceae  | Cassine creoea (Thunb.) C.Presl |                | Glycoside [140]|        |        |                |
| Celastraceae  | Cassine schlechteriana Loes.    |                | Crude  | [141]  |        |                |
| Celastraceae  | Celastrus binusii Benth.        |                |        |        |        |                |
| Celastraceae  | Celastrus orbiculatus Thunb.    | Root           | Crude  | [96]   |        |                |
| Celastraceae  | Esonjumus alatus (Thunb.) Siebold | Leaf     | Crude  | [96]   |        |                |
| Celastraceae  | Gymnosperma buchananii Loes.    |                | Crude  | [100]  |        |                |
| Celastraceae  | Gymnosperma senegalensis (Lam.) Loes. | Root     | Crude  | [100]  |        |                |
| Celastraceae  | Maytenus bucharanii (Loes.) R. Wilczek | Root, bark   | Crude  | [102]  |        |                |
| Celastraceae  | Maytenus macrocarpus (Ruiz & Pav.) Brig. | Triterpene [144]|        |        |        |                |
| Celastraceae  | Maytenus senegalensis (Lam.) Exell | Stem     | Crude  | [102]  | Crude  |                |
| Celastraceae  | Salacia chinensis L.            | Stem           | Crude  | [98]   |        |                |
| Celastraceae  | Tripterygium wilfordii Hook. f. | Root           | Salaspermic acid [145]|        |        |                |
| Chenopodiaceae| Chenopodium ambrosioides L.     | Leaf           | Crude  | [82]   |        |                |
| Chloranthaceae| Chloranthus japonicus Siebold  | Whole plant    | Disesquiterpenoids [149]| Crude  | [96]   |                |

*Note: HIV-RT, HIV-PR, and HIV-IN denote activity against HIV-1 Reverse Transcriptase (RT), HIV-1 Protease (PR), and HIV-1 Integrase (IN), respectively.*
| Family          | Plant                                      | Plant Part       | HIV-RT       | HIV-PR       | HIV-IN       | Anti-HIV               |
|-----------------|--------------------------------------------|------------------|--------------|--------------|--------------|------------------------|
| Cistaceae       | Whole plant                                | Whole plant      | Crude [61]   | Crude [61]   | Crude [61]   |                        |
| Cistaceae       | Tuberaria lignose Samp.                    | Whole plant      | Crude [61]   |              |              |                        |
| Cleomaceae      | Clematis viscosa L.                        | Seed             | Nevirapine [151] | Crude [85] |              |                        |
| Clusiaceae      | Allamblackia stuhlmannii (Engl.) Engl.     |                  |              |              |              | Benzophenone [152]     |
| Clusiaceae      | Calophyllum brasiliense Cambess.           | Leaf             | Crude [153]  | Dipyranocoumarins [154] | Coumarins [155] |              |
| Clusiaceae      | Calophyllum coriiferum Vesque              |                  |              |              |              |                        |
| Clusiaceae      | Calophyllum cordato-oblongum Thwaites      |                  |              |              |              |                        |
| Clusiaceae      | Calophyllum inophyllum L.                  | Bark             | Crude [158]  | Crude [158]  | Crude [158]  | Dipyranocoumarins [159] Inophyllum [160] |
| Clusiaceae      | Calophyllum lanigerum Miq.                 |                  |              |              |              | Calanolide [162]       |
| Clusiaceae      | Calophyllum rubiinoum M.R. Hend. & Wyatt-Sm. | Stem bark        | Crude [165]  |              |              |                        |
| Clusiaceae      | Calophyllum tegumnitii Miq.                |                  |              |              |              | Pyranocoumarins [141]  |
| Clusiaceae      | Clusia quadrangular Bartlett               |                  |              |              |              |                        |
| Clusiaceae      | Garcinia buchneri Engl.                    | Stem bark        | Crude [153]  |              |              |                        |
| Clusiaceae      | Garcinia gymmi-zatta Roxb.                 | Leaf             | Crude [158]  | Crude [158]  | Crude [158]  |                        |
| Clusiaceae      | Garcinia hamberty Hook. f.                | Root             |              |              |              | Xanthone [167]         |
| Clusiaceae      | Garcinia indica Choisy                    | Leaf             | Crude [158]  | Crude [158]  | Crude [158]  |                        |
| Clusiaceae      | Garcinia kingoensis Engl.                  | Stem bark        | Crude [166]  |              |              |                        |
| Clusiaceae      | Garcinia livingstonei T. Anderson          | Fruit            |              |              |              | Crude [168]            |
| Clusiaceae      | Garcinia mangostenu L.                    | Fruit bark       | Crude [58]   | Crude [169]  |              |                        |
| Clusiaceae      | Garcinia sensei Verde.                    | Stem bark        | Crude [166]  |              |              |                        |
| Clusiaceae      | Garcinia smeathmannii (Planch. & Triana) Oliv. | Stem bark        | Crude [166]  |              |              |                        |
| Colchicaceae    | Colchicum luteum Baker                    | Bulb             |              |              |              | Crude [56]             |
| Combretaceae    | Anogeissus acuminata (Roxb. ex DC.) Guill., Perr. & A. Rich. |                  |              |              |              | Lignans [170]          |
| Combretaceae    | Combretum adenogenium Steud. ex A. Rich.   | Root, Leaf and Stem bark | Crude [171] |              |              |                        |
| Combretaceae    | Combretum hartmannianum C. Schweinf.       | Stem             | Crude [74]   |              |              |                        |
| Combretaceae    | Combretum molle R. Br. ex G. Don           | Root             | Crude [172]  |              |              |                        |
| Combretaceae    | Combretum paniculatum Vent.               | Leaf             |              |              |              |                        |
| Combretaceae    | Terminalia arjuna (Roxb. ex DC.) Wight & Arr. | Stem bark        | Crude [68,63] |              |              |                        |

Table 1. Cont.
| Family         | Plant                                | Plant Part    | HIV-RT   | HIV-PR   | HIV-IN               | Anti-HIV  |
|---------------|--------------------------------------|---------------|----------|----------|----------------------|-----------|
| Combretaceae  | Terminalia bellirica (Gaertn.) Roxb. | Fruit         | Crude [58,175] | Crude [68] |                      | Crude [176] |
| Combretaceae  | Terminalia chebula Retz.             | Fruit         | Crude [58,175] | Crude [68,83] | Galloyl glycosides [177] | Crude [175] |
| Combretaceae  | Terminalia sericea Burch. ex DC.    | Crude [179]   |          |          |                      |           |
| Convulvulacae | Argucia nervosa (Burm. f.) Bojer     | Aerial part   | Crude [57]  |          |                      |           |
| Convulvulacae | Calystegia soldanella (L.) R. Br.    | Leaf, Stem    | Crude [96]  |          |                      |           |
| Convulvulacae | Cuscuta chinensis Lam.               | Fruit, Stem   | Crude [96]  |          |                      |           |
| Convulvulacae | Cuscuta japonica Choisy              | Semen         | Crude [66]  |          |                      |           |
| Convulvulacae | Ipomoea aquatica Forsk.              | Whole plant   | Crude [57]  |          |                      |           |
| Convulvulacae | Ipomoea cairica (L.) Sweet           | Whole plant   | Crude [57]  |          |                      |           |
| Convulvulacae | Ipomoea carnea Jacq.                | Aerial part   | Crude [57]  |          |                      |           |
| Convulvulacae | Merremia peltata (L.) Merr.          | Crude [181]   |          |          |                      |           |
| Cornaceae     | Cornus walteri Wangerin             | Aerial part   | Crude [96]  |          |                      |           |
| Cornaceae     | Campylothea acuminata Decne         | Rubitecan [182] |          |          |                      |           |
| Crassulaceae  | Orostachys japonica A. Berger       | Aerial part   | Crude [183] |          |                      |           |
| Crassulaceae  | Sedum album L.                      | Whole plant   | Crude [61]  |          |                      |           |
| Crassulaceae  | Sedum maximum Hoffm.                | Leaf          | Crude [62]  |          |                      |           |
| Crassulaceae  | Sedum polytrichoides Hems.          | Whole plant   | Crude [96]  |          |                      |           |
| Crassulaceae  | Sedum roseum Scop.                  | Crude [96]    |          |          |                      |           |
| Cucurbitaceae | Citrullus colocynthis (L.) Schrad.  | Fruit peel   | Crude [74]  |          |                      |           |
| Cucurbitaceae | Cynoglossum pentaphyllum (Thunb.) Makino | Tuber     | Crude [184] |          |                      |           |
| Cucurbitaceae | Hemsleya edeacephylla C. Y. Wu      | Tuber         | Crude [185] |          |                      |           |
| Cucurbitaceae | Momordica balsamina L.              | Leaf          | Crude [186] |          |                      |           |
| Cucurbitaceae | Momordica charantia L.              | Seed, Fruit   | Crude [187] |          |                      |           |
| Cucurbitaceae | Momordica cochinchenensis (Lour.) Spreng. | Semen        | Crude [96]  |          |                      |           |
| Cucurbitaceae | Trichosanthes kirilowii Maxim.      | Semen         | Crude [66,188] |          |                      |           |
| Cupressaceae  | Cupressus sempervirens L.            | Crude [189]   |          |          |                      |           |
| Cupressaceae  | Platycladus orientalis (L.) Franco   | Crude [66]    |          |          |                      |           |
| Cupressaceae  | Thuja occidentalis L.               | Crude [180]   |          |          |                      |           |
| Cyperaceae    | Bolboschoenus maritimus (L.) Palla  | Crude [66]    |          |          |                      |           |
| Cyperaceae    | Cyperus rotundus L.                 | Rhizome       | Crude [66]  |          |                      |           |
| Family           | Plant                          | Plant Part | HIV-RT | HIV-PR | HIV-IN | Anti-HIV       |
|------------------|-------------------------------|------------|--------|--------|--------|----------------|
| Davalliaceae     | Davallia mariesii T. Moore ex Baker | Root       |        |        |        | Crude [66]     |
| Dioscoreaceae    | Dioscorea bulbifera L.        |            |        |        | Flavonoid [191] |
| Dioscoreaceae    | Dioscorea hispida Denst.      | Rhizome    |        |        |        | Crude Protease [66] |
| Dioscoreaceae    | Dioscorea polystachya Turcz.  |            |        |        |        | Crude inhibition [66] |
| Dioscoreaceae    | Dioscorea tokoro Makino       | Root       |        |        |        | Crude inhibition [66] |
| Dipterocarpaceae | Monotes africana A. DC.        |            |        |        |        | Crude [192]    |
| Dryopteridaceae  | Cyrtomium fortunii J. Sm.     | Rhizome    |        |        |        | Crude Protease [66] |
| Dryopteridaceae  | Dryopteris crassirhizoma Nakai| Rhizome    | Flavonoid [193] | Triterpenes [194] |
| Ebenaceae        | Euclia natalensis A. DC.      |            |        |        |        | Naphthoquinone [195] |
| Elaeocarpaceae   | Elaeocarpus grandiflorus Sm.  | Fruit      |        |        |        | Crude [58]     |
| Ephedraceae      | Ephedra americana Humb. & Bonpl. ex Willd. | Stem |        |        |        | Crude [82]     |
| Ephedraceae      | Ephedra sinica Stapf          | Stem       |        |        | Crude [196] | Crude [68]    |
| Equisetaceae     | Equisetum arvense L.          | Stem       |        |        |        | Crude [82]     |
| Equisetaceae     | Equisetum giganteum L.        | Stem       |        |        |        | Crude [82]     |
| Equisetaceae     | Equisetum hyemale L.          | Aerial part |        |        |        | Crude [66]     |
| Erythroxylaceae  | Erythroxylum citrifolium A. St.-Hil. | Trunk |        |        |        | Crude [93]     |
| Eucomiaceae      | Eucommia ulmoides Oliv.       | Stem bark  |        |        |        | Crude [66]     |
| Euphorbiaceae    | Alysonia macrostachya Jacq.   | Leaf       |        |        |        | Crude [93]     |
| Euphorbiaceae    | Alchornea cordifolia (Schumach. & Thonn.) Müll. Arg. | Leaf |        |        |        | Crude [80]     |
| Euphorbiaceae    | Balsamoporum solanifolium (Geiseler) Suresh |            |        |        |        | Crude [99]     |
| Euphorbiaceae    | Chamaesyce hyoscyfolia (L.) Small | Whole plant |        |        |        | Crude [93]     |
| Euphorbiaceae    | Croton bilbergians Mull. Arg. | Trunk      |        |        |        | Crude [93]     |
| Euphorbiaceae    | Croton gratusimus Burch.      |            |        |        |        | Crude [74]     |
| Euphorbiaceae    | Croton ligulum L.             | Seed       |        |        |        | Crude [197]    |
| Euphorbiaceae    | Croton zambesiacus Mull. Arg. | Seed       |        |        |        | Crude [95]     |
| Euphorbiaceae    | Euphorbia erythropedia Boiss.  | Aerial part |        |        |        | Triterpene [198] |
| Euphorbiaceae    | Euphorbia granulata Forsk.    | Leaf       |        |        |        | Crude [95]     |
| Euphorbiaceae    | Euphorbia hirta L.            | Whole plant |        |        |        | Crude [58]     |
| Euphorbiaceae    | Euphorbia hysopifolia L.      | Whole plant |        |        |        | Crude [93]     |
| Euphorbiaceae    | Euphorbia kansui T.N. Liou ex S.B. Ho |        |        |        |        | Crude [199]    |
| Euphorbiaceae    | Euphorbia neriifolia L.       | Stem bark  |        |        |        | Diterpenoids [200,201] |
| Family          | Plant                          | Plant Part | HIV-RT | HIV-PR | HIV-IN | Anti-HIV |
|----------------|-------------------------------|------------|--------|--------|--------|----------|
| Euphorbiaceae  | Euphorbia polyacantha Boiss.  | Crude [74] |        |        |        |          |
| Euphorbiaceae  | Euphorbia prostrata Aiton     |            |        |        |        |          |
| Euphorbiaceae  | Euphorbia thunbergiana.       | Aerial part |        |        |        |          |
| Euphorbiaceae  | Homalanthus nutans (G. Forst.) Guill. |            |        |        |        |          |
| Euphorbiaceae  | Jatropha curcas L.            | Leaf       |        |        |        |          |
| Euphorbiaceae  | Mallotus japonicus (L.f.) Müll.Arg. | Tannins [203] |        |        |        |          |
| Euphorbiaceae  | Mallotus philippensis (Lam.) Müll. Arg. | Flower |        |        |        |          |
| Euphorbiaceae  | Maprounea africana Müll. Arg. | Leaf | Xanthone | Crude [90-93] | Crude [80-93] | Triterpene [205] |
| Fabaceae       | Neobalanus japonicus (Siebold & Zucc.) Esser | Leaf | Crude [96] |        |        |          |
| Fabaceae       | Ricinus communis L.           | Leaf       | Lectins [206] | Crude [83] |        |          |
| Fabaceae       | Sapium indicum Willd.         | Fruit      | Crude [58] |        |        |          |
| Fabaceae       | Shirakoupis indica (Willd.) Esser |            |        |        |        |          |
| Fabaceae       | Trigonostemon thyridoides Stapf | Stem | Diterpene | Triterpene [208,209] |        |          |
| Fabaceae       | Abrus precatorius L.          | Seed       | Saponins [210] |        |        |          |
| Fabaceae       | Acacia catechu (L. f.) Willd. | Resin      | Crude [58] |        |        |          |
| Fabaceae       | Acacia mellifera (Vahl) Benth. | Stem bark | Crude [102] |        |        |          |
| Fabaceae       | Acacia nilotica (L.) Willd. ex Delile | Bark | Crude [95] |        |        |          |
| Fabaceae       | Albizia gummifera (J.F. Gmel.) C.A. Sm. | Stem bark | Crude [102] |        |        |          |
| Fabaceae       | Albizia procera (Roxb.) Benth. |            | Crude [113] |        |        |          |
| Fabaceae       | Astragalus propinquus Schischk. | Aerial part | Crude [68] |        |        |          |
| Fabaceae       | Astragalus spinosus Muschl.    | Aerial part | Triterpene [213] |        |        |          |
| Fabaceae       | Bauhinia straphulina Craib     |            |        |        |        |          |
| Fabaceae       | Bauhinia variegata L.         |            | Crude [134] |        |        |          |
| Fabaceae       | Butea monosperma (Lam.) Taub. | Root       |        |        |        |          |
| Fabaceae       | Caesalpinia bonduc (L.) Roxb. | Seed       | Crude [83] |        |        |          |
| Fabaceae       | Caesalpinia sappan L.         | Stem       | Crude [58] |        |        |          |
| Fabaceae       | Cassia fistula L.             | Bark       | Crude [68,63] |        |        |          |
| Fabaceae       | Castanospermum auratum A. Gunn. & C. Fraser | Alkaloid [214] |        |        |        |          |
| Fabaceae       | Cullen corylifolium (L.) Medik. |            |        |        |        |          |
| Fabaceae       | Detarium microcarpum Guill. & Perr. | Flavonoids [215] |        |        |        |          |
Table 1. Cont.

| Family     | Plant                          | Plant Part | HIV-RT | HIV-PR | HIV-IN | Anti-HIV |
|------------|--------------------------------|------------|--------|--------|--------|----------|
| Fabaceae   | *Elephantorrhiza elephantine*  (Burch.) Skeels | Bulb       |        |        |        | Crude [79] |
| Fabaceae   | *Erthrina abpoosinica* Lam.    | Bark       | Crude [74] | 102   |        | Alkaloids [216] |
| Fabaceae   | *Erthrina senegalensis* DC.    |            |        |        |        | Flavonoids [217] |
| Fabaceae   | *Eucnrena formosana* (Hayata) Ohwi |            |        |        |        | Crude [218] |
| Fabaceae   | *Gleditsia japonica* Miq.      | Fruit      |        |        |        | Saponin [219] |
| Fabaceae   | *Glycine max* (L.) Merr.       |            | Crude [134] |      |        |          |
| Fabaceae   | *Glycyrrhiza glabra* L.        |            |        |        |        | Crude [56,221] |
| Fabaceae   | *Glycyrrhiza uralensis* Fisch. ex DC. |            |        |        |        | Crude [222] |
| Fabaceae   | *Hylodendron gabunense* Taub.  |            |        |        |        | Saponin [219] |
| Fabaceae   | *Lespedeza juncea* (L. f.) Pers. | Whole plant |        |        |        | Crude [96] |
| Fabaceae   | *Lespedeza tomentosa* (Thunb.) Siebold ex Maxim. | Leaf      |        |        |        | Crude [96] |
| Fabaceae   | *Melilotus suaveolens* Ledeb.  | Whole plant |        |        |        | Crude [96] |
| Fabaceae   | *Milletta erythrocalyx* Gagnep. | Leaf      |        |        |        | Flavonoid [224] |
| Fabaceae   | *Peltophorum africanum* Sond.  | Stem bark  | Crude [172] |      | Crude [172] | Betulinic acid [225] |
| Fabaceae   | *Phaseolus vulgaris* L.        | Seed       |        |        |        | [223] |
| Fabaceae   | *Pongamia pinnata* (L.) Pierre | Bark       | Flavonoids [227] |      | Crude [83] |          |
| Fabaceae   | *Prosopis glandulosa* Torr.    | Leaf       |        |        |        | Oleanolic acid [228] |
| Fabaceae   | *Pueraria lobata* L.           | Leaf       |        |        |        | Crude [82] |
| Fabaceae   | *Pterocarpus marsupium* Roxb.  |            |        |        |        | Crude [229] |
| Fabaceae   | *Pueraria montana* (Lour.) Merr. |            |        |        |        | Crude [66] |
| Fabaceae   | *Sessilia indica* L.           | Bark       |        |        |        | Crude [65] |
| Fabaceae   | *Securigera securidaca* (L.) Degener & Dorrll. | Aerial part |        |        |        | Kaempferol [230] |
| Fabaceae   | *Senna alata* Roxb.            | Aerial part |        |        |        | Crude [57] |
| Fabaceae   | *Senna garrettiana* (Crab) H.S.Irwin & Barneby | Aerial part |        |        |        | Crude [113] |
| Fabaceae   | *Senna obtusifolia* (L.) H.S. Irwin & Barneby | Aerial part |        |        |        | Crude [231] |
| Fabaceae   | *Senna occidentalis* (L.) Link | Leaf       |        |        |        | Crude [56] |
| Fabaceae   | *Sophora flavescens* Astron    | Root       | Crude [196] |      | Crude [105] |          |
| Fabaceae   | *Sophora japonica* L.          | Flower     |        |        |        | Crude [66] |
| Fabaceae   | *Sophora tonkinensis* Gagnep.  | Root       | Crude [60,68] |      |         |          |
| Fabaceae   | *SPATHOLOBUS SUBRECTUS* Dunn    | Rhizome    | Crude [60,68] |      | Crude [105] |          |
| Family      | Plant                                      | Plant Part      | HIV-RT | HIV-PR | HIV-IN | Anti-HIV          |
|------------|--------------------------------------------|-----------------|--------|--------|--------|------------------|
| Fabaceae   | *Styphnolobium japonicum* (L.) Schott     | Flower bud      |        |        | Crude [68] |                  |
|            | *Sutherlandia frutescens* (L.) R. Br.     |                 |        |        |        | Crude [132]      |
| Fabaceae   | *Tephrosia purpurea* (L.) Pers.            | Root            |        |        |        | Crude [83]       |
| Fabaceae   | *Vigna unguiculata* (L.) Walp.             | Seed            |        |        | Crude [83] |                  |
| Fagaceae   | *Quercus infectoria* Olivier              | Fruit           |        | Crude [58] |        |                  |
| Fagaceae   | *Quercus robur* L.                        |                 |        |        |        | Crude [175]      |
| Flacourtiaceae | *Hydnocarpus anthelminticus* Pierre ex Laness. | Semen |        |        |        | Crude [66]       |
| Gentianaceae | *Gentiana asclepiada* L.       | Leaf            |        |        | Crude [62] |                  |
| Gentianaceae | *Gentiana macrophylla* Pall.              | Root            |        | Crude [68] |        |                  |
| Gentianaceae | *Gentiana scabra* Bunge                   | Root            |        | Crude [68] |        |                  |
| Gentianaceae | *Suerita bimaculata* (Siebold & Zucc.) Hook. f. & Thomson ex C.B. Clarke |        |        |        | Sesterterpenoid [232] |                  |
| Gentianaceae | *Suerita franchetiana* Harry Sm.          | Root            |        | Xanthone [204] |        | Xanthone [233] |
| Gentianaceae | *Suerita punicea* Hemsl.                   |                 |        | Crude [234] |        |                  |
| Gentianaceae | *Tripterospermum lancolatum* (Hayata) H. Hara ex Satake |        | Crude [235] |        |        |                  |
| Gesneriaceae | *Drynaria serrulata* (Jacq.) Mart.        | Leaf            |        |        | Crude [95] |                  |
| Ginkgoaceae | *Ginkgo biloba* L.                        | Semen           | Crude [236] | Crude [236] | Ginkgolic acid [237] | Crude [66] |
| Gunneraceae | *Gunnera magellanica* Lam.                | Stem            |        |        |        | Crude [82]       |
| Hydrangeaceae | *Philadelphus schrenkii* Rupe.             | Stem            |        |        | Crude [96] |                  |
| Hydrocharitaceae | *Thalassia testudinum* Banks & Sol. ex K.D. Koernig |        |        |        |        | Crude [238]       |
| Hypericaceae | *Cratoxylum arborescens* Blume            | Leaf            |        |        |        | Xanthones [239]  |
| Hypericaceae | *Hypericum capitatum* Choisy              |                 |        |        |        | Crude [240]      |
| Hypericaceae | *Hypericum hircinum* L.                   |                 | Crude [241] |        |        |                  |
| Hypericaceae | *Hypericum perforatum* L.                 |                 |        |        |        | Crude [242]      |
| Hypericaceae | *Vismia baccifer* (L.) Triana & Planch.   |                 | Crude [155] |        |        |                  |
| Hypericaceae | *Vismia cayennensis* (Jacq.) Pers.        | Leaf            |        |        |        | Crude [243]      |
| Hypoxidaceae | *Hypoxis hemerocallidea* Fisch., C.A. Mey. & Avé-Lall. | Corm | Crude [75] |        |        |                  |
| Iridaceae   | *Aristea ecklonii* Baker                  |                 |        |        |        |                  |
| Iridaceae   | *Eleutherine bulbosa* (Mill.) Urb.         | Bulb            |        |        | Crude [75] | Naphthoquinone [245] |

Table 1. Cont.
| Family       | Plant                     | Plant Part | HIV-RT | HIV-PR | HIV-IN | Anti-HIV  |
|-------------|---------------------------|------------|--------|--------|--------|-----------|
| Iridaceae   | Iris domestica (L.) Goldblatt & Mabb. | Crude [68] |        |        |        |           |
| Juglandaceae| Juglans mandshurica Maxim. | Bark       |        | Crude [96] |        | Glycosides [246] |
| Lamiaceae   | Aegiphila anomala Pittier | Leaf       | Crude [93] |        |        |           |
| Lamiaceae   | Agastache rugosa (Fisch. & C.A. Mey.) Kuntze | Whole plant | Crude [60,96] | Crude [247] | Crude [248] |
| Lamiaceae   | Ajuga decumbens Thunb.  |            |        |        |        | Crude [249] |
| Lamiaceae   | Anisomeles indica (L.) Kuntze |           |        |        |        | Diterpenoid [250] |
| Lamiaceae   | Clinopodium bolivianum (Benth.) Kuntze | Leaf       |        |        |        | Crude [82] |
| Lamiaceae   | Clinopodium chinense (Benth.) Kuntze | Whole plant | Crude [96] |        |        |           |
| Lamiaceae   | Coleus forskohlii (Willd.) Briq. | Aerial part |        |        |        | Crude [56,251] |
| Lamiaceae   | Cornutia grandifolia (Schldfl. & Cham.) Schauer | Trunk |        |        |        | Crude [93] |
| Lamiaceae   | Cornutia pyramidata L. |           |        |        |        | Crude [93] |
| Lamiaceae   | Hyptis capitata Jacq. | Whole plant |        |        |        | Oleanolic acid [228] |
| Lamiaceae   | Hyptis lanatifolia Post. |            |        |        |        |           |
| Lamiaceae   | Hyssopus officinalis L. | Leaf       |        |        |        | Crude [252] |
| Lamiaceae   | Isodon excisus (Maxim.) Kudô | Whole plant | Crude [96] |        |        |           |
| Lamiaceae   | Isodon inflexus (Thurb.) Kudô |            |        |        |        | Crude [96] |
| Lamiaceae   | Leonurus leonurus (L.) R. Br. | Leaf       | Crude [75] | Crude [75] |        |           |
| Lamiaceae   | Leonurus japonicae Houtt. |            |        |        |        |           |
| Lamiaceae   | Leonurus sibiricus L. | Aerial part |        |        |        | Crude [96] |
| Lamiaceae   | Lycopus lucidus Turcz. ex Benth. | Whole plant |        |        |        | Crude [68] |
| Lamiaceae   | Marrubium vulgare L. | Leaf       | Crude [92] |        |        |           |
| Lamiaceae   | Melhania articulata (Miq.) Makino | Whole plant | Crude [96] |        |        |           |
| Lamiaceae   | Melissa officinalis L. | Whole plant |        |        |        | Crude [255] |
| Lamiaceae   | Mentha arvensis L. | Leaf       | Crude [66] |        |        |           |
| Lamiaceae   | Mentha canadensis L. | Whole plant |        |        |        | Crude [66,69] |
| Lamiaceae   | Mentha longifolia (L.) Huds. |            |        |        |        | Crude [254] |
| Lamiaceae   | Minthostachys mollis Cris. | Leaf       |        |        |        | Crude [82] |
| Lamiaceae   | Mosla scabra (Thurb.) C.Y. Wu & H.W. Li | Whole plant | Crude [96] |        |        |           |
| Lamiaceae   | Ocimum basilicum L. | Leaf       | Crude [98] |        |        |           |
| Lamiaceae   | Ocimum kilimandscharicum Baker ex Gürke |            |        |        |        | Crude [256] |
| Lamiaceae   | Ocimum labiatum (N.E. Br.) A. J. Paton |            |        |        |        | Triterpenoid [256] |
Table 1. Cont.

| Family           | Plant                        | Plant Part | HIV-RT | HIV-PR | HIV-IN | Anti-HIV |
|------------------|------------------------------|------------|--------|--------|--------|----------|
| Lamiaceae        | Ocimum tenuiflorum L.        | Leaf       | Crude  | [54,58]|        |          |
| Lamiaceae        | Perilla frutescens (L.) Britton | Leaf       |        |        |        |          |
| Lamiaceae        | Plectranthus amboinicus (Lour.) Spreng. | Leaf       |        | Crude  | [85,59] |          |
| Lamiaceae        | Plectranthus barbatus Andrews |            |        |        |        |          |
| Lamiaceae        | Pogostemon heynanus Benth.   | Leaf       |        |        |        | Crude [66] |
| Lamiaceae        | Prunella vulgaris L.         | Whole plant|        | Crude  | [60]   |          |
| Lamiaceae        | Rosmarinus officinalis L.    |            |        |        |        |          |
| Lamiaceae        | Salvia haemkei Benth.       |            |        |        |        |          |
| Lamiaceae        | Salvia miltiorrhiza Bunge    | Root       | Crude  | [60,68]|        |          |
| Lamiaceae        | Salvia officinalis L.        | Leaf       |        | Crude  | [262]  |          |
| Lamiaceae        | Salvia resolute Ruiz & Pav. |            |        |        |        |          |
| Lamiaceae        | Salvia yunnanensis C.H. Wright | Root       |        |        |        | Polyphenol [265] |
| Lamiaceae        | Satureja canescens Ten.      | Whole plant|        |        |        |          |
| Lamiaceae        | Satureja obovata Lag.        | Whole plant|        |        |        |          |
| Lamiaceae        | Scutellaria baicalensis Georgi | Root       | Crude  | [60,68]|        | Flavonoid [266] |
| Lamiaceae        | Teucrium buxifolium Schreib. | Whole plant|        |        |        |          |
| Lamiaceae        | Vitis glabrata R. Br.        | Branche    | Crude  | [57]   |        |          |
| Lamiaceae        | Vitis negundo L.             | Aerial part| Crude  | [57]   |        |          |
| Lamiaceae        | Vitis trifolia L.            | Aerial part| Crude  | [57]   |        |          |
| Lardizabalaceae  | Akebia quinata (Houtt.) Decne. | Lignum     |        |        |        |          |
| Lardizabalaceae  | Stauntonia abortifolia Hayata |            |        |        |        |          |
| Lauraceae        | Cinnamomum laurifolium Nees  | Stem bark  | Crude  | [58]   |        |          |
| Lauraceae        | Cinnamomum verum J. Presl    | Leaf       | Crude  | [63]   |        |          |
| Lauraceae        | Lindera aggregata (Samo) Kosterm. | Stem       | Crude  | [60]   | Crude [266] |        |
| Lauraceae        | Lindera chaunii Merr.        |            |        |        |        | Sesquiterpenoid [269] |
| Lauraceae        | Lindera elongata Makino      | Leaf       | Crude  | [270]  |        |          |
| Lauraceae        | Lindera obtusiloba Blume     | Leaf, Stem | Crude  | [96]   |        |          |
| Lauraceae        | Litsea glutinosa (Lour.) C.B. Rob. | Bark       | Crude  | [83]   |        |          |
| Lauraceae        | Litsea verticillata Honda    | Leaf       | Crude  | [38]   |        |          |
| Liliaceae        | Amara edulis (Miq.) Honda    |            | Crude  | [196]  |        |          |
| Liliaceae        | Asparagopsis (Miq.) Honda    |            | Crude  | [196]  |        |          |
| Family          | Plant                          | Plant Part | HIV-RT | HIV-PR | HIV-IN | Anti-HIV |
|-----------------|--------------------------------|------------|--------|--------|--------|----------|
| Liliaceae       | *Fritillaria cirrhosa* D. Don  | Rhizome    | Crude  | [60]   | Crude  | [105]    |
| Liliaceae       | *Fritillaria thunbergii* Miq.  | Rhizome    | Crude  | [68]   |         |          |
| Liliaceae       | *Cassyphea pentlandii* (Paxton ex Graham) G. Don ex Loudon | Leaf      |         |        |        | Crude [82] |
| Loganiaceae     | *Strychnos ignatii* P.J. Bergius | Semen     |        |        |        | Crude [66] |
| Loganiaceae     | *Strychnos nuxvomica* L.      | Seed       | Crude  | [58]   |        |          |
| Loganiaceae     | *Strychnos potatorum* L. f.   | Seed       | Crude  | [83]   |        |          |
| Loranthaceae    | *Scurrula parasitica* L.      | Aerial part| Crude  | [68]   |        |          |
| Lycopodiaceae   | *Lycopodium japonicum* Thunb. | Aerial part| Crude  | [58,83]|        |          |
| Lythraceae      | *Lythrum salicaria* L.        | Leaf       | Crude  | [62]   |        |          |
| Lythraceae      | *Panica granatum* L.          | Fruit bark | Crude  | [58]   | Crude  | [68,83] |
| Lythraceae      | *Woodfordia fruticosa* (L.) Kurz |         |        |        |        |          |
| Magnoliaceae    | *Magnolia biindi* Pamp.       | Flower bud | Crude  | [68]   |        |          |
| Magnoliaceae    | *Magnolia demutat* Desr.      | Flower    | Crude  | [96]   |        |          |
| Magnoliaceae    | *Magnolia obovata* Thunb.     | Bark      | Crude  | [68]   |        |          |
| Magnoliaceae    | *Magnolia officinalis* Rehdler & E.H. Wilson | Bark | Crude  | [68]   |        |          |
| Malpighiaceae   | *Tetrapterys goasudiana* Triana & Planch. | |        |        |        |          |
| Malvaceae       | *Adansonia digitata* L.       | Leaf      | Crude  | [273]  | Crude  | [275]    |
| Malvaceae       | *Corchoropsis tomentosa* (Thur. ) Makino | Aerial part |        |        |        |          |
| Malvaceae       | *Cresia mollis* Juss.         | Root      | Crude  | [102]  |        |          |
| Malvaceae       | *Hibiscus sabdariffa* L.      | Flower    | Crude  | [58]   |        |          |
| Malvaceae       | *Paroia schiedeana* Steud.    | Aerial part| Crude  | [93]   |        |          |
| Malvaceae       | *Sida cordata* (Burm. f.) Boess. Waalck. | Root | Crude  | [83]   | Polyphenols [274] | |
| Malvaceae       | *Sida myorensis* Wright & Arn. | Seed | Crude  | [68]   | Polyphenols [274] | |
| Malvaceae       | *Sida rhombifolia* L.         | Leaf      | Crude  | [80]   | Polyphenols [274] | |
| Malvaceae       | *Theosperma papulnea* (L.) Sol. ex Corrêa | |        |        |        |          |
| Malvaceae       | *Tilia amurensis* Rupr.       | Leaf, Stem | Crude  | [96]   |        |          |
| Malvaceae       | *Waltheria indica*            | Branch    | Crude  | [93]   |        |          |
| Meliaceae       | *Aeglea lauvi* (Wight) C.J. Saldanha | Leaf | Crude  | [276]  |        |          |
| Meliaceae       | *Azadirachta indica* A. Juss. | Leaf      | Crude  | [58,102]| Crude  | [83,95] |
| Meliaceae       | *Khaya senegalensis* (Desr.) A. Juss. | |        |        | Crude  | [95]   |
| Family            | Plant                          | Plant Part | HIV-RT | HIV-PR | HIV-IN | Anti-HIV |
|-------------------|--------------------------------|------------|--------|--------|--------|----------|
| Meliaceae         | Melia azedarach L.             | Fruit      | Crude  | [102]  |        |          |
| Meliaceae         | Swietenia macrophylla King     | Crude      | [66]   |        |        |          |
| Meliaceae         | Swietenia mahagoni (L.) Jacq.  | Bark       | Crude  | [276]  |        |          |
| Meliaceae         | Trichilia emetica Vahl         |            | Crude  | [95]   |        |          |
| Meliaceae         | Bersama alphavirica Fresen.    | Root       |        |        |        | Crude [174] |
| Menispermaceae    | Couscinium fenestratum Colebr.| Gali       | Crude  | [158]  | [83,158]| [158]   |
| Menispermaceae    | Pericampylus glaucus (Lam.) Merz.| Aerial part|        |        |        | Alkaloids [279] |
| Menispermaceae    | Sinomenium acutum (Thunb.) Rehder & E.H. Wilson | Root | Crude | [96] |        |          |
| Menispermaceae    | Stephanita cephalantha Hayata  | Root       |        |        |        | Crude [286] |
| Menispermaceae    | Tinopora crispa (L.) Hook. f. & Thomson | Vine | Crude | [57] |        | Crude [281] |
| Menispermaceae    | Tinospora sinensis (Lour.) Merr.| Stem bark  | Crude  | [54]   |        | Crude [56] |
| Menyanthaceae     | Nymphoides peltata (S.G. Gmel.) Kuntze | Whole plant|        |        |        | Crude [66] |
| Monimiaceae       | Bolidea fragrans Endl.         |            | Crude  | [82]   |        |          |
| Moraceae          | Artocarpus heterophyllus Lam.  | Seed       | Crude  | [58]   |        |          |
| Moraceae          | Ficus carica L.                | Leaf       |        |        |        | Crude [124] |
| Moraceae          | Ficus edelstii King            | Bark       | Crude  | [68]   |        |          |
| Moraceae          | Ficus racemosa L.              | Bark       | Crude  | [282]  |        |          |
| Moraceae          | Ficus religiosa L.             | Bark       | Crude  | [83]   |        |          |
| Moraceae          | Maclura cochinchinensis (Lour.) Corner | Stem | Crude | [58] |        |          |
| Moraceae          | Maclura tinctoria (L.) D. Don ex Steud. | Stem | Crude | [58] |        |          |
| Moraceae          | Morus alba L.                  | Stem bark  | Crude  | [66]   |        |          |
| Moringaceae       | Mortuga oleifera Lam.          | Seed       | Crude  | [58,74]|        |          |
| Musaceae          | Musa acuminate Colla           | Fruit      |        |        |        | Lectin [284] |
| Myricaceae        | Morella salicifolia (Hochst. ex. A. Rich.) Verdc. & Polhill | Root bark  | Crude  | [102]  |        |          |
| Myricaceae        | Myrica salicifolia Hochst. ex. A. Rich. | Root bark| Crude  | [102]  |        |          |
| Myristicaceae     | Myristica fragrans Houtt.      | Stem       | Crude  | [58]   |        | Crude [83] |
| Myrothamnaceae    | Myrothamnus flabellifolius Welw. | Leaf | Polyphenol | [285] |        |          |
| Myrtaceae         | Combria citriodora (Hook.) K.D. Hill & L.A.S. Johnson | Seed | Crude | [80] |        |          |
| Myrtaceae         | Eucalyptus citriodora Hook.    | Leaf       | Crude  | [80]   |        |          |
| Myrtaceae         | Eugenia biennis Cambess.       |            |        |        |        | Glycosides [286] |
## Table 1. Cont.

| Family      | Plant                  | Plant Part                  | HIV-RT          | HIV-PR          | HIV-IN          | Anti-HIV          |
|-------------|------------------------|-----------------------------|-----------------|-----------------|-----------------|-------------------|
| Myrtaceae   | *Psidium guajava* L.   | Leaf                        |                 |                 |                 | Saponin [287]     |
| Myrtaceae   | *Syzygium aromaticum* (L.) Merr. & L.M. Perry | Siquegium claviflorum (Roxb.) Wall. ex A.M. Cowan & Cowan | Leaf            |                 |                 | Oleanolic acid [228] |
| Myrtaceae   | *Syzygium cumini* (L.) Skeels | Bark                        |                 | Crude [63]      |                 |                   |
| Nyctaginaceae | *Boerhavia caribaea* Jacq. | Leaf                        |                 |                 |                 | Crude [82]        |
| Nyctaginaceae | *Boerhavia diffusa* L. | Root                        |                 |                 |                 |                   |
| Nyctaginaceae | *Boerhavia erecta* L. | Leaf                        |                 |                 |                 | Glycosides [291]  |
| Ochnaceae   | *Ochna integerrima* (Lour.) Merr. | Leaf                        |                 |                 |                 | Flavonoids [292]  |
| Oleaceae    | *Heisteria spiracae* Engl. | Bark                        |                 |                 |                 |                   |
| Oleaceae    | *Ximenia americana* L. | Stem bark                    |                 |                 |                 |                   |
| Oleaceae    | *Ximenia caffra* Sond. | Leaf                        |                 |                 |                 | Crude [293]       |
| Oleaceae    | *Chionanthus retusus* Lindl. & Paxton | Leaf                        |                 |                 |                 | Crude [96]        |
| Oleaceae    | *Ligustrum lucidum* W.T. Aiton | Fruit                      |                 | Crude [60]      | Crude [105]     |                   |
| Onagraceae  | *Epilobium angustifolium* L. | Leaf                        |                 |                 |                 | Crude [62]        |
| Onagraceae  | *Oenothera erythrosepala* (Borbás) Borbás | Leaf                        |                 |                 |                 | Oenothein [294]   |
| Onocleaceae | *Matteuccia struthiopteris* (L.) Tod. | Rhizome                     |                 |                 |                 |                   |
| Orchidaceae | *Arundina graminifolia* (D. Don) Hochr. | Whole plant                 |                 |                 |                 | Crude [295]       |
| Orchidaceae | *Bletilla striata* (Thunb.) Rchb. f. | Root                        |                 |                 |                 | Crude [66]        |
| Orchidaceae | *Dendrobium moniliforme* (L.) Soc. | Whole plant                 |                 |                 |                 | Crude [66]        |
| Orobanchaceae | *Melampyrum roseum* Maxim. | Whole plant                 |                 |                 |                 | Crude [96]        |
| Orobanchaceae | *Pedicularis resupnata* L. | Whole plant                 |                 |                 |                 | Crude [96]        |
| Orobanchaceae | *Rehmannia glutinosa* (Gaertn.) Lisobos. ex Fisch. & C.A. Mey. | Root                        |                 |                 |                 | Crude [66]        |
| Paremiaceae | *Paonia lactiflora* Pall. | Leaf                        |                 |                 |                 | Crude [66]        |
| Paremiaceae | *Paonia suffruticosa* Andrews | Root                        |                 | Crude [60,68]   | Crude [105]     |                   |
| Papaveraceae | *Argemone mexicana* L. | Leaf                        |                 |                 |                 | Crude [56]        |
| Papaveraceae | *Papaver somniferum* L. | Seed                        |                 |                 |                 | Crude [56]        |
| Papaveraceae | *Linnea florida* (L.) Weber ex F.H. Wigg. | Whole plant                 |                 |                 |                 | Crude [82]        |
| Pentaphylacaceae | *Ternstroemia gymnanthera* (Wight & Arn.) Sprague | Aerial part               |                 |                 |                 | Oleanolic acid [228] |
| Phrymaceae  | *Peyryia leptostachya* L. | Whole plant                 |                 |                 |                 | Crude [96]        |
| Family     | Plant                      | Plant Part | HIV-RT | HIV-PR | HIV-IN | Anti-HIV |
|------------|----------------------------|------------|--------|--------|--------|----------|
| Phyllanthaceae | Aporosa cardiosperma (Gaertn.) Merr. | Crude [99] |        |        |        |          |
| Phyllanthaceae | Bridelia ferruginea Benth. | Stem bark  |        |        | Crude [80] |          |
| Phyllanthaceae | Bridelia micrantha (Hochst.) Baill. | Root       |        | Crude [296] |        |          |
| Phyllanthaceae | Hymenocardia acida Tul. | Leaf       |        |        | Crude [80] |          |
| Phyllanthaceae | Phylanthus amarus Schumach. & Thonn. | Crude [297] |        |        |        |          |
| Phyllanthaceae | Phylanthus emblica L. | Fruit      |        | Crude [83] |        | Crude [175] |
| Phyllanthaceae | Phylanthus myriophyllus Moon ex Hook. f. | Lignans [137] |        |        |        |          |
| Phyllanthaceae | Phylanthus niruri L. | Crude [296] |        |        | Crude [108] |          |
| Phyllanthaceae | Phylanthus selloianus (Klotzsch) Mull. Arg. | Crude [122] |        |        |        |          |
| Pinaceae    | Pinus nigra J.F. Arnold | Seed       |        | Crude [299] |        |          |
| Pinaceae    | Pinus peregrina Siebold & Zucc. | Cone       |        | Crude [300] |        |          |
| Piperaceae  | Piper aduncum L. | Leaf       |        | Crude [82] |        |          |
| Piperaceae  | Piper elongatum Vahl | Leaf       |        | Crude [82] |        |          |
| Piperaceae  | Piper longum L. | Fruit      |        | Crude [82] |        |          |
| Plantaginaceae | Digitalis purpurea L. | Leaf       |        | Crude [301] |        |          |
| Plantaginaceae | Scopaia dulcis L. | Leaf       |        | Crude [301] |        |          |
| Plumbaginaceae | Plumbago indica L. | Root       |        | Crude [58] |        |          |
| Poaceae     | Chrysopogon zizanioides (L.) Roberthy | Root |        | Crude [83] |        |          |
| Poaceae     | Coix lacryma L. | Seed       |        | Crude [66] |        |          |
| Poaceae     | Cortaderia radiosa Stapf | Leaf       |        | Crude [82] |        |          |
| Poaceae     | Scirpus officinalis L. | Stem       |        | Crude [58] |        |          |
| Poaceae     | Sea lomas (Hack.) Makino & Shibata | Whole plant |        | Crude [96] |        |          |
| Polemoniaceae | Centua hibrida Herrera | Leaf       |        | Crude [82] |        |          |
| Polygonaceae | Polygala tenuifolia Willd. | Root |        | Crude [66] |        |          |
| Polygonaceae | Muehlenbeckia fruticosa (Walp.) Standl. | Leaf |        | Crude [82] |        |          |
| Polygonaceae | Persicaria tinctoria (Alton) H. Gross | Whole plant |        | Crude [96] |        |          |
| Polygonaceae | Polygonum articulare L. | Aerial part |        | Crude [66] |        |          |
| Polygonaceae | Polygonum senticosum (Meissn.) Franch. & Sav. | Whole plant |        | Crude [96] |        |          |
| Polygonaceae | Reynoutria japonica Houitt. | Root |        | Crude [68] |        |          |
| Polygonaceae | Reynoutria multiflora (Thunb.) Moldenke | Crude [60] |        |        |        |          |
| Polygonaceae | Rheum palmatum L. | Rhizome | Sennoside [302] | Crude [68] | Sennoside [302] | Sennoside [302] |
Table 1. Cont.

| Family          | Plant                          | Plant Part | HIV-RT | HIV-PR | HIV-IN | Anti-HIV          |
|-----------------|-------------------------------|------------|--------|--------|--------|-------------------|
| Polygonaceae    | Rheum tanguticum Maxim. ex Balf. | Root     |        |        |        | Glycosides [303]  |
| Polygonaceae    | Rumex crispus L.              | Crude     |        |        |        | [82]              |
| Polygonaceae    | Rumex cypricus Murb.          |            |        | Crude  | [175]  |                   |
| Polygonaceae    | Rumex frutescens Thouars      | Root       |        |        |        | [82]              |
| Polygonaceae    | Rumex nepalensis Spreng.      | Crude     |        |        |        | [111]             |
| Polygonaceae    | Rumex peruaeus Rech. f.       | Leaf       |        |        |        | [82]              |
| Polypodiaceae   | Drynaria roosi Nakaike        | Rhiome     |        |        |        | [68]              |
| Polypodiaceae   | Pleopeltis pyrocarnus (C. Chr.) A.R. Sm. | Crude |        |        |        | [82]              |
| Polypodiaceae   | Polypodium pyrocarnum C. Chr. | Root       |        |        |        | [82]              |
| Polypodiaceae   | Pyrosia lingae (Thrub.) Farw. | Aerial part|      |        |        | [66]              |
| Polypodiaceae   | Polychrichum commum Hedw.     |            | Crude  |        |        | [62]              |
| Portulacaceae   | Portulaca oleracea L.         | Aerial part|        | Crude  | [68]   |                   |
| Primulaceae     | Ardisia japonica (Thrub.) Blume | Aerial part|        |        |        | [304]             |
| Primulaceae     | Embelia rhes Burm. f.         | Fruit      |        |        |        | [56]              |
| Proteaceae      | Conopsernum incurium Lindl.   |            |        |        |        | [305]             |
| Ranunculaceae   | Aconitum ferox Wall. ex Ser.  | Tuber      |        |        |        | [83]              |
| Ranunculaceae   | Aconitum jahense Kom.         | Root       |        |        |        | [66]              |
| Ranunculaceae   | Aconitum subfomai Nakai       | Root       |        |        |        | [96]              |
| Ranunculaceae   | Actaea heracleifolia (Kom.) J. Compton | Rhizome |        |        |        | [68]              |
| Ranunculaceae   | Asarum chinensis Bunge        | Root       |        |        |        | [68]              |
| Ranunculaceae   | Clematis chinensis Osbeck     | Root       |        |        |        | [60,68]           |
| Ranunculaceae   | Clematis mandshurica Max.     |            |        |        |        | [96]              |
| Ranunculaceae   | Coptis chinensis Franch.      | Rhizome    |        | Crude  | [60,68]| Crude [105]       |
| Ranunculaceae   | Nigella sativa L.             | Seed       |        |        |        | [63]              |
| Ranunculaceae   | Pulsatilla cernua (Thrub.) Bercht. ex J. Presl | Root |        |        |        | [66]              |
| Resedaceae      | Reseda latif L.               | Whole plant|        |        |        | [61]              |
| Resedaeae       | Reseda suffraticosa Loefl.    | Whole plant|        |        |        | [61]              |
| Rhamnaceae      | Berchemia berchemifolia (Makino) Koidz. | Bark   |        |        |        | [96,270]          |
| Rhamnaceae      | Rhamnus staddo A. Rich.       |            |        |        |        | [102]             |
| Rhamnaceae      | Zizyphus spina-christi (L.) Desf. | Fruit     |        |        |        | [74]              |
| Rhizophoraceae  | Rhizophora macrolimata Lam.   | Leaf       |        | Crude  | [34]   | Crude [55]        |
| Rosaceae        | Agrimonia pilosa Lede.        | Whole plant|        |        |        | [96]              |
| Family    | Plant                        | Plant Part | HIV-RT | HIV-PR | HIV-IN | Anti-HIV     |
|-----------|------------------------------|------------|--------|--------|--------|--------------|
| Rosaceae  | *Alchemilla andina* (L.M. Perry) J.F. Macbr. | Stem       |        |        |        | Crude [82]   |
| Rosaceae  | *Chaenomeles sinensis* (Thouin) Koehne | Fruit      |        |        |        | Crude [66]   |
| Rosaceae  | *Crataegus pinmatifida* Bunge | Leaf       |        | Crude [96] | Triterpenes [306] |        |
| Rosaceae  | *Eriobotrya japonica* (Thunb.) Lindl. | Leaf       |        | Crude [96] |        | Crude [66]   |
| Rosaceae  | *Malus baccata* (L.) Borkh. | Whole plant |        | Crude [66] |        |              |
| Rosaceae  | *Malus sieboldii* (Regel) Rehder | Stem       |        | Crude [96] |        |              |
| Rosaceae  | *Pruina africana* (Hook. f.) Kalkman | Stem bark  |        | Crude [102] |        |              |
| Rosaceae  | *Pruina armenica* L. | Seed       |        | Crude [68] |        |              |
| Rosaceae  | *Pruina persica* (L.) Batsch | Semen      |        | Crude [66] |        |              |
| Rosaceae  | *Pruina yedoensis* Matsum. | Stem bark  |        | Crude [102] |        |              |
| Rosaceae  | *Rosa damascena* Mill. |            |        | Crude [307] |        |              |
| Rosaceae  | *Rosa davurica* Pall. |            |        | Crude [308] |        |              |
| Rosaceae  | *Rosa laevigata* Michx. | Fruit      |        | Crude [66] |        |              |
| Rosaceae  | *Rosa s expanding Lindl. | Leaf       |        | Oleanolic acid [228] |        |              |
| Rosaceae  | *Sangisivora minor* Scop. | Whole plant |        | Crude [61] |        |              |
| Rosaceae  | *Sangisivora officinalis* L. | Root       |        | Crude [809] |        |              |
| Rosaceae  | *Sorbus commixta* Hedl. | Stem       |        | Crude [96] |        |              |
| Rosaceae  | *Stephanandra incise* (Thunb.) Siebold & Zucc. ex Zabel | Crude [96] |        |        |        |              |
| Rubiaceae | *Cantium coromandelicum* (Burm.f.) Alston | Leaf |        | Crude [310] |        |              |
| Rubiaceae | *Cinchona pubescens* Vahl | Bark       |        | Crude [82] |        |              |
| Rubiaceae | *Cruciata glabrata* Ehrend. |          |        | Crude [62] |        |              |
| Rubiaceae | *Galium aparine* L. | Leaf       |        | Crude [62] |        |              |
| Rubiaceae | *Galium mollugo* L. | Leaf       |        | Crude [62] |        |              |
| Rubiaceae | *Galium verum* L. | Whole plant |        | Crude [96] |        |              |
| Rubiaceae | *Gardenia ternifolia* Schumach. & Thonn. |            |        | Crude [74] |        |              |
| Rubiaceae | *Gardenia tubifera* Wall. ex Rosb. | Leaf | Cycloartanes [311] |        |        |              |
| Rubiaceae | *Hedyotis corymbosa* (L.) Lam. |          |        | Crude [99] |        |              |
| Rubiaceae | *Hedyotis diffusa* Wild. | Aerial part |        | Crude [66] |        |              |
| Rubiaceae | *Morinda citrifolia* L. | Leaf       | Crude [158] | Crude [158] | Crude [158] |              |
| Rubiaceae | *Oldenlandia diffusa* (Wild.) Roxb. | Whole plant | Crude [60,68] | Crude [105] |        |              |
| Family       | Plant                                      | Plant Part | HIV-RT | HIV-PR | HIV-IN | Anti-HIV |
|--------------|--------------------------------------------|------------|--------|--------|--------|----------|
| Rubiaceae    | *Oldenlandia herbacea* (L.) Roxb.          | Root       | Crude  |        |        | [83]     |
| Rubiaceae    | *Rubia cordifolia* L.                      | Root       |        | Crude  |        | [229]    |
| Rubiaceae    | *Sarcocephalus latifolius* (Sm.) Bruce     |            |        |        |        | [95]     |
| Rutaceae     | *Aegle marmelos* (L.) Corrêa              | Leaf       |        | Crude  |        | [83]     |
| Rutaceae     | *Citrus hystrix* DC.                       | Fruit bark |        |        |        | [58]     |
| Rutaceae     | *Clusena anisata*                         | root       | Crude  |        |        | [102]    |
| Rutaceae     | *Clusena exarata* (Willd.) Hook. f. ex Berth. | Aerial part |        |        |        | [57]     |
| Rutaceae     | *Dictamnus albus* L.                      | Root bark  | Crude  |        |        | [68]     |
| Rutaceae     | *Murraya koenigii* (L.) Spreng.            | Aerial part |        |        |        | [57]     |
| Rutaceae     | *Phellodendron amurense* Repr.             | Bark       | Crude  |        |        | [68]     |
| Rutaceae     | *Tetradium ruticarpum* (A. Juss.) T.G. Hartley |            |        |        |        | [83]     |
| Rutaceae     | *Todalia asiatica* (L.) Lam.              | Root       | Crude  |        |        | [102]    |
| Rutaceae     | *Vepris simplicifolia* (Engl.) Mairay      |            |        | Crude  |        | [102]    |
| Rutaceae     | *Zanthoxylum bungeanum* Maxim.             | Fruit peel |        |        |        | [68]     |
| Rutaceae     | *Zanthoxylum chalybeum* Engl.              | Root bark  | Crude  |        |        | [102]    |
| Rutaceae     | *Zanthoxylum schinifolium* Siebold & Zucc. | Fruit peel |        |        |        | [68,96]  |
| Salvadoraceae| *Salvadora persica* L.                     | Stem       | Crude  |        |        | [74]     |
| Santalaceae  | *Phoradendron juniperinum* Engelm. ex A. Gray | Whole plant |        |        |        | Crude    |
| Santalaceae  | *Viscum album* L.                          | Flower     |        |        |        | Oleanolic acid [228] |
| Sapindaceae  | *Acer okamotoanum* Nakai                   | Leaf       |        |        |        | Flavonoid [316] |
| Sapindaceae  | *Acer pictum* Thunb.                       | Stem       | Crude  |        |        | [96]     |
| Sapindaceae  | *Aesculus chinesis* Bunge                   | Seed       |        |        |        | Triterpenoid [317] |
| Sapindaceae  | *Aesculus turbinata* Blume                 | Fruit      | Crude  |        |        | [96]     |
| Sapindaceae  | *Allophylus cobbe* (L.) Raesch.            | Leaf       |        |        |        | Crude [318] |
| Sapindaceae  | *Dodonaea viscosa* Jaq.                    | Leaf       |        |        |        | [62,174] |
| Sapindaceae  | *Koelreuteria paniculata* Laxm.            | Stem       | Crude  |        |        | [96]     |
| Sapindaceae  | *Nepheleium lappaceum* L.                  | Seed       | Crude  |        |        | [319]    |
| Sapindaceae  | *Serjania mexicana* (L.) Willd.            | Whole plant |        |        |        | Crude    |
| Sapodaceae   | *Madhuca longifolia* (J. Koenig ex L.) J.F. Macbr. | Bark      |        |        |        | [56]     |
| Sapodaceae   | *Mimusops elengi* L.                       | Bark       | Crude  |        |        | [320]    |
| Sapodaceae   | *Tieghemella heckelii* Pierre ex A. Chev.   | Leaf       |        |        |        | Crude    |

Table 1. Cont.
Table 1. Cont.

| Family            | Plant                          | Plant Part                  | HIV-RT       | HIV-PR     | HIV-IN      | Anti-HIV      |
|-------------------|--------------------------------|-----------------------------|--------------|------------|-------------|---------------|
| Sauruaceae        | Houttuynia cordata Thunb.       | Aerial part                 | Crude [66,322] |            |             |               |
| Sauruaceae        | Saururus chinensis (Lour.) Baill. | Rhizome                     | Lignans [323] |            |             |               |
| Saxifragaceae     | Astilbe grandis Stapf ex E.H. Wilson | Aerial part                 | Crude [96]   |            |             |               |
| Saxifragaceae     | Astilbe rubra Hook. f. & Thomson ex Hook. | Whole plant                | Crude [96]   |            |             |               |
| Schisandraceae    | Illicium verum Hook. f.         | Root                        | Phytochemicals [324] |            |             |               |
| Schisandraceae    | Kadsura angustifolia A.C. Sm.   |                              | Lignans [325] |            |             |               |
| Schisandraceae    | Kadsura heteroclit (Roeb.) Craib |                              | Triterpenoid [326] |            |             | Crude [327]   |
| Schisandraceae    | Kadsura longipedunculata Finet & Gagnep. |                        | Lignans [328] |            |             |               |
| Schisandraceae    | Schisandra chinensis (Turcz.) Baill. | Fruit                      | Protease [68] |            |             |               |
| Schisandraceae    | Schisandra lancifolia (Rehder & E.H. Wilson) A.C. Sm. | Leaf, Stem | Triterpenoid [329] | Nortriterpenoid [330] |            |               |
| Schisandraceae    | Schisandra propinqua Hook. f. & Thomson | Aerial part | Lignans [331] |            |             |               |
| Schisandraceae    | Schisandra rubriflora (Franch.) Rehder & E.H. Wilson | | Lignans [332] |            |             |               |
| Schisandraceae    | Schisandra sphenanthera Rehder & E.H. Wilson | Stem | Triterpenoid [333] | Triterpenoid [333] |            |               |
| Schisandraceae    | Schisandra sphenanthera Rehder & E.H. Wilson | Leaf, Stem | Triterpenoid [334] | Nortriterpenoid [335] |            |               |
| Schisandraceae    | Schisandra wilsoniana A.C. Sm.  | Fruit                       | Lignans [336] |            |             |               |
| Scrophulariaceae  | Buddleja officinalis Maxim.     | Flower                      | Crude [66]   |            |             |               |
| Scrophulariaceae  | Scrophularia buergeriana Muq.   | Root                        | Crude [96]   |            |             |               |
| Scrophulariaceae  | Scrophularia hakuroensis Franch. | Aerial part | Crude [96]   |            |             |               |
| Scrophulariaceae  | Verbascum densiflorum Bertol.   |                              | Crude [62]   |            |             |               |
| Scrophulariaceae  | Verbascum thapsiforme Schrad.   |                              | Crude [62]   |            |             |               |
| Selaginellaceae   | Selaginella tamariscina (P. Beauv.) Spring | Aerial part | Crude [66]   |            |             |               |
| Simaroubaceae     | Ailanthus altissima (Mill.) Swingle | Stem bark  | Crude [66]   |            |             |               |
| Simaroubaceae     | Bruca javanica (L.) Merr.       | Seed                        | Crude [58]   | Crude [68] |             |               |
| Simaroubaceae     | Leitneria floridana Chapm.      |                              | Crude [337]  |            |             |               |
| Simaroubaceae     | Quassia amara L.                | Bark                        | Crude [82]   |            |             |               |
| Smilacaceae       | Smilax campestres Griseb.       | Root                        | Crude [82]   |            |             |               |
| Smilacaceae       | Smilax china L.                 | Fruit                       | Crude [96]   |            |             | Crude [338]   |
| Solanaceae        | Cestrum parqui L’Her.           | Leaf                        | Crude [82]   |            |             |               |
| Solanaceae        | Lycium chinense Mill.           | Fruit                       | Crude [66]   |            |             |               |
| Solanaceae        | Physalisstrum japonicum (Franch. & Sav) Honda | Aerial part | Crude [96]   |            |             |               |
| Family          | Plant                        | Plant Part | HIV-RT | HIV-PR | HIV-IN | Anti-HIV          |
|-----------------|------------------------------|------------|--------|--------|--------|-------------------|
| Solanaceae      | Solanum incanum L.          |            |        |        |        | Betulinic acid [339] |
| Solanaceae      | Solanum tomentosum L.       |            |        |        |        | Crude [340]         |
| Solanaceae      | Solanum virginianum L.      |            |        |        |        | Crude [341]         |
| Solanaceae      | Withania somnifera (L.) Dunal | Root       |        | Crude [342] |        |                  |
| Staphyleaceae   | Staphylea bumalda DC.       | Whole plant|        |        |        |                  |
| Styracaceae     | Styxys japonicas Siebold & Zucc. | Stem      |        |        |        | Lignins [343] |
| Styracaceae     | Styxys obassia Siebold & Zucc. | Stem      |        |        |        |                  |
| Tamaricaceae    | Tamarix senegalensis DC.    |            |        |        |        | Crude [74]         |
| Taxaceae        | Taxus caespitosa Nakai      | Stem       |        |        |        | Crude [96]         |
| Taxaceae        | Taxus cuspidate Siebold & Zucc. | Stem       |        |        |        | Crude [96]         |
| Theaceae        | Camellia japonica L.        | Leaf       |        |        |        | Crude [344]         |
| Theaceae        | Steurartia korai Nakai ex Rheder | Leaf    |        |        |        | Crude [96]         |
| Thymelaeaceae   | Daphne acutiloba Rehder     |            |        |        |        | Diterpene [345] |
| Thymelaeaceae   | Daphne feddei H.Lév.       | Leaf, Stem |        |        |        | Lignans [346] |
| Thymelaeaceae   | Wikstroemia indica (L.) C.A. Mey. | Leaf      |        |        |        | Crude [347] |
| Typhaceae       | Typha domingensis Pers.     |            |        |        |        | Crude [102]         |
| Ulmaceae        | Ulmus davidiana Planch.     | Leaf, Stem |        |        |        | Crude [96]         |
| Ulmaceae        | Ulmus pumila L. Eng.        | Bark       |        |        |        | Crude [66]         |
| Urticaceae      | Myriophyllum helotii Engl.  |            |        |        |        | Lectin [348] |
| Urticaceae      | Phenax angustifolius (Kunth) Wedd. | Leaf |        |        |        | Lignans [349] |
| Urticaceae      | Urtica dioica L.            | Rhizome    |        |        |        | Crude [62]         |
| Urticaceae      | Urtica macellamus Juss. ex Poir. | Leaf |        |        |        | Crude [82]         |
| Urticaceae      | Urtica urens L.             | Leaf       |        |        |        | Crude [82]         |
| Verbenaceae     | Lampaca medicinalis Phil.   | Leaf       |        |        |        | Crude [82]         |
| Verbenaceae     | Lippia javanica (Burm f) Spreng. | Phytochemicals [351] |        |        |        |                  |
| Verbenaceae     | Stachypoditis jantzianensis (L.) Vahl | Whole plant |        |        |        | Crude [57]         |
| Violaceae       | Viola pohosensis Makino     | Whole plant|        |        |        | Crude [60]         |
| Vitaceae        | Cissus quadrangularis L.    | Stem       |        |        |        | Crude [74]         |
| Vitaceae        | Vitis vinifera L.           |            |        |        |        | Phytochemicals [352] |
| Xanthorrhoeaceae| Aloe ferox Mill.            |            |        |        |        | Crude [353] |
| Xanthorrhoeaceae| Aloe vera (L) Burn. f.      |            |        |        |        | Crude [354] |
| Family        | Plant                      | Plant Part | HIV-RT | HIV-PR | HIV-IN | Anti-HIV |
|--------------|----------------------------|------------|--------|--------|--------|----------|
| Xanthorrhoeaceae | Asphodelus ramosus L.     | Whole plant | Crude [61] |        |        |          |
| Xanthorrhoeaceae | Bulbine alooides Willd.   | Roots      | Crude [75] | Crude [75] |        |          |
| Zingiberaceae  | Alpinia galangal (L.) Willd. |            | Crude [355] |        |        |          |
| Zingiberaceae  | Alpinia officinarum Hance | Root       | Crude [68] | Crude [66] |        |          |
| Zingiberaceae  | Boesenbergia rotunda (L.) Mansf. |    | Phytochemicals [357] | Flavonoid [358] |        |          |
| Zingiberaceae  | Curcuma longa L.          | Rhizome    | Crude [58] | Crude [83] | Crude [359] | Crude [66] |
| Zingiberaceae  | Curcuma zanthorrhiza Rosb. |            | Crude [58] |        |        |          |
| Zingiberaceae  | Elettaria cardamomum (L.) Maton | Fruit   |        | Crude [83] |        |          |
| Zingiberaceae  | Kaempferia parviflora Wall. ex Baker |    | Crude [355] |        |        |          |
| Zygophyllaceae | Balanites aegyptiacus (L.) Delile | Bark   |        | Crude [95] |        |          |
| Zygophyllaceae | Larrea tridentata (Sessé & Moc. ex DC.) Coville |        | Lignan [360] |        |        |          |
| Zygophyllaceae | Tribulus terrestris L.     | Fruit      | Crude [95] |        |        | Crude [66] |
Table 2. Plant names which are having synonyms found in the plantlist.org.

| Reported Name | Accepted Name |
|---------------|---------------|
| Aglais andamanica Hiern | Aglais laura (Wight) C.J. Saldanha |
| Andropogon maricatatus Retz. | Chrysopogon zizanioides (L.) Roberty |
| Angelica koreana Maxim. | Angelica grosseserrata Maxim. |
| Aporous lindleyana (Wight) Baill. | Aporous cardioposperma (Gaertn.) Merr. |
| Asterol koraiensis Nakai | Miyamayomea koraiensis (Nakai) Kitam. |
| Aster scaber Elliott | Symphyotrichum undulatum (L.) G.L. Nesom |
| Astilbe chinensis (Maxim.) Franch. & Sav. | Astilbe rubra Hook. f. & Thomson ex Hook. |
| Astilbe koreana (Kom.) Nakai | Astilbe grandio Stapt ex E.H. Wilson |
| Astragalus membranaceus Moench | Astragulus propinquus Schischk. |
| Baliospernum montanum (Willd.) Müll. Arg. | Baliospernum solanifolium (Geiseiler) Suresh |
| Baphicacanthus cusia (Nees) Bremek. | Strobilanthes cusia (Nees) Kuntze |
| Belamcanda chinensis (L.) Redouté | Saposnikovia divaricate (Turcz.) Schischk. |
| Boreonbergia pandurata (Rosxb.) Schltr. | Boreonbergia rotunda (L.) Manf. |
| Brassica alboglabra L.H. Bailey | Brassica oleracea L. |
| Brassica campestris L. | Brassica rapa L. |
| Cauvalpina boudicca (L.) Fleming | Cauvalpina boudicca (L.) Roebb. |
| Carissa edulis (Forneuk.) Vahl | Carissa spinarum L. |
| Cassia argustellia Craib | Cassia argustellia Craib |
| Cassia accidentalis L. | Cassia argustellia Craib |
| Chamaesacce hypsophila (L.) Small | Euphorbia hypsophila L. |
| Cinnamomum heuffelacoe (Kom.) | Actaea heuffelacoe (Kom.) J. Compton |
| Clerodendrum inerme (L.) Gaertn. | Volkameria inerme L. |
| Coleus ambovicosus Lour. | Plectranthus ambovicosus (Lour.) Spreng. |
| Curcuma domestica Valeson | Curcuma longa L. |
| Cydonia vulgaris Pers. | Chamaemexis sinesis (Thouin) Koehne |
| Dictamnus dasyarbus Turez. | Dictamnus albus L. |
| Dodonaea angustifolia L. f. | Dodonaea viscoso Jacq. |
| Delichus biflorus L. | Vigna unguiculata (L.) Walp. |
| Drymara diandra Blume | Drymara cordata (L.) Willd. ex Schult. |
| Drymara fortunei (Kunze ex Mett.) J. Sm. | Drymara rovisi Nakaike |
| Elseonodendron crocuse (Thunb.) DC. | Cassia crocuse (Thunb.) C. Pres. |
| Eleuthera americana (Aubl.) Merr. ex K. Heyne | Eleuthera bulbosa (Mill.) Urb. |
| Enanta chlorantha Oliv. | Annicka chlorantha (Oliv.) Setten & Maas |
| Epninetrum villosa Trupolin | Albertisa villosa Forman |
| Erythroxylum lucidum Kunth | Erythroxylum macrophyllum Cav. |
| Eugenia carpophyllata Thunb. | Syzygium aromaticum (L.) Merr. & L.M. Perry |
| Eugenia jambolana Lam. | Syzygium cumini (L.) Skeels |
| Euapterum buniifolium Hook. ex Arn. | Acanthothyes buniifolius (Hook. ex Arn.) R.M. King & H. Rob. |
| Eucalytus ruticarpus (A. Juss.) Benth. | Tepladum ruticarpum (A. Juss.) T.G. Hartley |
| Ferula sambul (Kaufm.) Hook. f. | Ferula moschat (H. Reinsch) Koso-Pol. |
| Gardnia cambogia Rosb. | Gardinia gymno-gutta Rosb. |
| Gardinia edulis Exell | Gardinia buchneri Engl |
| Gardinia polyantha Oliv. | Gardinia smetanina (Plantch. & Triana) Oliv. |
| Gardinia japonicum Thunb. | Gardinia macrophyllum Willd. |
| Ginkgo biloba L. | Ginkgo biloba (L.) Rich. |
| Glycosmis montana Pierre | Glycosmis lanceolata (Blume) Teijms. & Binn. ex Kurz |
| Kadura inferior A.C. Sm. | Kadura heterociste (Rosxb.) Craib |
| Kalopanax pictus (Thunb.) Nakai | Aesor pictum Thunb. |
| Ledebuoria divaricate (Turcz.) Hiroe | Saposnikovia divaricate (Turcz.) Schischk. |
| Lespedea eunota (Dam. Cours.) G. Don | Lespedea junoca (L.) F. Pers. |
| Lindera glauca (Siebold & Zucc.) Blume | Lindera communis Hemsl. |
| Lithsea sotheri Pers | Lithsea glutinosa (Lour.) C.B. Rob. |
| Loranthus parasiticus (L.) Merr. | Scyrella parasitica L. |
| Madhuca indica J.F. Gmel. | Madhuca longifolia (J. Koenig ex L.) J.F. Macbr. |
| Magnolia fargesii (Finet & Gagnep.) W.C. Cheng | Magnolia biondii Pamp. |
| Magnopircus setosus Ruiz & Pav. | Magnopircus pinnatus (Lam.) Kuntze |
| Marptssus heterophylla (Eckl. & Zeyh.) N. Robson | Gymnosporia hetrophylla (Eckl. & Zeyh.) Loes. |
| Marptssus senegalensis (Lam.) Exell | Gymnosporia senegalensis (Lam.) Loes. |
| Melandrium seoulense (Nakai) Nakai | Silene seoulensis Nakai |
| Mentha haplocalyx Briq. | Mentha canadensis L. |
| Moa punctulata (J.F. Gmel.) (Nakai) | Moa seabra (Thunb.) C.Y. Wu & H.W. Li |
| Mutisia vicicfolia to. internodia Cuatrec. | Mutisia acuminate Ruiz & Pav. |
| Orthosiphon labiatus N.E. Br. | Ocimum labiatus (N.E. Br.) A.J. Paton |
| Persicaria senticosa (Meissn.) H. Gross ex Nakai | Polygonum senticosum (Meissn.) Franck. & Sav. |
| Peucedanum graveolens (L.) Hierrn | Anethum graveolens L. |
| Phoradendron juniperinum Engelm. ex A. Gray | Phoradendron ligatum Trel. |
| Polanisia kosandra (L.) Wight & Arn. | Cleome viscosa L. |
| Polygonum cuspidatum Sieb. et Zucc. | Reynoutria japonica Houtt. |
| Polygonum multiformum (Meissn.) H. Gross ex Nakai | Reynoutria multiflora (Thunb.) Moldenke |
3. Plant Extracts and Some Secondary Metabolites with Anti-HIV Activity

Most of the world’s cultures have centuries of tradition in the use of plant materials in order to control diseases. With recent advancement in pharmacognosy and technology along with the current trends of a more health-conscious general public, natural products are becoming a popular resource for researchers to discover novel and more effective antiviral drugs, considering the relatively reduced adverse effects and cost effectiveness of natural products in commercial scale [361]. Plants, as evolutionary responses to infections by fungi, nematodes, and other organisms, to avoid herbivory, and to compete for light and space, produce numerous secondary metabolites such as phenolics, glycosides, alkaloids, coumarins, terpenoids, essential oils and peptides. These metabolites have been identified with different biological activities. Some of them play an important role in immune system enhancement, exhibiting antiviral potential [362], including viral infections associated with Human Immunodeficiency Virus type 1 (HIV-1) and 2 (HIV-2) as genetic variabilities. An increasing number of patients with HIV infection cannot use the currently approved anti-HIV drugs including the reverse transcriptase and protease inhibitors, due to the adverse reactions, particularly liver diseases, that have been reported for antiretroviral drugs. The best antiretroviral therapy (HAART) has also fallen short of completely suppressing HIV replication [363]. Therefore, the discovery and development of new anti-HIV agents or new mechanisms of activity from medicinal plants are required to reduce toxicity in drug application and to minimize side effects when compared with current synthetic drugs [364]. The potential utilization of plant extracts and their secondary metabolites to combat the development of anti-HIV agents is considered to be one of the most important approaches toward effective therapy for AIDS [365]. Bioassay-guided fractionation and isolation of secondary metabolites from medicinal plants according to their preliminary high throughput screenings provide systematic source to the novel compounds. The in vitro and in vivo evaluation affirmed the therapeutic potentials in these chemical compounds. Thus, traditional medicines can serve as sources of potential new drug candidates and initial research has focused on the isolation of bioactive lead compounds [366].

Many compounds with anti-HIV-1 effects have been screened and isolated from natural sources and discovered to inhibit HIV at nearly all stages of the viral life cycle. They include alkaloids, sulfated polysaccharides, polyphenolics, flavonoids, coumarins, phenolics, tannins, triterpenes,
lectins, phloroglucinols, lactones, iridoids, depsidones, O-caffeoyl derivatives, lignans, ribosome inactivating proteins, saponins, xanthones, naphthodianthrones, photosensitisers, phospholipids, quinones and peptides [367]. Natural products provide a large reservoir for screening of anti-HIV agents with novel structures and anti-viral mechanisms because of their structural diversity. A variety of natural products have been found to inhibit unique enzymes and proteins crucial to the life cycle of HIV including efficient intervention with the reverse transcription process, virus entry, and integrase and protease inhibition [368]. However the mechanism of anti-HIV activities of many natural products is still unknown. Some of the plant extracts have significantly inhibited the enzyme activity of HIV-1 replication and protected cells infected with HIV-1. These extracts with anti-HIV activity are also active against other retroviruses such as Herpes Simplex Virus (HSV). Most studies have used in vitro test systems for anti-HIV-1 enzyme assays such as HIV-1 reverse transcriptase colorimetric assay, HIV-1 integrase assay, and HIV-1 protease fluorogenic assay, but a few in vivo studies have been carried out using compounds isolated from natural sources [369]. The anti-HIV activities of extracts from some medicinal plants have been reviewed.

3.1. *Artemisia annua* L. (Asteraceae)

The anti-HIV activity of the tea infusion prepared from the Chinese medicinal plant identified as *Artemisia annua* L. by using the validated cellular systems were examined. The tea infusion of *Artemisia annua* was found to be highly active with IC\textsubscript{50} values as low as 2.0 µg/mL. In addition, artemisinin was found as inactive at 25 µg/mL and the related species *Artemisia afra* (not containing artemisinin) has also shown a similar level of activity [370].

3.2. *Astragalus membranaceus* Bunge (Fabaceae)

*Astragalus membranaceus* is well-known Chinese traditional medicine as an immunostimulant. Studies in immune-suppressed and immune-competent human patients have demonstrated restoration or augmentation of local graft versus host rejection using *Astragalus* extracts. These extracts have improved symptomology in HIV-infected patients. These results are suggested that the extracts of *Astragalus* to be safe, however mutagenecity has yet to be examined [115].

3.3. *Calendula officinalis* L. (Asteraceae)

In India, the flowers of *Calendula officinalis* are used in ointments for treating wounds, herpes, ulcers, frostbite, skin damage, scars and blood purification. The infusions prepared from the leaves have been used for treating varicose veins in traditional use. Dichloromethane-methanol (1:1) extract of *Calendula officinalis* flowers exhibited potent anti-HIV activity in in vitro (3-(4,5-dimethylthiazolyl-2)-2,5-diphenyltetrazolium bromide)(MTT)/tetrazolium-based assay. This activity was attributed to inhibition of HIV1-RT at a concentration of 1000 µg/mL as well as suppression of the HIV mediated fusion at 500 µg/mL [371]. The organic and aqueous extracts of dried flowers from *Calendula officinalis* were examined for their ability to inhibit the human immunodeficiency virus type 1 (HIV-1) replication. Both extracts were relatively nontoxic to human lymphocytic Molt-4 cells, but only the organic one exhibited potent anti-HIV activity in an in vitro MTT tetrazolium-based assay. In addition, in the presence of the organic extract (500 µg/mL), the uninfected Molt-4 cells were completely protected for up to 24 h from fusion and subsequent death, caused by cocultivation with persistently infected U-937/HIV-1 cells. It was also found that the organic extract from *Calendula officinalis* flowers caused a significant dose- and time-dependent reduction of HIV-1 reverse transcription (RT) activity. An 85% RT inhibition was achieved after a 30 min treatment of partially purified enzyme in a cell-free system. These results suggested that organic extract of flowers from *Calendula officinalis* are possessed anti-HIV properties of therapeutic interest [163].
3.4. Calophyllum lanigerum Miq. var. austrocoriaceum (T.C. Whitmore) P.F. Stevens (Clusiaceae)

Calophyllum lanigerum var. austrocoriaceum has been found to inhibit the cytopathic effects of in vitro HIV infection. Bioassay-guided fractionation of the extract and the chemical along with biological characterization of active constituents as coumarine derivatives have been reported [372]. The latex of Calophyllum teysmannii L. has shown to be active against HIV-1 reverse transcriptase mediated by soulattrolide, a coumarin isolated from the latex of Calophyllum teysmannii [373].

3.5. Cassia abbreviata Oliv. Oliv., C. sieberiana D.C. (Fabaceae)

Cassia abbreviata growing in Botswana used by traditional healers to manage HIV/AIDS, was tested for their inhibitory effects on HIV replication against a clone of HIV-1c (MJ4) measuring cytopathic effect protection and levels of viral p24 antigen in infected PBMCs. Cassia sieberiana and Cassia abbreviata extracts have shown significant inhibition of HIV-1c (MJ4) replication. Anti-HIV activity of Cassia sieberiana root and bark extracts, and Cassia abbreviata root extracts were occurred in a concentration-dependent manner with an effective concentration (EC₅₀) of 65.1 µg/mL, 85.3 µg/mL and 102.8 µg/mL, respectively [374].

3.6. Chelidonium majus L. (Papaveraceae)

The anti-retroviral activity of the freshly prepared crude extract of Chelidonium majus L. was examined and a low-sulfated poly-glycosaminoglycan moiety with molecular weight of ~3800 Da. was isolated from the extract [173]. The substance prevented infection of human CD4⁺ T-cell lines AA2 and H9 with HIV-1 at concentration of 25 µg/mL as well as the cell-to-cell virus spread in H9 cells continuously infected with HIV-1 were determined by the measurement of reverse transcriptase activity and p24 content in cell cultures. In addition, in a murine AIDS model that the treatment with purified substance significantly prevented splenomegaly and the enlargement of cervical lymph nodes in C57Bl/6 mice chronically infected with the pool of murine leukemia retroviruses were also reported [173].

3.7. Combretum molle (R. Br. ex. G. Don.) Engl & Diels (Combretaceae)

In vitro anti-HIV activity of various extracts prepared from the stem bark of Combretum molle widely used in Ethiopian traditional medicine for the treatment of liver diseases, malaria and tuberculosis has been assessed against human immunodeficiency virus type 1 (HIV-1) and type 2 (HIV-2). The extracts were prepared by percolation with petroleum ether, chloroform, acetone and the methanol extract was obtained by successive hot extraction using Soxhlet apparatus. Selective inhibition of viral growth was assessed by the simultaneous determination of the in vitro cytotoxicity of each of the extracts against MT-4 cells [375]. The results obtained in this study indicate that the acetone fraction possessed the highest selective inhibition of HIV-1 replication. Phytochemical investigation of the acetone fraction has resulted in the isolation of two tannins and two oleanane-type pentacyclic triterpene glycosides. One of the tannins was identified as punicalagin (an ellagitannin), while the structure of the other (CM-A) has not yet been fully elucidated. On the other hand, both punicalagin and CM-A had displayed selective inhibition of HIV-1 replication with selectivity indices (ratio of 50% cytotoxic concentration to 50% effective antiviral concentration) of 16 and 25, respectively and afforded cell protection of viral induced cytopathic effect of 100% when compared with control samples.

3.8. Diospyros lotus L. (Ebenaceae)

Methanol extract of the fruits of Diospyros lotus were tested for anti-HIV-1 activity. Gallic acid was found the most active compound against HIV-1 with Therapeutic Index (TI) value of >32.84 and the other compounds were less potent active. Diospyros lotus fruits could provide a chemical reservoir of anti-HIV agents. All identified compounds were tested for their cytotoxicity and anti-HIV-1
activities. For positive control, the marketed drug azido-thymidine (AZT) was also tested as a reference according to the same methods. The activity data were described as 50% cytotoxicity concentration (CC_{50}), 50% effective concentration (EC_{50}%), and therapeutic index (TI), the ratio of CC_{50}/EC_{50}). Seven isolated phenolic compounds (CC_{50} > 200 µg/mL) have shown less toxicity to C8166 cells compared to ellagic acid (CC_{50} = 35.84 µg/mL). Gallic acid inhibited HIV-1 replication with EC_{50} value of 6.09 µg/mL and TI value of > 32.84, higher than any other compounds. The anti-HIV-1 activity assay was performed by syncytia formation. The seven phenolic compounds showed a good anti-HIV-1 activity and compound gallic acid, a simple tannin compound was the most active and its TI value was the highest [376].

3.9. Dittrichia viscosa (L.) Greuter (Asteraceae)

The aqueous extract of Dittrichia viscosa was tested for its ability to inhibit the HIV replication. HIV infection of MT-2 cells was used for evaluating antiviral test as rapid and sensitive assay system for the detection of potential antiviral drugs effective against AIDS. The aqueous extract of Dittrichia viscosa has showed inhibitory effects against HIV-1 induced infections in MT-2 cells at concentrations ranging from 25 to 400 µg/mL of therapeutic interest [377].

3.10. Galanthus nivalis L. (Amaryllidaceae)

Agglutinin isolated from Galanthus nivalis (GNA) is a member of a superfamily of strictly mannose-binding specific lectins widespread among monocotyledonous plants, and is well-known to possess a broad range of biological functions such as anti-tumor, anti-viral and anti-fungal activities [378]. The molecular mechanisms of GNA exerting anti-viral activities by blocking the entry of the virus into its target cells, preventing transmission of the virus as well as forcing virus to delete glycan in its envelope protein and triggering neutralizing antibody were discussed. These findings may provide a new perspective of GNA-related lectins as potential drugs for virus therapeutics in the future.

3.11. Garcinia edulis Exell (Clusiaceae)

The isoprenylated xanthone derivative determined as 1,4,6-trihydroxy-3-methoxy-2-(3-methyl-2-butenyl)-5-(1,1-dimethyl-prop-2-enyl)xanthone was isolated from the ethanolic extract of the root bark of Garcinia edulis. It exhibited anti-HIV-1 protease activity with IC_{50} value of 11.3 µg/mL in vitro while acetyl pepstatin was used as a positive control possessing an anti-HIV-1 PR activity of IC_{50} value of 2.2 µg/mL [379]. However, this compound has also showed potent lethality with LC_{50} value of 2.36 µg/mL against brine shrimp larvae in vitro.

3.12. Helichrysum populifolium (Asteraceae)

The methanol:water (1:1) extract of the aerial parts of Helichrysum populifolium growing in South Africa was tested for the anti-HIV test by using HeLa-SXR5 expressed the CD4 receptor and the CXCR4/CCR5 chemokine receptors and the extract was found to be active (IC_{50} value of 12 µg/mL) [123]. The anti-HIV compounds identified from H. populifolium were three dicaffeoylquinic acid derivatives, i.e., 3,4-dicaffeoylquinic acid, 3,5-dicaffeoylquinic acid and 4,5-dicaffeoylquinic acid as well as two tricaffeoylquinic acid derivatives, i.e., 1,3,5-tricaffeoylquinic acid and either 5-malonyl-1,3,4-tricaffeoylquinic or 3-malonyl-1,4,5-tricaffeoylquinic acid.

3.13. Hoodia gordonii (Masson) Sweet ex Decne (Apocynaceae)

The in vitro anti-HIV potential of the ethanol and ethylacetate extracts of Hoodia gordonii was examined. Both extracts had shown good inhibition in a dose-dependent manner against HIV-1 reverse transcriptase (RT) with IC_{50} values of 73.55 ± 0.04 and 69.81 ± 9.45 µg/mL, respectively. Doxorubicin, a known RT inhibitor was used as a positive control and inhibited HIV RT by 68% at
25 µg/mL (IC<sub>50</sub> < 25 µg/mL). Both extracts also demonstrated inhibitory activity against HIV protease (PR) with IC<sub>50</sub> values of 97.29 ± 0.01 and 63.76 ± 9.01 µg/mL for ethanol and ethyl acetate extracts, respectively. Acetyl pepstatin was used as a known PR inhibitor and inhibited HIV PR by as much as 82% at 50 µg/mL (IC<sub>50</sub> < 50 µg/mL). In addition, both ethanol and ethyl acetate extracts had weak inhibition against HIV-1 integrase (IN) with <50% inhibition at the highest concentration tested of 400 µg/mL. Sodium azide was used as a positive control compound for IN inhibition [101]. In the same study, phytochemical screening of Hoodia gordonii was revealed the presence of phenolics, alkaloids, terpenes, steroids, cardiac glycosides and tannins in the ethanolic extract, while the ethyl acetate extract only showed the presence of phenolics, cardiac glycosides and steroids.

3.14. Hypericum perforatum L. (Hypericaceae)

Hypericum perforatum, known as St. John’s Wort, has been used for medicinal purposes, particularly wound healing, since the Middle Ages. It was also used in treatment of AIDS [380]. In a clinical trial, hypericin and pseudohypericin isolated from this plant have shown antiretroviral activity in HIV-infected patients [381].

3.15. Hyssopus officinalis L. (Lamiaceae)

Hyssopus officinalis has been used as herbal medicine and the extracts of this species have demonstrated strong activity against HIV-1 due to the content of polysaccharide-type compounds [252]. The 50% hydroalcoholic extract of Hyssopus officinalis was examined for its ability to inhibit HIV replication. Among the variety of assays for evaluating antiviral tests, HIV infection of MT-2 cells was used as a rapid and sensitive assay system for the detection of potential antiviral drugs effective against AIDS. This extract had shown inhibitory effects against HIV-1 induced infections in MT-2 cells at concentrations ranging from 50 to 100 µg/mL.

3.16. Justicia gendarussa Burm. f. (syn: Gendarussa vulgaris Nees) (Acanthaceae)

Justicia gendarussa was identified as a potent anti-HIV-1 active lead from the evaluation of over 4500 plant species growing in Vietnam and Laos by showing complete inhibition against HIV replication at a concentration 20 µg/mL. The methanol extract of the stems and barks of the plant have led to the isolation of justiprocumins A and B as new arylnaphthalide lignan glycosides by using bioassay-guided isolation. Justiprocumin B has shown potent activity against a broad spectrum of HIV strains with IC<sub>50</sub> values in the range of 15–21 nM (AZT, IC<sub>50</sub> 77–95 nM, as positive control). Justiprocumin B also displayed potent inhibitory activity against the NRTI (nucleoside reverse transcriptase inhibitor)-resistant isolate (HIV-1<sub>1617-1</sub>) of the analogue (AZT) as well as the NNRTI (non-nucleoside reverse transcriptase inhibitor)-resistant isolate (HIV-1<sub>N119</sub>) of the analogue (nevirapine) [382]. The dichloromethane plant extract has shown complete inhibition of HIV replication at a concentration of 20 µg/mL. This bioactivity was confirmed by the evaluation of the MeOH extract prepared from a re-collected sample of the same plant, with HIV-1 replication inhibition at an IC<sub>50</sub> value of 40 ng/mL. Bioassay-guided separation of the extracts of the stems and roots of this plant led to the isolation of an anti-HIV arylnaphthalene lignan (ANL) glycoside, patentiflorin A. Evaluation of the compound against both the M- and T-tropic HIV-1 isolates showed it to possess a significantly higher inhibition effect than the clinically used anti-HIV drugs known as the nucleotide analogue (AZT) and non-nucleotide analogue (nevirapine). Thus, patentiflorin A has the potential to be developed as a novel anti-HIV drug [382]. Patentiflorin A showed anti-HIV-1 activity with an IC<sub>50</sub> value of 26.9 nM in the defective HIV-based pseudotyped assay. The results clearly showed that patentiflorin A has broad-spectrum activity against both M-tropic and T-tropic HIV-1 isolates with IC<sub>50</sub> values lower than that of AZT, the first anti-HIV drug developed and still used in the treatment of HIV/AIDS. Like AZT, it inhibited the particle production of all four HIV isolates effectively in a dose-dependent manner. Patentiflorin A gave an IC<sub>50</sub> value of 24–37 nM, compared to 77–95 nM for AZT.
3.17. Momordica charantia L. (Cucurbitaceae)

*Momordica charantia*, known as bitter melon and widely exploited in folkloric medicine, has been shown to inhibit HIV-1 reverse transcriptase due to its protein coded as MRK29 [383]. The efficacies and molecular mechanisms of bitter gourd-induced anti-diabetic, anti-HIV, and antitumor activities contributed by over twenty active components were determined. Therefore, bitter gourd is a cornucopia of health and it has been deserved in-depth investigations for clinical application in the future.

Anti-HIV properties of the fruit pulp extract of *Momordica balsamina*, commonly used in the northern part of Nigeria for its anti-viral efficacy in poultry, was studied in vitro and was found as a potent inhibitor of HIV-1 replication; further research on fruit pulp extract should be pursued for its potential in the prophylaxis and therapy of retroviral infections in humans [384].

3.18. Pachyma hoelen Rumph (Polyporaceae)

The hexane extract of *Pachyma hoelen* Rumph used in folk medicine in Korea was shown to have the best anti-HIV-1 activity compared to the other extracts tested. This extract had 37.3 µg/mL (EC<sub>50</sub>) on the p24 antigen assay as the highest value, 36.8% on the RT activity test (at 200 µg/mL). In addition, this extract had shown protective effects on infected MT-4 cells; the protection was the highest observed at 58.2%. The 50% cytotoxic concentration (CC<sub>50</sub>) of the hexane extract of this plant species was found 100.6 µg/mL [196].

3.19. Phyllanthus pulcher (Euphorbiaceae)

The methanol extract of *Phyllanthus* species growing in Malaysia was evaluated for anti-HIV-1 reverse transcriptase (RT) activity using the HIV-RT assay by inhibition of the HIV-1 RT enzyme based on their IC<sub>50</sub> values. Azido-deoxythymidine-triphosphate (AZT151TP) was used as a positive control. The inhibition of HIV-RT for *P. pulcher* was IC<sub>50</sub> of 5.9 µg/mL [385].

3.20. Rhus chinensis Mill (Anacardiaceae)

The anti-HIV-1 activities of the petroleum ether, ethyl acetate, butanol and aqueous extracts of *Rhus chinensis* growing in China and Japan where it is known as Chinese Sumac were examined. The petroleum ether extract had significantly suppressed HIV-1 activity in vitro and was found to inhibit syncytium formation and HIV-1 p24 antigen at non-cytotoxic concentrations, the EC<sub>50</sub> were 0.71 and 0.93 µg/mL respectively. The petroleum ether extract had no activity on inhibiting HIV-1 recombinant RT or HIV-1 entry into host cells cycle. *R. chinensis* would be a useful medicinal plant for the chemotherapy of HIV-1 infection. The petroleum ether extract of this plant likely inhibit the post entry steps or target the new sites of HIV-1 replication [386].

3.21. Sceletium tortuosum (L.) N.E. Brown (Aizoaceae)

The ethanolic and ethyl acetate extracts prepared from the whole part of *Sceletium tortuosum*, distributed throughout southern Africa, were investigated for their inhibitory activity against HIV-1 enzymes including protease (PR), reverse transcriptase (RT) and integrase (IN) [172]. The HIV-1 RT inhibition testing had IC<sub>50</sub> values of <50 and 121.7 ± 2.5 µg/mL for ethanol and ethyl acetate extracts, respectively. In addition, both extracts had also inhibited HIV-1 PR with IC<sub>50</sub> values < 100 µg/mL. *Sceletium tortuosum* might be a potential source of new lead compounds in the development of new anti-HIV compounds [67].

3.22. Smilax corbularia Kunth (Smilaceae)

The ethanolic and aqueous extracts were tested for their inhibitory effects against HIV-1 protease (HIV-PR) and HIV-1 integrase (HIV-1 IN). The results indicated that the ethanolic extract of *S. corbularia* exhibited anti-HIV-1 IN activity with an IC<sub>50</sub> value of 1.9 µg/mL, approximately two-fold lower
than that of suramin ($IC_{50} = 3.4 \mu g/mL$) as the positive control. The value of $IC_{50} = 5.4 \mu g/mL$ was determined for the water extract of *Smilax corbularia* [120].

3.23. *Terminalia paniculata* (Combretaceae)

The in vitro anti-HIV1 activity of acetone and methanol extracts prepared from the fruits of *Terminalia paniculata* was examined. The $EC_{50}$ values of the acetone and methanol extracts of *T. paniculata* were $\leq 10.3 \mu g/mL$. The enzymatic assays were performed to determine the mechanism of action and indicated that the anti-HIV1 activity might be due to inhibition of reverse transcriptase ($\geq 77.7\%$ inhibition) and protease ($\geq 69.9\%$ inhibition) enzymes [387].

3.24. *Tuberaria lignosa* (Sweet) Sampaio (Asteraceae)

*Tuberaria lignosa* was widely used in the folk medicine to treat diseases of viral origin of the Iberian Peninsula and the ethanolic and aqueous extracts were evaluated for its anti-HIV activity by inhibiting HIV replication. The toxicity of the extracts to MT-2 cells was also investigated. The ethanolic extract was especially toxic, which prevented the evaluation of their potential antiviral effects at higher concentrations. However, the aqueous extract of *T. lignosa* tested was relatively nontoxic to human lymphocytic MT-2 cells, but did show anti-HIV activity at concentrations ranging from 12.5 to 50 $\mu g/mL$ [61].

In conclusion, terrestrial plants produce secondary metabolites for their chemical defense, which possess unique chemical structures and have played pivotal roles in human health. There is a continuous need to introduce new drug candidates to treat diseases and the drug discovery process can be realized using both ancient and modern research methodologies in a complementary manner. Some medicinal plants are still unexplored; therefore there are numerous avenues of research for the determination of their biological activities. In this review, the anti-HIV activity of some plant extracts and their potential utilization for anti-HIV agents have been summarized. Among them *Calendula officinalis*, *Justicia gendarussa* and *Sceletium tortuosum* might be useful potential sources for new lead compounds in the development of new candidates with anti-HIV properties of therapeutic interest. These studies are considered to be one of the most important approaches toward effective therapy for AIDS.

4. Human Clinical Trials

There are few reports about using the herbal medicine in clinical studies and treatment for HIV/AIDS. This area is not well researched. But, in Africa, where HIV, AIDS and HIV related diseases are the most widespread problems, herbal medicines are used as primary treatment for them. Highly active antiretroviral therapy is also applied in China and implies three types of treatment systems. One of them is traditional Chinese medicine provided by trained Chinese herbalists. There are several randomized studies related to beneficial effects of traditional medical plants on patients with HIV or AIDS which were compared with control group (without treatment and placebo). The effects in promoting CD4$^+$ cells were followed. Based on selected, different, studies approximately eleven different Chinese traditional medical plants such as *Panax ginseng*, *Astragalus membranaceus*, *Lycium barbarum*, *Trichosanthis kirilowii*, and *Viola mandshurica* were tested in about 1000 patients within different studies. Compared with placebo, treatment with traditional medical plants showed positive effect, increasing CD4 cells, but studies need to be improved [388].

Some Chinese herbal preparation which consists of 14 plants (*Coptis chinensis*, *Jasminum officinale*, *Wolfiporia extensa*, *Sparganium stoloniferum*, *Polygonatum odoratum*, and *Scrophularia buergeriana*) was investigated during 24 weeks and observed to have increased plasma CD4 count and also showed inhibition of HIV growth [389]. According to one US study, 26% of HIV-infected people use herbal medicine as part of their treatment. A European study showed that herbal medicines are used by approximately 25% of HIV infected people [390].
The study, which included 366 HIV-positive African-American women who were enrolled in herbal medicine therapy, showed that in these patients experienced 1.69 time stronger anti-retroviral effect compared to women not using the therapy based on medical plants [391]. Thirty-three HIV-positive volunteers (7 men and 26 women between 22 and 43 years of age) who used *Calendula officinalis* or *Agastache rugosa* were evaluated in South Africa. There was a significant decrease in viral loads and in CD4 T-cell counts [392].

The Ministry of Health of South Africa is actively promoting the use of traditional medicines with antiretroviral treatments and recommended two plants remedies which have been used for HIV/AIDS treatment: *Hypoxis hemerocallidea* and *Sutherlandia frutescens* [393]. Also, in Romania it was noticed that children with AIDS who were treated with natural herbal remedies showed a decrease in mortality rate [393]. Furthermore, in blood samples of 30 adults who used an extract of *Alternanthera pungens*, a significant increase of CD4 and CD8 lymphocytes was observed [394].

The study which was conducted to demonstrate using medical plants in different districts in Uganda, where this disease first described and one million inhabitants are infected, 25 traditional medicine practitioners were interviewed. The practitioners received on average 29 (range, 2–250) patients each year. They mentioned 145 belong to families Asteraceae, Fabaceae and Euphorbiaceae. It was also noted that the most used plants were *Aloe* spp., *Erythrina abyssinica*, *Sarcocephalus latifolius*, *Psorospermum febrifugum*, *Mangifera indica*, and *Warburgia salutaris*. In patients involved in herbal medicine treatment progressive loss of CD4 positive T-cell lymphocytes in the blood was observed [311].

5. Conclusions

Focusing on phytochemicals that have reached clinical trials, if there are any; highlighting medicinal plants where high level of scientific evidence has been reached; future perspectives.

Although there have been major accomplishments in HIV chemotherapy, there remains a need for new anti-HIV drug discovery, and medicinal plants can play an important role in this endeavor. Several plant species have shown remarkable anti-HIV activity, especially *Artemisia annua*, *Garcinia edulis*, *Justicia gendarussa*, *Phyllanthus pulcher*, *Rhus chinensis*, *Smilax corbularia*, *Terminalia paniculata*, and *Tuberaria lignosa*. These plant species are worthy of further study for the development of new anti-HIV chemotherapeutic options. In particular, in vivo testing and, ultimately, human clinical trials need to be carried out on key lead plants and phytochemical isolates. In addition, continuous evaluation of medicinal plants for anti-HIV activity should be pursued.

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