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ANTIVIRAL ACTIVITY OF HERBAL PLANTS AND ITS PHYTOCOMPOUNDS: AN OVERVIEW

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ABSTRACT

Genetically and functionally different therapeutic applications against the virus have been found in a variety of active phytochemicals. The antiviral mechanism of those agents is often explained by their antioxidant activity, their scavenging capabilities, DNA inhibition, RNA synthesis, or inhibition of viral reproduction. Numerous epidemiological and experimental studies have proven that antiviral actions work against a large number of phytochemicals. Especially in the last decade, several phytocompounds have been identified using various biological tests *in vitro* and *in vivo* studies. On the other hand, the plant has proven to be a powerful source of antiviral agents with some great advantages over traditional medicine therapy due to its extensive therapeutic potential and limited side effects. Plants synthesize and produce a wide variety of biochemical products that have a potential therapeutic index, thus helping to inhibit the growth of virus. This review provides insights into herbal plants and their metabolism, explaining their potential role as the main option in the treatment of viral infections.

Key words: Antiviral activity, *in vitro, in vivo* and Ayurveda formulation.

INTRODUCTION

Folk remedies have been used in folk medicine and ethnobotanical literature to describe the use of plant extracts, infusions, and powders for certain diseases caused by microorganisms such as *P. aeruginosa*, *E. coli*, *C. albicans*, *S. aureus*, *M. canis*, *T. mentagrophytes*, *M.*

smegmatis, *B. subtilis*, PV-1, PV-2, PV-3, Measles morbilli virus, HSV1, HSV-2, Coxsackie B4 virus, Semliki forest virus [1-6]. The treatment of viral infections is often unsatisfactory with available antiviral drugs due to the problem of viral resistance, viral

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latency, and paradoxical efficacy in recurrent infection among the immunocompromised patients [7]. Ethnopharmacology offers an alternative approach to the discovery of antiviral agents by studying about the herbal plants with a history of traditional uses for medical applications [8]. Detailed investigation and documentation of plants used in local health traditions and ethnographic evaluation to verify their effectiveness and safety may lead to the development of precious herbal medicine for therapeutic values [9]. A number of compounds extracted from herbal plants have shown prominent antiviral properties of the plant extracts, which are given in Table 1 and Table 2.

Virus inhibitor mechanism

A deeper understanding of the many features of viruses about their cytomorphology, multiplication, replication, translation, and many other strategies by reverse transcription can be used to benefit the host in antiviral therapy (Fig. 1).

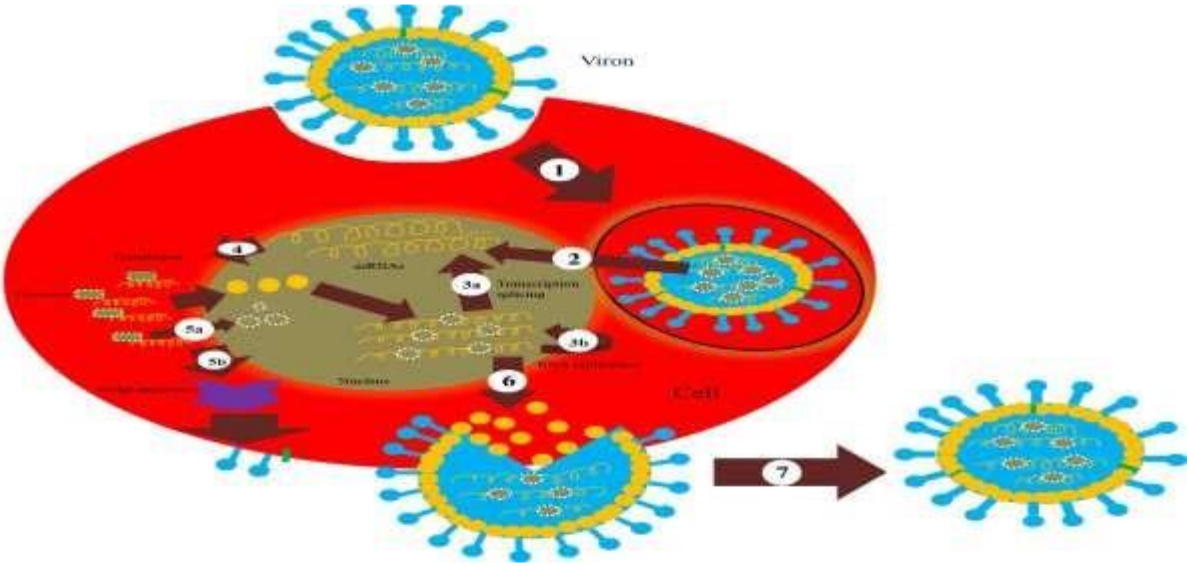

Fig. 1: Virus inhibitor mechanism

Table 1: *In vitro* antiviral activity of herbal plant extracts and its isolated compounds

Name of the plant species/Compounds	Parts used*	Solvent **	Name of the virus	Concentration used	Assay	Ref.
A.sieberiana, C. cajan, C.tomentosa, C.myricoides, C. abyssinica, C. multicorymbosum, C. mesopontica, D. steudtneri, D. inaequalis, E. grantii, E. hirta, E. abyssinica, G. javanica, I. arrecta, L. brevipes, L. nepetaefolia, M. kilimandscharica, M. lutea, P. ternifolia, P. palmate, P. pulchrum, R.vulgaris, S. incanum, T. rhomboidea, V. aenulans, V. amygdalina* and *V. lasiopus	R,S,SS,L,WP and SD	80% E	PV-1, PV-2, PV-3 and Coxsackie B4 virus	0.2 ml of serial two-fold dilutions of plant extract	MTT	10
C. jagus, S. mombin, P. nitida, S. afzelii, A. conyzoides, H. indicum, T. ivorensis, T. superba, I. asarifolia, B. pinnatum, L. breviflora, T. alnifolia, C. gratissimus, M. barteri, H. opposite, C.portoricensis, E. utile, M. pudica, B. diffusa, M.whitei, P. nigrescens, P. alliacea, P.guineensis, E. indica, S. latifolius* and *L. multiflora	B,L,S and R	M, 70% AM, NH, DM and EA	Echovirus (E7, E13, and E19)	1000 to 0.01 µg/ml	MTT	11
B.gaudichaudiana, B.spicata, B.subalternans, P.sagittalis, T.minuta* and *T. absinthioides	L	AE	BVDV, HSV-1, PV2 and VSV	30 to 300 µg/ml	MTT	12
C. quadrangularis	S	M	HSV-1 and 2	100, 200, 300 and 400 µg/ml	MTT	13
S. chirata	L	AE	HSV-1		MTT and PCR	14

A. figarianum, A. hamulosa, A. asak, A. ehrenbergiana, A. laeta, A. oerfota, A. salicina, A. tortilis, A. aspera, A. procera, A. pungens, A. alba, A. arvensis, A. ochroleuca, A. suberecta, A. javanica, B. monieri, B. aegyptiaca, B. diffusa, B. spectabilis, C. decidua, C. filiformis, C. ambrosioides, C. laucum, C. maxima, C. droserifolia, C. inerme, C. grandis, C. molle, C. epigeus, D. noxia, D. elata, D. regia, D. angustifolia, E. sativa, E. tirucalli, E. hirta, F. benghalensis, F. palmate, F. trineriva, F. parviflora, G. senegalensis, H. tuberculum, I. caerulea, I. cairica, I. tinctoria, J. curcas, J. phonicea, J. procera, M. vulgare, M. balsamina, P. tomentosa, P. uajava, P. crispa, R. communis, R. dentatus, S. obtusifolia, S. occidentalis, S. alexandrina **and** ***S. surrattense***	L,SS,S,R and F	AE, M, EA and DM	Hepatitis B virus	0, 6.25, 12.5, 25 and 50 µg/ml	MTT	15
M. elmer, T. malayana, S. apiculata, A. disticha, T. macrophylla, B. angulate, T. macrophylla, C. lanigerum **and** ***A. corniculata***	WP, L,S and R	DM and M	H1N1 and H3N1	0.78–100 mg/ml	MTT	16

F. gummosa, F. assa-foetida, P. ferulacea, B. integerrima, E. arvense, Z. clinopodioides, T. daenensis, H. officinalis, P. granatum, A. capillus-veneris, C. azarolus **and** ***P. harmala***	R,S,L,AP and G	70% E	H1N1	25, 50 and 100 µg/ml	MTT	17

A. paniculata, C. longa, G. pentaphyllum, K. parviflora **and** ***P. guajava***	R and L	95% E	H5N1	8.2 g/ml, 69.3 g/ml, 135.6 g/ml, 2.2 g/ml, and 90.7 g/ml	MTT and RT-PCR	18
N. nuda	AP	M and CH	HSV-1 and 2	75, 100, 150, 250, 500, 750 and 1000 mg/ml	MTT	19
S. montana, O. vulgare, M. piperita, M. officinalis, T. vulgaris, H. officinalis, S. officinalis **and** ***D. canadense***	R and L	E and 40% AE	Avian infectious bronchitis (IBV)	50 mg/ml	MTT and RT-PCR	20
A. calamus, C. citratus **and** ***M. fatua***	R and L	M	Huh7 it-1	5-160 µg/ml	MTT	21
I. brevicuspis, I. theezans, B. erioclada, B. megapotamica, M. ilicifolia, G. marifolia, G. spathulata, A. gratissima, C. sylvestris, C. menthiformis, G. ciliate, P. actinia, P. alata, P. capsularis, P. edulis, P. misera, P. suberosa, P. warmingii, B. decumbens, C. marginatum, S. cernuum, S. nigrescens, S. leprosum, S. uniflora, L. divaricate **and** ***Lantana camara***	WP, L,S and R	E and AE	HSV-1	1-10 µg/ml	MTT	22

A. indica, M. oleifera* and *M. alba	L	E	FMDV	200 µg/ml, 100 µg/ml, 50 µg/ml, 25 µg/ml, 12 µg/ml, 6 µg/ml, and 1 µg/ml	MTT	23
P. niruri	L	E	HSV-1	118, 60, and 185 µg/ml	MTT	24
C. sempervirens	WP, L,S and R	80% E	HSV-1	12.5, 25, 50, 100, 200 and 400 µg/ml	MTT	25

R. repens, R. communis, W. tinctoria, A. indica, P. daemia, G. sylvestre, W. chinensis, S. indicus, D. zibethinus, T. indicum, C. pentaphylla, C. bonduc, C. alata, E. alsinoides, M. maderaspatana, J. curcas, I. tinctoria, C. ternatea, G. mangostana, L. aspera, W. fructicosa, A. indicum, A. Mexicana, P. murex, M. pubescens, O. corymbosa, S. hispida, C.halicacabum, D. metel, C. inerme* and *V. trifolia	AP and L	M	HSV-1, Influenza virus (FLU), Mouse corona virus (MCV) and feline calicivirus (FCV)	7.8 to 62 µg/ml	MTT	26

F. vesca, G. aristata, G. applanatum, G. macrophyllum, G. littoralis, H. maximum, H. cylindrical, H. discolour, H. splendens, H. perforatum, I. aggregate, J. communts, K. microphylla, L. occidentalis, L. groenlandicum, L. oregano, L. dissectum, L. ciliosa, L. involucrate, L. sericeus, L. clavatum, L. americanwn, M. aqurjolium, M. racemosum, M. stellatum, M. uniflora, M. uniflora, N. lutea, O. horridus, O. fragilis, O. purpurea, P. fruticosus, P. lewisii, P. contorta, P. ponderosa, P. major, P. glycyrrhiza, P. munitum, P. tremuloides, P. arguta, P. virginiana, P. virginiana, R. sanguineum, R. nutkana, R. parviflorus, S. bebbiana, S. cerulean, S. racemosa, S. lanceolatum, S. Canadensis, S. betultjolia, S. albus, U. dioica **and** ***V. thapsus***	RZ, WP, L and S	M	bovine coronavirus (BCV), bovine herpesvirus type 1 (BHVl), bovine parainfluenza virus type 3 (BP13), bovine rotavirus (BRV), bovine respiratory syncytial virus (BRSV), vaccinia virus (Poxviridae) and vesicular stomatitis virus (VSV)	NS	MTT	27

B. variabilis B. Gates, B. intermedia, C. xanthocarpa, E. deciduum, L. hasslerianum, O. pulchella, S. adstringens **and** ***X. aromatica***	L	AE	Equine herpesvirus 1 (EHV-1), herpes simplex virus 1 (HSV-1) and swine herpesvirus 1 (SuHV-1)	250 to 31.2 µg/ml	MTT	28

P. longum* and *P. nigrum	SS	M and CH	Vesicular stomatitis Indiana virus and Human para influenza viruses	200, 600, 1000 and 2000 µg/ml	MTT	29
***C. metuliferus*/ alkaloids**	F	NS	Infectious Bursal Disease Virus (IBDV)	100 50 25 12.5 6.25 3.125 1.562 0.781 0.391 0.195 mg/ml	MTT	30
A. paniculata, A. sessilis, C. manghas, C. gigantean, B. chinensis, C. caudatus, E. scaber, A. indica, C. uariegatum, E. hirta, E. indica, P. amboinicus, M. aruensis, O. tenuijlorum, O. aristatus, L. indica, H. rosasinensis, E. michelii, B. excels, L. ollaria, M. jalapa, F. malaccensis, P. sarmentosum, P. minus, H. auricularia, M. elliptica, S. americanum, C. asiatica, P. odorata, C. speciosus* and *E. elatior	WP, L,S and R	E	HSV-1 and vesicular stomatitis virus (VSV)	0.1 to 0.5 mg/ml	MTT	31
C. Myrica and U. Lactuca	SW	A	HSV-1 and 2	NS	MTT	32
T. aurea	S	E	encephalomyocarditis virus (EMCV), HSV-1 and vaccinia virus	166.6 µg/ml	MTT	33

G. thunbergii	AP	E	HSV-1, HIV-1, dengue virus type 2 (DENV2) and human enterovirus 71 (E71)	100 or 200µg/ml	MTT, Qrtpcr, cell cycle analysis and western blot	34
*** Root – R, Stem – S, Fruit – F, Seeds – SS, Leaves – L, Bract – B, Aerial part – AP, Gum – G, Rhizome – RZ, Flowers – FL, Seaweed - SW and whole plant – WP** **** Ethanol – E, Methanol – M, Aqueous methanol – AM, n-hexane – NH, Dichloromethane – DM, Ethyl acetate – EA, Aqueous extract – AE and Chloroform – CH** ***** Not specified - NS**						

Table 2: *in vivo* antiviral activity of herbal plant extracts and its isolated compounds

Name of the plant/parts	Solvents/compounds	Name of the virus	Animal model	Concentration	Ref.
C. edulis/ Lupeol, Oleuropein, Carissol, β –amyrin and Acyclovir	M	HSV-1	Balb/C mice	The groups were administered with the test drug or acyclovir or placebo orally three times a day for seven consecutive days	35

C. longa	90% E	DENV	ddY mice	10 mice (5 male and 5 female mice) each group. Group 1, mice were administered with 500 mg/kgBW of extract in 0.5% CMC. Group 2, mice were administered with 1000 mg/kgBW of extract in 0.5% CMC. Group 3, mice were administered with 0.5% CMC only. Extract was admitted orally admitted orally once day for 14 days.	36
G. glabra / diammonium glycyrrhizinate, an extract of liquorice roots	NS	COVID-19	animal and clinical trials	NS	37
*** Root – R, Stem – S, Fruit – F, Seeds – SS, Leaves – L, Bract – B, Aerial part – AP, Gum – G, Rhizome – RZ, Flowers – FL, Seaweed - SW and whole plant – WP ** Ethanol – E, Methanol – M, Aqueous methanol – AM, n-hexane – NH, Dichloromethane – DM, Ethyl acetate – EA, Aqueous extract – AE and Chloroform – CH *** Not specified - NS**					

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CONCLUSION

Plants are significant for food as well as for medication. Understanding of taxonomic classification, ecology, nature conservation of herbs and pathways for the synthesis of secondary metabolism for the development of medicine. Ethnobotany, phytochemistry, plant physiology and ecology research are needed to protect the world population from current and future infections.

Conflicts of Interest: The authors declare no conflict of interest.

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