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Effectiveness of *Jatropha curcas* as Antiviral Agent: A Review

Glenn Fiel D. Buquia, Almarie T. Dionaldo, Chlaire Dimple Buyser, Eddo Erum, Marc Ronan S. Ng, Erwin M. Faller*

Pharmacy Department, San Pedro College, Davao City, Philippines

ABSTRACT

Among the viruses known to infect humans, the influenza virus is a virus that can infect 5-15% of the population worldwide [1] and globally there are around 37.7 million individuals known to be infected with the human immunodeficiency virus [2]. Influenza virus is a particular virus which exists today that originated from both birds and swine. There are three identified influenza viruses which are A, B, and C which are further classified into subtypes. The human immunodeficiency virus is a type of virus which can be transmitted through body fluids. There are two subtypes of the HIV recognized which are the HIV-1 and HIV-2. *Jatropha curcas*, *a plant* which belongs to the Euphorbiaceae family, is used through multiple ways such as medicine, industrial products, and in biodiesel. Through multiple studies on *Jatropha curcas* has been investigated to have a potential to inhibit the hemagglutinin protein that is present in the influenza virus and an anti-HIV activity that prevents the entrance of an HIV-1 cell. Thus, *Jatropha curcas* can be a potential antiviral treatment for future drug development.

KEYWORDS: Influenza Virus, Human Immunodeficiency Virus, Antiviral agent, *Jatropha curcas*

INTRODUCTION

The influenza virus is a unique virus among the respiratory viruses that exists in regards to their frequent antigenic changes, periodic occurrence, and its influence in the population.The influenza virus is able to cause onset of febrile respiratory disease across different age brackets which can be a cause of mortality for aged and chronically ill persons [3]. The greatest effect of the influenza virus was observed when the novel strains which are most susceptible caused worldwide outbreaks or a pandemic. In 1918, the influenza virus outbreak claimed as many as 100 million lives worldwide [2]. The medical knowledge about HIV is still currently evolving that leads to the comprehension of the disease in both its immunology and clinical symptoms. The antiretroviral therapy medications present, provided the method of mitigating HIV that resulted in patients living longer and leading a healthy life with the disease [4]. Strategies present worldwide include universal testing and implementation of the antiretroviral therapy, reducing the spread and rate of new diagnosis of HIV [4]. Although, there are still an estimated 1 in 4 individuals that are not aware of their diagnosis with HIV [4].

The plant *J. curcas* is known for its various medicinal actions. Due to its ample range of activity, extracts for cytotoxicity and its potential to be able to hinder hemagglutinin is currently being investigated [5]. The compounds that are present in the lead extracts contain the presence of flavonoids, saponins, and tannins [5].

Most approved antiviral drugs are currently associated with side effects which raised the concern for the development of antiviral medication towards plant-derived products since it is less toxic and has a low possibility of being resistant. Known bioactive chemicals have been used traditionally to cure certain diseases and are reported to inhibit both viral replication and transcription. 50% of existing plant derived plants are used in the western countries of the world. Plants have a variety of phytochemicals and they have antioxidant activities that can help to be able to hinder thriving genomes. Several plant products have also been investigated towards certain viruses such as the herpes simplex virus, HIV, influenza, and hepatitis [6].

Types of Virus that Affects Human

In the world there are currently 219 viruses which are reported to infect the human population. A particular earliest virus discovered that can infect the human species was the yellow fever virus in the year 1901 and currently there are around three to four species that are still being found every year. Among the viruses that can infect humans, there are around more than a fraction of existing viruses that infect other than human hosts such as animals.There are also various viruses that came from wildlife in origin. Among these viruses' half can be able to be transmitted by humans and the other half can be transmitted, which is enough to possibly cause major outbreaks. It is unavoidable that new unknown human viruses can be able to appear as the years progress that can come from other mammals or birds [7]. Occurrence of both emerging or re-emergence of viral infections had significantly influenced human health despite the advancement of biomedical knowledge.

Reservoirs to which human viruses came from are mainly from farm and wild animals, and insects [8]. The complicated relationship of "host to pathogen to environment" remains as the key to be able to understand both emergence or re-emergence of discovered pathogenic viruses. Factors such as the increasing population density, construction works, poor sanitation, weather change, and anthropophilic vector created the selective pressure on both reservoirs of the host and pathogen. Although a fraction of certain identified viruses is responsible for the origin of human diseases, there can still be an enormous number of microorganisms that are currently remaining to be able to cause disease and adjust around the world [9].

Influenza Virus

In each year influenza virus infects 5 %-15 % of the general human population that resulted in the mortality of about 500,000 individuals worldwide [2]. The influenza virus which belongs under the family Orthomyxoviridae is a single-stranded RNA virus segment [10]. There are three identified influenza viruses which are A, B, and C. Influenza A originated from both birds and swine. It can be further distributed into different subtypes which are found on both combinations of the haemagglutinin (HA) and neuraminidase (NA) proteins of the exterior of the virus [7].

At the present time there are about 18 hemagglutinin and 11 neuraminidase glycoprotein classifications that are known,which circulated on wild avian animals but there are only about three particular combinations that turned out to be reported to circulate to humans [7].

The three combinations that circulated to humans are the H1N1, H2N2, and H3N2. In the three combinations, H1N1 and H3N2 are the current cause of seasonal influenza virus outbreaks. Influenza B virus has no known source in animals but it has circulated in humans since the 1940s and it falls under two particular lineages which are the Victoria and Yamagata which separated during around the 1970s [11]. Influenza B virus however has been rarely studied than influenza virus A due to the fewer and smaller cases of epidemics. It also evolves slower compared to influenza A and it primarily infects children [9]. The influenza C is a kind of the virus which is not often known and it triggers symptoms that are similar to a cold and infection of the lower respiratory tract area [7]. The influenza C is a human pathogen but it has been reported to be found in animals such as pigs, dogs, and cattle. The influenza C was found in 1947 and the disease burden is poorly described in detail up until recently because of the struggle of separating the virus in a cell or tissue culture [7]. The virus contains a seven (7) segmented genome that is able to encode 9 viral proteins while both the influenza A and B have about 8 particular segmented complete sets of genetic information that are able to encode 10 viral proteins [7]. The influenza C hemagglutinin esterase fusion that is decoded in the segment 4 carries the roles of both the HA and NA proteins in aiding the receptor binding, dividing of the sialic acid including the membrane fusion [7].

HIV

The human immunodeficiency virus or HIV is a particular lentivirus that exists under the Retroviridae. This can be passed on both through the blood and body fluids [4]. At the present time there are currently two of the HIV subtypes that are recognized and those are the HIV-1 and HIV-2. The Human immunodeficiency-1 subtype originated from chimpanzees while the HIV-2 subtype originated from white-collared mangabey monkeys [12]**.** Human immunodeficiency virus-1 can be primarily discovered around the world, once it does go untreated it can possibly progress to acquired immunodeficiency syndrome. HIV-1 can further be identified towards four genetic classifications which are the group M, group N, group O, and group P [4]. Among the genetic groups of the HIV-1, the group M of the genetic group is the individual reportedly accountable for the global rampant spread of HIV which can be further classified into subtypes or clades [4]. Each of the subtypes of the group M can be associated with certain geographical areas. HIV-2 can cause an illness that is similar towards HIV-1 yet it can be slightly aggressive and it is typically happening in western Africa [4]. In the perspective of treatment, Human immunodeficiency virus-2 is innately resistant towards the non nucleoside reverse transcriptase inhibitors. If an individual were to be infected with Human immunodeficiency virus-1, the individual would have the virus in the bloodstream, also in this current phase the virus can be detected across the blood through the nucleic acid amplification over the viral RNA or identification of the viral protein p24.

After a span of 28-35 days since the virus infection has occurred, the antibodies towards the virus become noticeable [4]. If specific antibodies have developed in the body, the viral levels can be able to decline in a constant condition and the patient will mainly last as asymptomatic for some years to come. Around a period of time has passed the CD4 T lymphocyte can gradually reduce due to the death of particular cells in combination with the stimulation of the CD8 T lymphocytes [4].

Antiviral Medications

Drug-resistant HIV

Researchers employed in vitro microco-culture followed by drug susceptibility assays to assess resistance to Azidothymidine (AZT) and Lamivudine (3TC) [13]. Using the Soxhlet apparatus, Jatropha curcas leaves were extracted. Further research was conducted on methanolic (ME) and aqueous (AE) extracts. Secondary metabolites were detected using high-performance thin layer chromatography, and in vitro cytotoxicity was determined using the MTT assay. In post- and pre-infection interaction experiments, antiviral activity was assessed by p24 inhibition [13]. HIV isolates that are resistant to AZT/3TC have been obtained, and genotypic drug resistance is being investigated. The leaf extracts of *Jatropha curcas* had previously unreported antiviral and likely entrance inhibitory efficacy against potentially drug-resistant HIV. With more research, we believe *Jatropha curcas* could be a suitable candidate for anti-HIV therapy [13].

Virus and viral titration

A 50 percent tissue culture infective dose (TCID50) titration was used to measure viral titre after influenza virus stocks were grown in cell culture using Madin Darby canine kidney (MDCK) cells [14]. MDCK cells were cultured in full MEM for viral titration.

A confluent MDCK cell monolayer on 96-well tissue culture plates was washed once with serum-free MEM before use. Serial 10-fold dilutions of virus were incubated for 4 days at 37 C with 5% CO2 in triplicate wells (200 uL/well) in serum-free MEM containing 0.3 percent BSA and 2 ug/mL L-(toslyamido 2- phenyl) ethyl chloromethyl ketone (TPCK)- treated trypsin and Nystatin (50 U/mL) [7].

Wells positive for viral development were identified by staining the cells with 0.1 percent trypan blue, and the TCID50 titre was calculated using the Reed and Muench technique [11].

***Jatropha curcas* Linn.**

Jatropha curcas also commonly known as "*Tubang bakod*," "*Tuba-tuba*," or "*kasla*" in the Philippines, this plant belongs to the family of *Euphorbiaceae.* Jatropha curcas is used in multiple ways, including: in herbal medicine, industrial products and, in biodiesel. Jatropha curcas' sap, oil, wood, and leaves is used for wound healing, anti-rheumatism, bleeding, and skin diseases. It is also reported that it is used as a cough remedy, laxative, toothache reliever, help in relieving sprains, antidote for poisoning, and treatment of gonorrhea and syphilis [15].

Further, *Jatropha curcas* contains multiple phytochemicals, including Diterpenes (phorbol esters, dinorditerpenes, deoxypreussomerins, pimarane, lathyrane, rhamnofolane, sesquiterpenoids, and triterpenes), alkaloids, flavonoids, phenolics, Lignans, neolignans, coumarins, cuomarine-lignoids, phytosterols, and proteins [15].

Similarly, according to the study of Prasad *et al.*, every section of the plant (leaves, stem bark, latex, seeds, and roots) has different isolated chemical compositions (both harmful and beneficial phytochemicals)[10]. Moreover, according to Chhabra et al (1990), flavonoids, vitexin, sterol stigmasterol, triterpenae alcohol, β-D-sitosterol, apigenin, β- D-glucoside, alkaloids, sapogenins, isovitexin, and 1 - triacontanol can be found on the leaves of J.curcas[16]. While Staubmann et al (1999) mentioned that leaves of the said plant contains isolated pyrimidine-2,4-dione, and 5-hydrxypyrrolidin-2-one [17]. Aside from the mentioned chemical composition above, dimer of tripene alcohol, stigmast-5-en-3β, 7-keto-β-sitosterol, cholest-5-en-3fl, 7β-diol, and campesterol were also found in Jatropha curcas leaves [18 - 21]. Moving to the othe part of the plant, stem bark is composed of different chemicals including B-amyrin, alkaloids, glycosides, taraxerol, saponins, flavonoids, steroids, beta-sitosterol, and tannins [22, 23]. Meanwhile, latex contains curcacycline (A and B), wax, saponins, curcain, and also tannins [24 - 28]. Steroids, saponins, Jatropholol, beta-sitosterol, marmesin, alkaloids, curculathyranes A, curculathyranes B, Jatropholone A and B, propacin, curcusones (A, B, C, and D), coumarin (coumarino - lignan jatrophin a,d tromentin, beta - d - glucoside, and taraxerol is found to be a component of roots of J. curcas [29 - 31]. Also, seed contains chemicals including phorbol esters, curcin, JL (lipase found in J.curcas), and JEA and JEB (two esterases found on J.curcas) [32 - 35].

However, aside from the medicinal properties of *Jatropha curcas* it cannot be denied that this contains toxins which may bring harm to those who use it. It was stated that the most toxic phytochemicals of this plant are curcin and phorbol ester. It was also stated that 96.5% of phytate, 95.3% of trypsin inhibitors, and 85.7% of phorbol ester (all of which are major toxic components) is located on the endosperm of the seeds. The toxicity of *J. curcas* on humans expresses the symptoms of vomiting, delirium, giddiness, decrease in visual capacity, diarrhea, muscle shock, and high pulse rate [36].

Moreover, according to the study of Abdelgadir, H.A., and Van Staden, J. (2013), there are numerous pharmacological benefits of Jatropha curcas, and this includes anti-inflammatory effects, antioxidant activity, antimicrobial activity, anticancer activity, antidiabetic activity , analgesis activity, hepatoprotective activity, wound healing activity, anticoagulant and procoagulant activity, antifertility activity, and antiviral activity [36].

Due to the expansive activity of *Jatropha curcas* the researchers Agrawal *et al*., (2020) investigated *Jatropha curcas* for its potential cytotoxicity and inhibition of hemagglutinin protein of influenza virus through the extraction of aqueous and methanolic extract in the leaf of the aforementioned plant [37].

Potential Anti-HIV Activity of *Jatropha curcas*

The majority of India's traditional medical systems include herbs or natural plant products of some kind of medicinal plant. As a result, it's not unexpected that ancient medications are still active. Fighting Aids can be investigated thoroughly to see what function plant natural chemicals play for anti-HIV action [38].

Several medicinal plants Anti-HIV properties have been identified in plants. Significant Improvement was already achieved from the investigation of organic chemicals with Anti-Human Immunodeficiency Virus properties from over the past two decades [39].

Secondary sources Natural-source metabolites exhibited moderate to good results against HIV. Other antibacterial properties of *Jatropha curcas* Linn, despite the fact that *Jatropha curcas* Linn has been found to have antimicrobial action, there are little findings on its anti-HIV potential [39].

According to one research, *J. curcas* Linn decoction had presence of anti enzyme activity and decreased HIV-induced mortality with minimal anticancer activity. Anti-HIV efficacy was observed in *J. curcas, J. multifida, S. africanus,* and *Trigonostemm xylophylloides* by inhibiting HIV-1 cell entry [38]. From another investigation, the leaves of *J. curcas* were employed to treat human immunodeficiency virus associated symptoms such as dermatitis and thrush in Tanzania. The current study looked at multiresistant HIV-1 inside a patient cohort in Mumbai setting [39]. The phenotypic drug resistance assays used a limited sample size to detect drug-resistant HIV-1. Plant extracts from *Jatropha curcas* Linn leaves were tested for antiviral, virucidal, and/or entrance inhibitory activities [38].

Jatropha oil, used to manufacture biodiesel, can also be utilized as an initial ingredient. Both sources are freely available. The scientists used five steps to convert croton oil to prostratin and DPP. The synthesis method is versatile enough to produce related compounds with improved therapeutic efficacy or decreased side-effect profiles. Both chemicals have demonstrated to activate HIV in cultured cells and protect healthy cells from infection. The AIDS Research Alliance, a non-profit organization based in California, wants to continue preclinical study on prostratin. This is believed to be the first time traditional healers gave local groups a stake in a complex [39].

An alternate and less expensive treatment for drug-resistant HIV is suggested. The antiviral efficacy of *Jatropha curcas* leaf extracts was evaluated using an isolated potentially drug-resistant HIV. After virus isolation, medication susceptibility assays were used to determine AZT and Lamivudine resistance (3TC). Soxhlet extraction of *Jatropha curcas* leaves was used. Then followed by methanolic (ME) and aqueous (AE) extracts. Secondary metabolites were identified using HPTLC and cytotoxicity by the MTT test. Antigen antibody inhibition was used to assess antiviral activity post and pre-infection. HIV strains resistance to AZT/3TC have been identified, and genotypic drug resistance is being investigated. Antiviral and anti-HIV effectiveness of *J. curcas* methanolic extract combat drug-resistant human immunodeficiency virus was observed. *Jatropha curcas* could be an anti-HIV alternative with more research [13].

Thirty-nine (39) anti-HIV effects of Panamanian plant compounds have been examined to methanolic aqueous extracts. Extracts suppressed HIV-induced cytotoxic effects as well as human immunodeficiency virus, human immuno-virus reverse polymerase and protease enzymes in cultured cells [40]. *Chamaesyce hyssopifolia* (Euphorbiaceae), *Cordia spinescens* (Boraginaceae), *Hyptis lantanifolia* (Labiatae), and *Tetrapterys macrocarpa* (Malpighiaceae) aqueous extracts were shown to be effective hindrance of HIV-1 reverse transcriptase with a half-maximal inhibitory concentration of six to eight grams per milligrams. 7 of the 39 plants inhibited HIV-1 protease moderately with a Half-maximal inhibitory concentration of forty three to one hundred grams per milliliter. The inhibitory chemicals of Chenopodium spinescens, Jatropha curcas, and Cuphea hyssopifolia, are likewise known to have a potential mechanism of action [41].

Anti-HIV drugs are being developed to target various aspects of the viral growth cycle, including adherence and reproduction, entrance, reverse transcriptase gene transcript, and protease protein processing [16]. PR is an acylated enzyme that degrades viral particles to form and generate contagious and mature virions. , whereas RT transforms viral replication RNA into virions' dual DNA . They are thus essential enzymes in HIV replication prevention. Developing an effective AIDS therapy has been a huge public health issue all over the globe. In recent years, combining RT and PR inhibitors has proven to be the most effective HIV treatment. This shows promise for treating HIV-infected people [40].

Twenty-two Thai medicinal herbs were extracted with water and 80% ethanol and radiometrically testedHIV-1 reverse transcriptase inhibiting activities in vitro . Eleven water extracts and seven ethanol extracts were revealed to have antiHIV-1 RT activity. *Jatropha curcas* L. water extracts *Elephantopus scaber* L. stem barks, water extracts. leaves and roots, and ethanol extracts of *Securinega virosa* Baill branches and leaves all had potent HIV-1 RT inhibitory effects. The percentage of inhibition ratio (percent IR) for them was 97.5, 96.9, and 88.2, respectively. The extracts of *J. curcas* and *S. virosa* showed positive tannin reactions, whereas the extract of *E. scaber* did not [41].

Flavonoid is another metabolic component discovered in *J. curcas* stem bark preparations. Among other biological actions, it had bactericidal, anti-allergic, anti-angiogenic, anesthetic,anti-inflammatory, anticancer, and antioxidative characteristics [42].

As a result, availability of these substances in Jatropha curcas confirms the antibacterial activity that has been found. Individuals of remote regions in India's Churu district utilized and used this plant's branches as toothbrushes to improve gums and treat mouth sores [43]. The toxic effect of HIV was significantly reduced when *J. curcas* branches were extracted with water as the solvent [44]. *J. curcas* stem bark has been discovered to become the origin of biologically live antibacterial chemicals, comprehensive research a description of its in vivo potency and toxicity profile presently underway, making the plant a potential candidate for antibiotic and antifungal drug bioprospecting [45].

Anti-influenza virus Activity of *Jatropha curcas*

Influenza virus has long been a danger and a strain to humanity, with a variety of types causing diseases. Seasonal illnesses, outbreaks, and even pandemics are frequently caused by these distinct influenza virus subtypes [5]. The search for all possible and potential sources of antiviral drugs is a must, especially when the various strains of this virus can quickly develop resistance to such drugs especially when they are greatly used. One of the greatest potential sources would be the vastly unexplored natural substances such as the *Jatropha curcas* from the *Euphorbiaceae* family [5].

A majority of the *Jatropha curcas'* parts have been used for a variety of treatments for both human and veterinary complications.

This plant is already well-known for its wide range of medicinal applications, including antibacterial and antibiotic properties against *Escherichia coli* and *Staphylococcus aureus*, and the anticancer properties of the Jatrophine alkaloid found in the latex of Jatropha curcas. Latex may also be used to treat mouth infections in children, rheumatism and skin diseases, muscular aches, antimalarial characteristics, and even ulcers in domesticated cattle [46]. The extent of the therapeutic capabilities of the *Jatropha curcas* lead to the investigation of capabilities of inhibiting the hemagglutinin of influenza virus [5].

METHODS

The review of *Jatropha curcas* was based on information collected from journal databases and publicly accessible sources, including Sciencedirect, Google Scholar, Research Gate, FDA news sites, Elsevier, PubMed, MDPI, and Open access journals. The article search began on April 7, 2022. Furthermore, the effectiveness of *Jatropha curcas* has been evaluated. For easy accessibility and to avoid any documentation conflicts, all journals reviewed were arranged methodically and placed in one file. The investigation was thorough in order to determine the value of *Jatropha curcas* as an antiviral agent.

RESULTS

HIV isolation and phenotypic medication resistance assessment using PBMC co-cultivation

30 samples were processed for PBMC co-cultivation, resulting in seven HIV isolates, or a 23.33 percent isolation rate [13]. By comparing published against Escherichia coli and Staphylococcus aureus, the anti-cancer capabilities of the Jatrophine alkaloid discovered in the of the drugs against HIV isolates, phenotypic drug resistance was estimated (HIV-1IIIB) [5][47]. The fold increases in IC50 values are shown in table 1. Secondary metabolite extraction and detection [5] .

HIV isolate	AZT (µM)	Fold increase	3TC (µM)	Fold increase	D4T (µM)	Fold increase
HI/4C	0.001418	0.01	15.35	**64.58**	ND	ND
HI/15C	0.03146	0.19	2.645	**11.13**	66.23	**76.18**
HI/23C	72.13	**445.25**	8.041	**33.83**	20.82	**23.95**
HI/35C	3.071	**18.96**	3.503	**14.74**	45.66	**52.52**
HI/53C	48.81	**301.30**	14.41	**60.62**	33.41	**38.43**
HI/60C	82.73	**510.68**	5.403	**22.73**	18.55	**21.34**
Standard IC_{50}	*0.162*		*0.2377*		*0.8694*	

Resistance is represented by figures of fold increase in bold type.

Table 1: Fold increases in IC_{50} values of AZT, 3TC, d4T against HIV isolates [47].

Secondary metabolite extraction and detection

Jatropha curcas Linn leaves were extracted with 2.2 g of hexane, 1.3g of methanolic extract, 1.5 g of dichloromethane (DCM), and 1.8 g of aqueous extract using the Soxhlet apparatus [45]. Hexane and DCM extracts were excessively sticky and insoluble in water or RPMI-1640 medium, only Methanolic (ME) and Aqueous extracts (AE) were used for the following tests [47].

Jatropha curcas Linn. secondary metabolites HPTLC examination revealed the presence of leaf extracts. Tannins, flavonoids, and saponins were found in ME plant extracts, whereas flavonoids and saponins were found in ME plant extracts (Table 2) [45]. The plant extracts' HPTLC fingerprint is displayed. in Figure 1 [5][47].

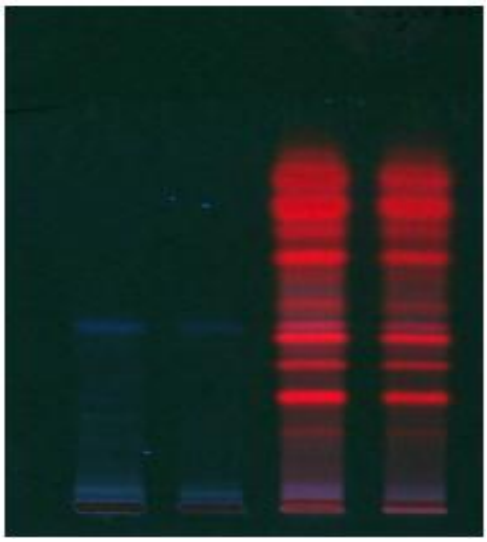

Figure 1: Jatropha curcas Linn extracts were HPTLC fingerprinted at 366 nm wavelength with a Linomat 5 Semi-automatic Sampler and densitometric evaluation with a Camag TLC Scanner and Visualizer. Aqueous Extract fingerprints are shown in Lanes 1 and 2, while Methanolic Extract fingerprints are shown in Lanes 3 and 4 [5][47].

2° Metabolite	Methanolic Extract	Aqueous Extract
Alkaloids	-	-
Tannins	-	+
Flavonoids	+	+
Saponins	+	+

Key: '-' :Not detected; '+' :Detected

Table 2. Secondary metabolites in methanolic and aqueous extracts of *Jatropha curcas* Linn. leaves [47].

Plant extract cytotoxicity in vitro

The CC_{50} was calculated after using the MTT test to detect in vitro cytotoxicity. Figure 2 reveals that Methanolic extract had 35.49 mg/mL and Aqueous extract had 32.07 mg/mL of Jatropha curcas Linn CC50 values [5].

Figure 2: Jatropha curcas Linn. cytotoxicity MTT test on Peripheral Blood Mononuclear Cells using methanolic (■) and aqueous (●) leaf extracts (PBMCs). GraphPad Prism software was used to calculate the CC_{50} [5][47].

Anti-influenza Activity

The *Jatropha curcas* leaves' methanol and aqueous extracts were subjected to an investigation to discover its potential to inhibit hemagglutinin of the influenza virus. Flavonoids, saponins, and tannins were present in the extracts after a phytochemical screening. A study has evaluated the aqueous and methanol extracts through three varied experiments of the in vitro system; Pre-penetration, simultaneous, and post-penetration exposure [5].

Methanol extracts' inhibitory effect

Methanol extracts of the leaves of *Jatropha curcas*' inhibitory effect was put through a hemagglutination assay. Inhibition is determined when HA hemagglutinin (HA) titre is reduced. The concentrations used in the assay for the methanol extracts of the *Jatropha curcas* range from 0 mg/mL to 15 mg/mL. From the three experiments, pre-penetration, simultaneous, and post-penetration exposures, they all show a complete inhibition of the virus from concentrations 1 mg/mL to 15 mg/mL of the methanol extracts. [5].

Aqueous extracts' inhibitory effect

A hemagglutination assay was also performed for the aqueous leaf extracts of the *Jatropha curcas*. Similar to the experiments done to the methanol extracts, inhibition is determined by the reduction of hemagglutinin (HA) titre. The concentrations used in the assay for the aqueous extracts of the *Jatropha curcas* range from 0 mg/mL to 25 mg/mL. The virus was completely inhibited across all three experiments, pre-penetration, simultaneous, and post-penetration exposures, in concentrations ranging from 5 mg/mL to 25 mg/mL. Post-penetration exposure, however, yielded only 93.75% inhibition at 5 mg/mL [5].

Further lowering the concentration shows consistency and yields better inhibition to post-penetration and simultaneous exposures against pre-penetration exposure [5]. The study revealed that both extracts have higher anti-influenza activities during the simultaneous and post-penetration exposures in contrast to the pre-penetration experiments.

This showcases the ability of the *Jatropha curcas* leaf extracts to prevent the cells from viral adsorption as it inhibits the viral hemagglutinin. This inhibition effect is further pronounced when added post-infection several more times. This suggests that there is a successful prevention of the infection of newer cells [5].

A study conducted by Matsuse et.al. (1998) on the aqueous extracts of *Jatropha curcas* showed the presence of inhibitory substances from the active fraction, specifically the 6,7-dimethoxycoumarin and the 5,7-dimethoxycoumarin, which exhibited satisfactory viral concealing effects [43].

CONCLUSION

Due to all the data gathered by the researchers, it is concluded that there is a relationship with Jatropha curcas and antiviral activity on influenza virus and Human Immunodeficiency Virus (HIV). As a result of the literature review, it has been found that Jatropha curcas was one of the plants considered to have an anti-HIV activity by preventing the HIV-1 cell entrance. It is also used to treat HIV-related symptoms like oral candidiasis and skin rashes. Also, Jatropha curcas has a potential in inhibiting the hemagglutinin protein of influenza virus, making it a potential antiviral treatment against the aforementioned disease.

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