CORPUS PUBLISHERS

Advance Research in Organic and Inorganic Chemistry (AROIC)

Volume 3 Issue 1, 2022

Article Information

Received date : December 12, 2021

Published date: March 10, 2022

*Corresponding author

KN Ngbolua, Department of Biology, Science faculty, University of Kinshasa, P.O Box 190, Kinshasa 11, DR Congo. E-mail: jpngbolua@unikin.ac.cd, mobile: +243 816879527

Keywords

Fruits; Antiviral Activity; Covid-19; Management; Democratic Republic of the Congo

Review Article

Phytochemistry and Antiviral Activities of Some Fruit Plant Species As Potential Resources For Anti-Viral Agents

Mbadiko CM[1], Matondo A[2], Kilembe TJ[2], Bongo NG[1], Inkoto CL[1], Lengbiye EM[1], Gbolo BZ[1], Falanga MC[1], Tshilanda DD[2], Tshibangu DST[2], Mbemba TF[1], Ngbolua KN[1*], Mpiana PT[2]

[1]*Department of Biology, Science faculty, University of Kinshasa, P.O Box 190, Kinshasa 11, DR Congo*

[2]*Department of Chemistry, Science faculty, University of Kinshasa, P.O Box 190, Kinshasa 11, DR Congo*

Abstract

The aim of the present work was to review data on the antiviral activities of some fruit plant species and their macronutrient composition. This was done with the aim of promoting these plants for the management of viral diseases, particularly covid-19. Several fruit plant species are mentioned in the literature for their antiviral properties. These include: Cocos nucifera, Garcinia mangostana, Malus domestica, Mangifera indica, Musa acuminate, Musa balbisiana, Musa paradisiaca, Nephelium lappaceum, Passiflora edulis, Persea americana, Syzygium aromaticum, Syzygium guineense, Syzygium malaccense, Vitis vinifera. Some compounds of the above-mentioned fruit plants can interact with the therapeutic targets of various viruses including SARS-Cov-2 proteases. Others, on the other hand, are known to have immunostimulatory or both antiviral and immunostimulatory activities.

Introduction

African continent abounds in very diverse food and medicinal plants. According to Mangambu et al. [1], out of about 300,000 species of medicinal plants recorded on the planet, more than 200,000 are found in tropical African countries. Some of these plants are used to treat diseases of bacterial, parasitic and viral origin [2]. Regarding viral diseases, they are mentioned among the main causes of death in the world [3]. The pandemic due to the Covid-19 virus is a good example of the level of threat posed by viral pathologies [4,5]. However, there are few effective therapies for these types of diseases. Moreover, given the rapid emergence of resistance, the high cost of classical antiviral drugs and especially the side effects of synthetic antiviral drugs, it is mandatory to find alternatives nowadays. The exploration of plants likely to have antiviral properties is an indispensable approach [4]. Indeed, plants have been considered since the dawn of time as an important source of active compounds. Scientists are inspired by phytocompounds to develop new drugs including antiviral compounds [3]. In addition, plant-derived antiviral phytocompounds in most cases have multiple therapeutic targets and can affect several stages of the viral cycle. Preclinical and clinical trials have indicated that natural antivirals including those from plants have acceptable antiviral value [3]. There are several publications in the literature on the action of extracts of many food and/or medicinal plants against various types of viruses causing diseases in animals including humans [4-7]. In this work, we have listed some fruit plants whose extracts have antiviral properties according to the literature. These are in particular: *Carica papaya* L., *Cocos nucifera* L., *Garcinia mangostana* L., *Malus domestica* Borkh, *Mangifera indica* L., *Musa acuminate*, *Musa balbisiana* (Colla), *Nephelium lappaceum* L., *Passiflora edulis*, *Persea americana* Mill, *Syzygium spp.* (S. *aromaticum*, *Syzygium cordatum* Hochst. ex Krauss, *Syzygium guineense* (Willd) DC) and *Vitis vinifera* cv. Tshibangu et al. [8], showed that most of the fruits of the above plants are commonly consumed in the city of Kinshasa, Democratic Republic of Congo. We believe that since these plants have been used for centuries in food and/or traditional medicine, they would be good candidates for the management of viral pathologies including especially Covid-19 given their approved antiviral properties. The present review consisted of an inventory of data on the actions of these plants against different types of viruses, including SARS-CoV-2, as well as the compilation of information on their nutrient composition. This work is part of the objective to enhance the value of fruit plants consumed in the Democratic Republic of Congo and elsewhere by promoting their possible use in the management of viral pathologies, particularly Covid-19.

Literature Review Method

Several databases were used to collect information on the phytochemistry and antiviral activity of our fruit plants. Among these databases, we can mention PubMed, PubMed Central, Science Direct, Scielo, DOAJ, Science alert and Google scholar. Were used the scientific names of fruit plants surveyed as keywords during the data search. Moreover, other keywords such as antiviral compounds and vuricidal or antiviral activity of edible fruits were also used.

Literature Review

Bioactive compounds and Antiviral properties

Data on bioactive compounds isolated from some fruits and their antiviral properties are summarized in the table above:

Table 1: Antiviral properties of fruit plant species and their bioactive compounds

Scientific Names	Types of Exracts or Identified Active Compounds	Names of Viruses	Mechanism of Action	References
Carica papaya **L**	Carpaine, dehydrocarpaine I and II, cardenolide, p-coumaric acid, chlorogenic acid, caricaxanthin, violaxanthin and zeaxanthi**n**	Dengue virus (DENV)	Dengue serotype 3 RNA-dependent RNA polymerase (RdRp) (*in silico*)	[9]
	Carpaine, dehydrocarpaine I and II (alKaloids)	Influenza A (H1N9)	Influenza neuraminidase (NA) (in silico)	[9]
	Caricaxanthin, violaxanthin and zeaxanthin	chikungunya virus	Glycoprotein (E3-E2-E1) (in silico)	[9]
	p-coumaric acid and chlorogenic acid		Non-structural protein 2 (nsP2) protease	[9]
	Caffeic acid	HSV-1	HSV-1 multiplication mainly before the completion of viral DNA replication	[10]
		Human coronavirus NL63 (HCoV-NL63),	Inhibited the replication of HCoV-NL63, and specifically blocked virus attachment	[10]
	Methanolic and aqueous extracts of Leaves	DENV2	nd	[11,12]
		HIV	nd	[13,14]
Cocos nucifera L.	Catechins, MCFA (Medium chain saturated acids), Coconut oil: Mono, di and tri-triglycérides, saturated Fas, **lauric acid**, caprylic **acid**, **capric acid** or **myristic acid**	Visna virus, cytomegalovirus (CMV), and Epstein-Barr virus, Herpes Simplex Virus, influenza virus, leukemia virus, pneumono virus, Hepatis C	MCFA (Medium chain saturated acids) in coconut oil destroy primarily these organisms by disrupting their membranes, interfering virus assembly and maturation, Monoglycerides are active, di and tri triglycérides, inactive against these virus	[15,16,17]
	Coconut oil	HIV	destroy the viruses by disrupting their membranes, interfering virus assembly and maturation	[17]
Garcinia mangostana L.	α-Mangostins	HIV	Inhibiting role in the replication cycle of HIV virus, inhibits HIV-1 protease, Reverse transcriptase HIV-1	[18,19,20]
		Dengue virus (DENV-2)	Inhibit replication	[21]
		HCV	Inhibit HCV replication and decrease the NS3	[22]
	γ-Mangostin	HCV	-	[22]
	methanol extracts of Leaves	HSV-1	Inhibit HCV replication and NSSA leves	[23]
Malus domestica Borkh.	Genistei**n**	DENV	Inhibition of focal adhesion of virus	[24]
		JEV (Japanese encephalitis virus)	Suppress virus induced TNF production JEV	[24]
	Ursolic aci**d**	HIV and Epstein-Barr virus	nd	[25]
		HSV-1, HCV	Inhibit replication	[26,27]
	Apple pomace extracts	herpes simplex virus type 1 HSV-1) and 2 (HSV-2)	Inhibit both HSV-1 and HSV-2 replication	[28]
Mangifera indica L	Mangiferin	herpès simplex virus de type 1 et 2	Inhibit replication	[29,30]
		HIV	Inhibit réplication	[30,31]
		Hepatitis B virus	nd	[29]
		Poliovirus (PV)	Prevents virus adsorption and/or has a virucidal effect by preventing viral protein synthesis	[30]
	Aqueous leaf extracts	Newcastle Disease Virus (NDV)	nd	[6]
		IBD viruses	nd	[6]
	Extract pulp	Influenza virus H9N2	nd	[2]
Musa acuminate Colla	Inflorescence extract	human herpes virus type 1 and simple human herpes virus type 2	Inhibit replication	[32,33]
		Tobamovirus	Inhibit replication	[32,33]
Musa balbisiana (Colla)	Extract of flowers	*Tobamovirus*	Inhibit replication	[33]
Nephelium lappaceum L	Geraniin	DENV-2	Inhibited DENV-2 from attaching to the cells	[34,35]
		HSV-1 and HSV-2, HBV	nd	[34,35]
		HIV-1	HIV-1 replication	[34,35]
		enterovirus 71	Inhibit the human enterovirus 71 replications	[34,35]
	Hexadecanoic acid (palmitic acid)	HIV-1	Inhibit HIV-1 infection	[36]
	Apigenin	HSV, ADV, HBV, EV, CVB1	nd	[37]
	Seed extract (trypsin inhibitor extracted from the seeds)	HIV-1	Inhibiting the reverse transcriptase of HIV-1	[35,38]
	Ethanolic extract of Pulp	Type 2 dengue virus (DENV-2)	nd	[38]
	Rind extract	HSV-1	Anti-herpes simplex virus type 1	[39]

Passiflora edulis Sims	Aqueous and ethanolic extract of leaves	Herpes simplex viruses 1 and 2 (HSV-1, HSV-2), and on Varicella-Zoster virus (VZV)	Nd	[40]
	Nd	Anti-HSV-1 activity		[13]
Persea americana Mill	-2R,4R)-1,2,4-trihydroxyheptadec-16-yne [Avocadyne] -1,2,4-trihydroxyheptadec-16-ene -2,4-methylene-dioxyheptadec-16-ene-1-ol -1-acetoxy-2,4-dihydroxyheptadec-16-yne -(2R,4R)1,2,4-Nonadecanetriol. -(2R,4R,6E)-6-Nonadecene-1,2,4-triol (2R,4R,16E)-16-Nonadecene-1,2,4-triol [Avocadenol D	Dengue virus	Inhibition of the dengue virus replication	[41,42]
	Eugenol	HIV-1, HSV-1/ HSV-2	Nd	[26, 43]
	Apigenin	HSV, ADV, HBV, EV, CVB1	Nd	[26,43]
	Aqueous extract Leaf	AD3 (adenovirus type 3), HSV-1, ADV	Nd	[44]
Syzygium malaccense (L.) Merr. & L.M.Perry	Epicatechin gallate	SARS-Covid 2	Interact with SARS-Covid-2 Protease	[45]
Syzygium aromaticum (L.) Merr. & L.M.Perry	Nd	Hepatitis C Virus	nd	[46]
Syzygium cordatum Hochst. ex Krauss	Nd	Anti-HIV activity	Nd	[13]
Syzygium guineense (Willd) DC.	nd	HIV-1	Inhibits HIV-1 reverse transcriptase	[13]
Syzygium brazzavillense Aubr. &Pellegr.	Aqueous extracts (Bark, leaves)	Enteroviruses (CVB 2,3 and 4, Poliovirus 1), Interfere in the interaction between the capsid of these viruses and their receptor or interact with the capsid of CVB4, CVB2, CVB3, and poliovirus 1	Inhibit replication	[47]
Vitis vinifera cv	kaempferol 3-O-β-D-glucuronopyranosyl methyl ester, naringenin 7-O-β-D glucopyranoside, quercetin 3-O-β-D-glucuronopyranosyl methyl ester,	Syncytial Virus (RSV)	Nd	[48]
	Resveratrol	Murine polyomavirus (Py)	Inhibit synthesis of the viral progeny DNA, inhibit the viral replication	[49]
		MERS-CoV (Middle East Respiratory Syndrome coronavirus)	Inhibited MERS-CoV infection and prolonged cellular survival after virus infection, decreased expression of nucleocapsid (N) protein essential for MERS-CoV replication	[50]
		Epstein-Barr virus (EBV) enterovirus (EV71), herpes simplex virus (HSV), influenza, respiratory syncytial virus (RSV), and rhinovirus	Exert antiviral effects against these viral	[50]
	Caffeic acid	HSV-1	HSV-1 multiplication mainly before the completion of viral DNA replication	[10]
	Scirpusins A et **B**	HIV-1	Nd	[51]
	chloroform fraction of Fruit	*Herpes simplex-1* (HSV-1), virus *Parainfluenza* (PI).	nd	[52]
	Aqueous, ethanol and acetone extracts of fruit	AIV H5N1	Nd	[53]

Légend:
nd= non determine

The analysis of reports provided in the above table displayed that fruit plants investigated possess several interesting compounds. The literature indicates that several of these compounds are thought to have antiviral potential.

Among these compounds we have:

1) carpain, 2) dehydrocarpain I and II, 3) cardenolide, 4) caricaxanthin, 5)violaxanthin, 6) zeaxanthin, 7) p-coumaric acid, 8) chlorogenic acid, 9) Quercetin, 10) Kaempferol, 11) Catechin, 12) Epicatechin, 13) Epicatechin gallate, 14) Apigenin, 15) Geraniin, 16) Eugenol, 17) α-Mangostin, 18) γ-Mangostin, 19) Mangiferin, 20) Genistein, 21) scirpusins A, 22) scirpusins B, 23) Resveratrol, 24) lauric acid, 25) caprylic acid, 26) capric acid, 27) myristic acid, 28) Hexadecanoic acid, 29) Ursolic acid, 30) 2R,4R)-1,2,4-trihydroxyheptadec-16-yne [Avocadyne], 31) 1, 2,4-trihydroxyheptadec-16-ene, 32) 2,4-methylene-dioxyheptadec-16-ene-1-ol, 33) 1-acetoxy-2,4-dihydroxyheptadec-16-yne, 34) (2R, 4R)1,2,4-Nonadecanetriol, 35) (2R,4R,6E)-6-Nonadecene-1,2,4-triol (Avocadenol D), 36) caffeic acid, 37) Gallic acid, 38) Delphinidin.

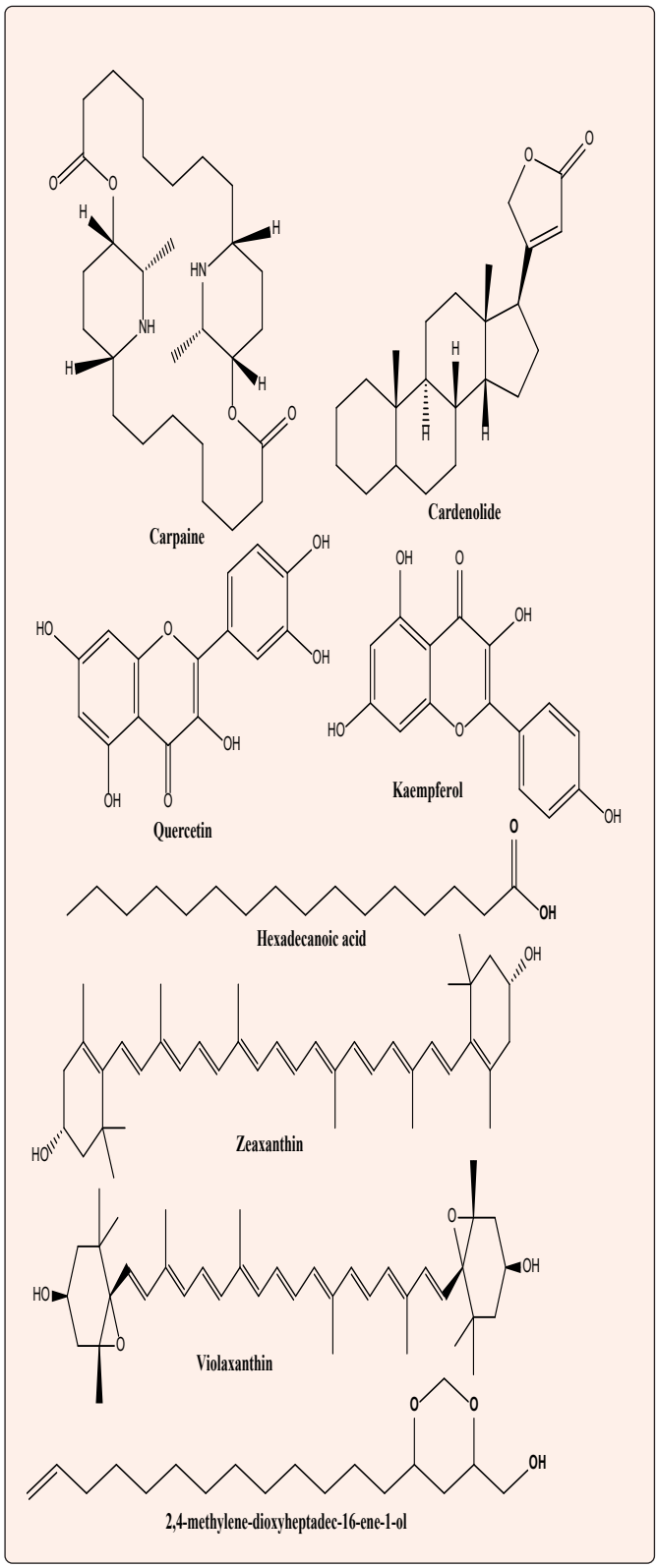
Several sources indicate that most of the plant compounds listed above, particularly polyphenols (corilagin, ellagic acid, and geraniin, etc.) accumulate in ripe fruits and that these levels can vary between cultivars [35,54].

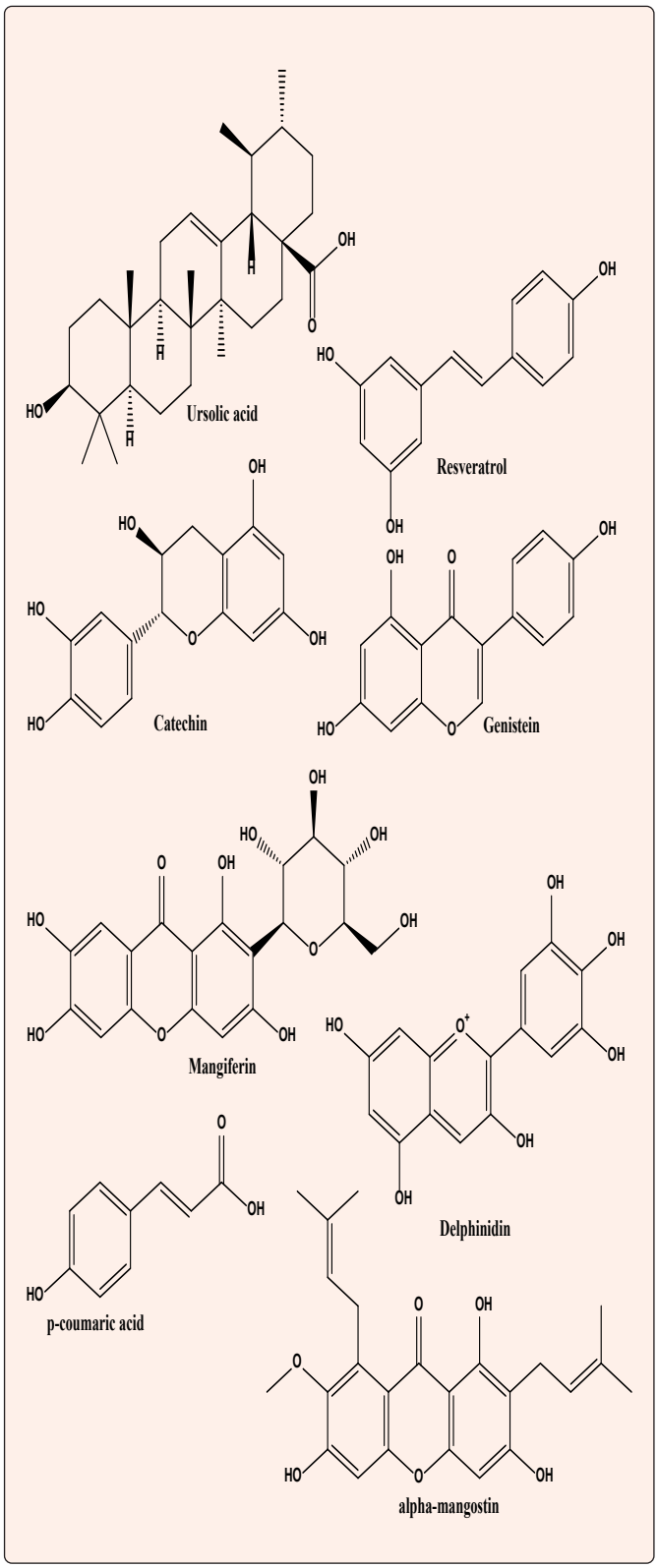
It also appears from Table 1 that *Carica papaya* extracts would be active against Dengue virus type 1 and 2, Influenza A (H1N9), chikungunya virus, HIV, HSV-1. Radhakrishnan et al. [9], identified *in silico* the compounds potentially responsible for the antiviral activity of *C. papaya*. These compounds belong to the groups of alkaloids (carpain, dehydrocarpain I and II, cardenolide), polyphenols (p-coumaric

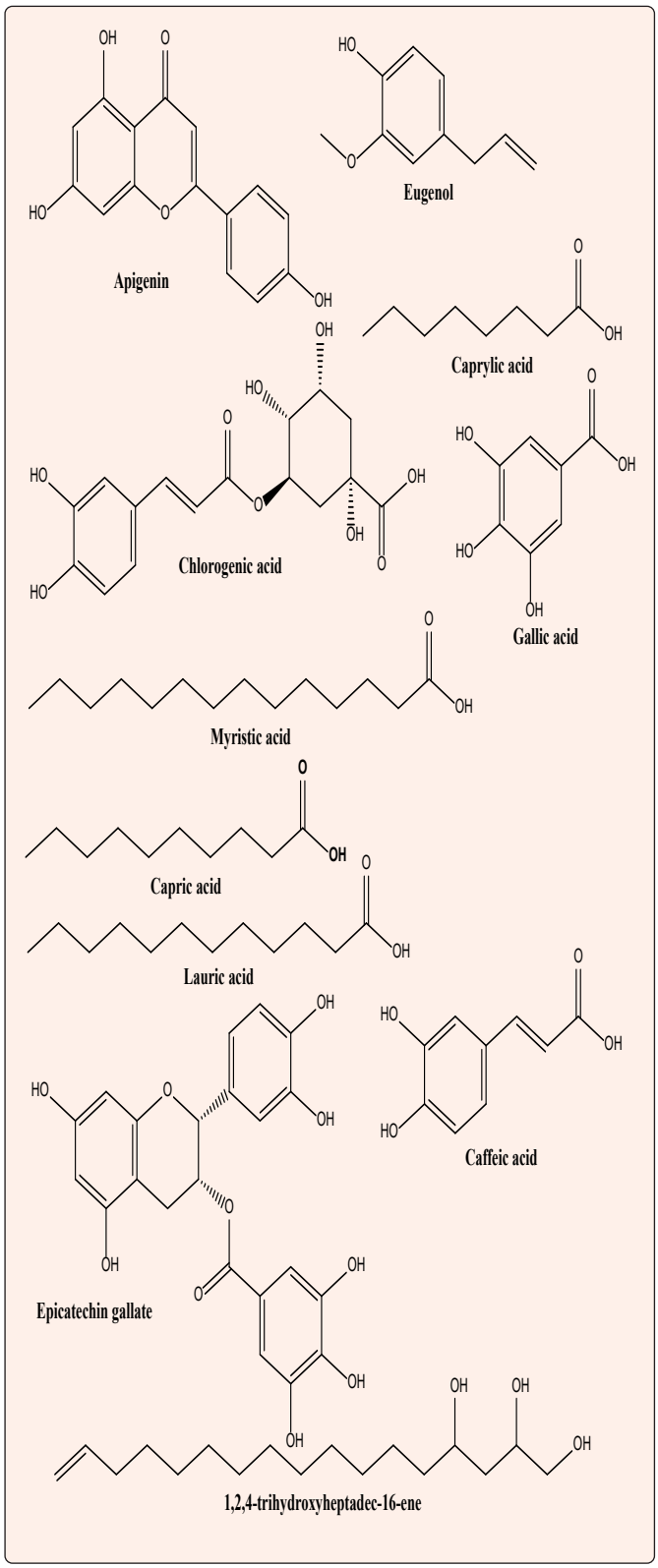
acid, chlorogenic acid, Caffeic acid) and carotenoids (caricaxanthin, violaxanthin and zeaxanthin). However, the compounds responsible for action against HIV or DENV2 have not yet been identified [12,13]. Furthermore, the literature indicates that the above compounds act via multiple therapeutic targets, including Dengue virus RNA polymerase (RdRp), Influenza Neuraminidase (NA), glycoprotein (E3-E2-E1) and chikungunya virus protease (Radhakrishnan et al., 2017) [9]. The action of caffeic acid against HSV demonstrated by Ikeda et al. (2011) [10], who estimated that caffeic acid prevents the completion of viral DNA. Meanwhile, Weng et al. [55], showed that p-coumaric acid, chlorogenic acid and Caffeic acid present an activity against the human coronavirus NL63 (HCoV-NL63). Regarding *Cocos nucifera*, Table 1 shows that it would have an action against Visna virus, Cytomegalovirus (CMV), Epstein-Barr virus, Herpes Simplex Virus, influenza virus, leukemia virus, pneumono virus, Hepatis C, and HIV, and informs that catechin and essential oil compounds: Mono, di or triglycerides or fatty acids (lauric acid, capric acid or myristic acid), would be at the origin of this activity by destroying the viral membrane or by interfering with the process of virus maturation [15,16,17]. As for *Garcinia mangostana*, Table 1 reveals that their antiviral action is linked to the presence of polyphenolic compounds called xanthones (α-Mangostins, γ-Mangostin). α-Mangostine acts on HIV type 1 by inhibiting the action of the reverse transcriptase, HIV-1 protease, or by interfering with other replication processes [18,19,20]. According to the literature, this compound is also believed to act against Dengue virus type 2 and viral hepatitis C virus by inhibiting the replication of these viruses [21,22]. In addition, Wahyunia et al. [21], showed that γ-Mangostin has an action against Hepatitis C virus although the mechanism of action of this compound has not been elucidated. The action of methanolic extracts of *G. mangostana* leaves on HSV-1 has also been reported by Nugrahaa et al. [23]. Concerning *Malus domestica* Borkh, Table 1 shows its action on Dengue Virus (DENV) and Japanese Encephalitis Virus (JEV). The literature indicates that this action is linked to the presence of Genistein and ursolic acid [24]. The effect of ursolic acid against Herpes Virus (HSV) or adenovirus strains (ADV-8,11), hepatitis virus B or C (HBV, HCV) or CVB has also been reported in the literature [26,27,37,56]. The action of *Malus domestica* extracts on Herpes Simplex Virus Type 1 (HSV-1) and type 2 has also been reported by Nurraihana et al. [28]. Caffeic acid is thought to be responsible for this activity [10]. It also appears from Table 1 that the antiviral action of *Mangifera indica* would be linked to the presence of xanthones and Mangiferine in particular. Mangiferin inhibits the replication of herpes simplex virus types 1 and 2, as well as HIV. It would also prevent the adsorption of Poliovirus (PV) in the host cell and also has a virucidal action on this virus by preventing the synthesis of viral proteins [30]. The action of aqueous extracts of *M. indica* leaves on Newcastle Disease Virus (NDV) or IBD viruses has also been reported in the literature [6]. Ali et al. [57], had shown that extracts from the pulp of *M. indica* showed an action on Influenza virus H9N2. Although these studies did not elucidate the mechanisms of action or identify therapeutic targets. In addition, an anthocyanin called Delphinidin was isolated from *M. indiaca* leaf extracts; its derivative Delphinidin-3-rutinoside showed activity against HSV-1. The presence of Kampferol in leaf extracts increases the antiviral potential of the extracts. The same is true for gallic acid isolated from the leaves of *Mangifera indica*. The action of the acid on HIV has been reported in the literature [58,59].

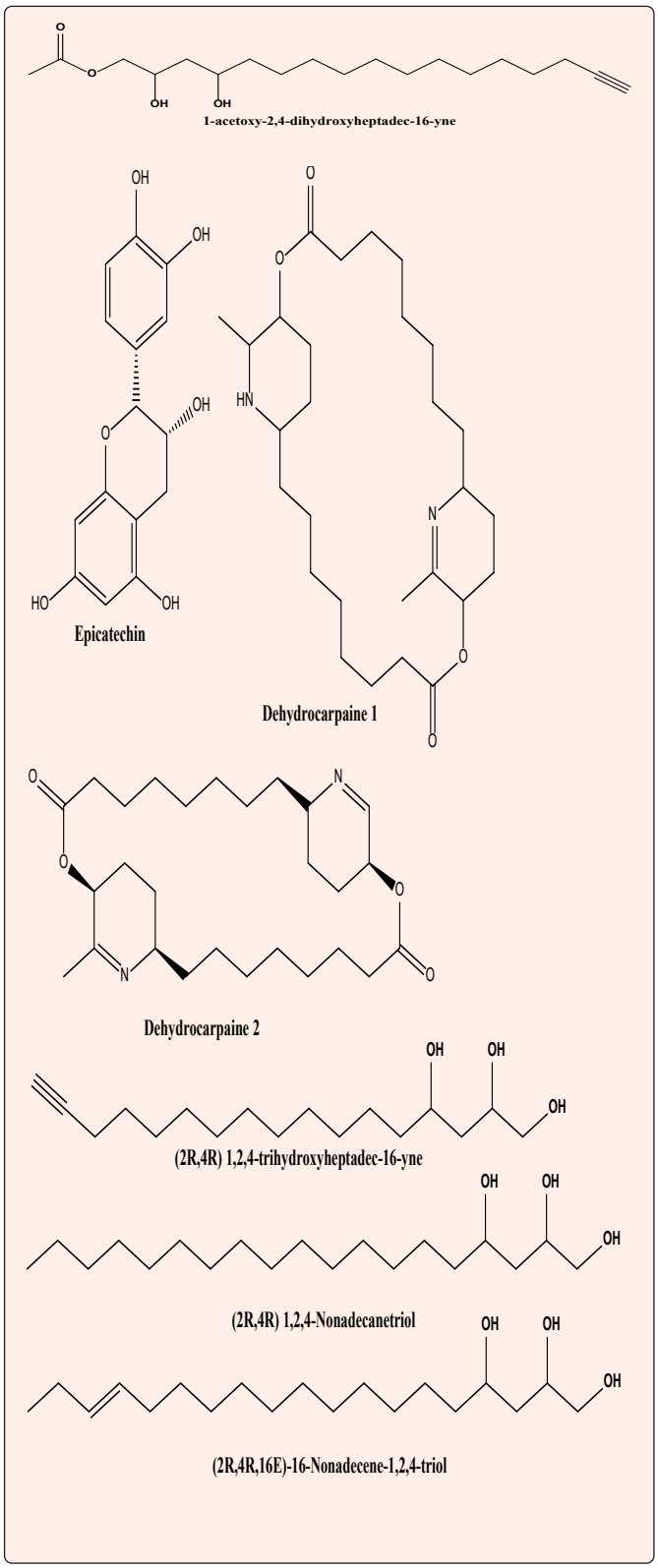
According to Ediriweera et al. [60], different organs of *M. indica* (Bark, leaves, fruit and flowers) include anti-viral compounds (Catechin, quercetin, Isomangiferin, Mangiferin, Methyl gallate, N-Pentyl gallate). Table 1 shows that extracts from the inflorescence of *Musa acuminata* show an action against human herpes virus type 1 and 2 or Tobamovirus by inhibiting their replication. The same is true for extracts from flowers of *Musa balbisiana* [32,33]. Sidhu et al. [61], showed the presence of gallic acid in the fruit of species of the genus Musa, which is considered to have an antiviral action. The analysis in Table 1 shows that *Nephelium lappaceum* is thought to be active against Dengue virus type 2 (DENV-2), HSV-1 and 2, hepatitis B virus, HIV type 1 and enterovirus 71. This action would be linked to the presence of a polyphenolic compound (Geraniin) or a palmitic acid (Hexadecanoic acid) whose actions against various types have been reported in the literature [34,62]. Geraniin is known as the major component from the rind of *N. lappaceum* [63]. Except for HSV-1 and 2 or the mechanism of action of Geraniin has not been elucidated, the literature indicates that Geraniin prevents attachment to the host cell in the case of Dengue virus and blocks replication in the case of HIV-1 and enterovirus 71 [34,35]. In addition, hexanoic acid inhibits HIV-1 infection to the host cell [36]. Ali et al. [57], showed the presence of apigenin in extracts from the peel or pulp of *Nephelium lappaceum* fruit. According to the literature, this compound has an action against HSV-1, ladenovirus (ADV), Hepatitis B Virus (HBV) and CVB1 [37]. In addition, Hernández-Hernández et al. [38] and Bhat et al. [35]. showed that the extract from the fruit seeds of *Nephelium lappaceum* inhibits the action of HIV-1 reverse transcriptase. They also showed that extracts from the fruit pulp of this plant are active against Dengue Virus Type 2 (DENV-2). Thinkratok et al. [30], showed the action of *Nephelium lappaceum* fruit peel extracts on HSV-1. The presence of gallic acid, a major antiviral phytocompounds of *N. lappaceum* fruit has also been reported in the literature [62]. *Passiflora edulis* are active against Herpes simplex viruses type 1 and 2, and Varicella-Zoster Virus (VZV) [40]. Maroyi [13], also reported the action of *Passiflora edulis* extracts against HSV-1. The majority of the active components in this plant are *C*-glycosyl flavones based on apigenin and luteolin, while harman alkaloids are found in trace amounts. Among these alkaloids we can mention among others: passaflorine, and possibly harmine (telepathine), harmaline, harmol and harmalol. Passiflora family contains these alkaloids [64]. According Ingale and Hivale [64], many different types of glycosides are present in passion flower such as apigenin, homoorientin, 7-isoorientin, isoshaftoside, isovitexin, kaempferol, lucenin, luteolin, norientin, passiflorine (named after the genus), quercetin, rutin, saponaretin, saponarin, shaftoside, vicenin and vitexin. There is little work in the literature on antiviral phytocompounds from *P. edulis*. Concerning *Persea americana*, Table 1 shows that it has action against Dengue virus, HSV and adenovirus [41,42,44]. In addition, the presence of apigenin in its leaves and fruits gives it a potential action against HSV-1/HSV-2. The same is true for the eugenol contained in its fruits [43,56]. Chiang et al. [37], also showed the action of apigenin against Herpes Simplex Virus (HSV), adenovirus, HBV, CVB1 and EV. Temitope al. [65], and Ngbolua et al. [7], had reported the presence of quercetin, catechin, naringenin, eugenol, kaempherol, zeaxanthin,and apigenin in fruits and leaves of *P. americana*. These compounds are known for their antiviral properties. The above table also shows the antiviral action of compounds such as : 2R,4R)-1,2,4-trihydroxyheptadec-16-yne [Avocadyne] ; 1,2,4-trihydroxyheptadec-16-ene ; 2,4-methylene-dioxyheptadec-16-ene-1-ol ; 1-acetoxy-2,4-dihydroxyheptadec-16-yne; (2R,4R)1,2,4-Nonadecanetriol et (2R,4R,6E)-6-Nonadecene-1,2,4-triol (2R,4R,16E)-16-Nonadecene-1,2,4-triol [Avocadenol D]. Table 1 shows that Syzygium species (*Syzygium aromaticum*, *Syzygium cordatum*, *Syzygium guineense*) show activity against various types of viruses (Hepatitis C Virus, HIV, HIV-1). Maroyi 13], showed that extracts of *Syzygium guineense* inhibit HIV-1 reverse transcriptase. Moreover, the presence of epicatechin gallate contained in its fruits (peel or pulp) of *Syzygium malaccense*, would interact, according to Siti et al. [45], with the protease of SARS-Covid 2. Other compounds with antiviral properties (catechin, quercetin, kaempferol, coumaric acid, catechin, quercetin) have been reported in extracts of different species of the genus of Syzygium by Calderón-Montaño et al. [66] and Batista et al. [67].

As for *Vitis vinifera*, Table 1 shows that it is active against Syncytial Virus (RSV) and Murine polyomavirus, MERS-CoV (Middle East Respiratory Syndrome coronavirus), Epstein-Barr Virus (EBV), Enterovirus (EV71), Herpes Simplex Virus (HSV-1), influenza, respiratory, rhinovirus, HIV-1, and that these actions would be linked to the presence of Kaempferol, kaempferol 3-O-β-D-glucuronopyranosyl methyl ester, naringenin 7-O-β-D glucopyranoside , quercetin 3-O-β-D-glucuronopyranosyl methyl ester, Resveratrol, caffeic acid, and scirpusins A and B [10, 48,49, 50,51, 52]. Kammerer et al. [68], Krithika et al. [69], have also reported the presence of some antiviral phytocompounds such as:delphinidin, epicatechin, quercetin, *p*-coumaric acid, myristic acid in extracts from different organs from *Vitis vinifera*. Only the mechanisms of action of resveratrol have been elucidated [10,48,49,50, 51,52]. In addition, the presence of epicatechin gallate in fruit peel seed extracts confers a probable action against the SARS-Covid 2 protease [45]. Another antiviral, gallic acid, has also been identified in *Vitis vinifera* (grape skins and Seed) seed extracts. Deliorman et al. [52] and Gaafar et al. [53], showed that fruit extracts show an action against Herpes simplex-1 (HSV-1), Parainfluenza Virus (PI) and AIV H5N1. Recent studies have shown the effect of several compounds found in fruit plant extracts investigated on the new strain of corona virus (SARS-Cov-2). These compounds are: hesperitin, hesperidin, nobiletin, tangeretin, Naringenin, Kaempferol, Quercetin, Catechin, apigenin [45,70]. According to Williams [71], an antiviral compound must beyond its antiviral effect, is not immunosuppressive. The immunostimulant action of our fruit plant extracts has been reported in the literature. We can cite the work of Javed et al. [72], Shaza et al. [73], Rechenchoski et al. [30], Minh et al. [74], etc. In addition, the literature also indicates that some compounds of the investigated plant species have both antiviral and immunostimulant properties. This is the case of: Mangiferin, Nobiletin, -mangostin, **β**-mangostin, **γ**-mangostin, garcinone E and gartanin [72,75,76].









Nutritional Values

Scientific name	Family	Used Part	Macronutrient	Micronutrient	Vitamins	References
Carica papaya L.	Caricaceae	**Bark**	Sugar (glucose, fructose, sucrose, galactose and xylitol)	-	-	[77]
		Fruit	Proteins, Total lipid, Carbohydrates	Sodium, Potassium, Magnesium, Calcium, Iron, Copper, Zinc, Phosphorus (nd)	Vitamin C, thiamin, riboflavin, niacin	[14,77]
		Leaves	Protein, Crude fibre, Carbohydrate	Phosphorus, Sodium, Potassium, Calcium, Chromium.	Vitamin C, Vitamin B1, Vitamin B2, Vitamin E,	[14,77,78]
		Seed	Fatty acids, crude, proteins, crude fibre	-	-	[77]
Cocos nucifera L.	Arecaceae	liquid albumen	Amino acids, L-arginine	-	vitamin B, nicotinic acid (B3), pantothenic acid (B5), biotin, riboflavin, folic acid, with trace quantities of vitamins B1 (thiamine), B6 (pyridoxine), and C,	[16]
Musa spp	Musaceae	Fruit	-	Magnesium, Phosphorus, Potassium, Sodium 1 mg, Zinc	Pantothenic acid (B5), Pyridoxine (B6), Choline, Vitamin C,	[61]
Mangifera indica L	Anacardiaceae	Fruit (pulp and kenel)	-	-	vitamins A and C	[60,79,80]
Nephelium lappaceum L	Sapindaceae	Fruit	Protein, Fat, Fibre	calcium, magnesium, potassium, iron and phosphorus	-	[35,62]
		Peel/Fruit Pulp	Sugar (Glucose, fructose, and sucrose)	-	Vitamin C, niacin, riboflavin and thiamine	[35,62]
		Seed	Fat, Protein, Carbohydrate, Fatty acids (Oleic acid, arachidic acid, Palmitic acid, stearic, gadoleic acid, behenic acid, linoleic acid, palmitoleic acid, erucic acid and myristic acid).	-	-	[42, 63]
Passiflora edulis Sims	Fruit or seeds		Essential fatty acids (as linoleic acid: omega-6, oleic acid (omega-9, palmitic acid and linolenic acid (omega-3), protein and amino acids (ysine, Met + Cys, threonine), ,	Minerals (phosphorus, Sodium, Calcium, Chlorine, Potassium	ascorbic acid	[81,82]
Persea americana Mill	Lauraceae	Fruit	Dietary fiber, Proteins, Carbohydrates, Fatty acids (with Palmitoleic acid, Stearic acid, Oleic acid, Linoleic acid, Linolenic acid, -	Sodium, Potassiu, Magnesium	Vitamin B, Pantothenic acid, Riboflavin, Niacin, Vitamin A, Vitamin C, Vitamin E, Vitamin K, Folate, Choline	[44,65]
		Leaves	-	Phosphorus, sodium, potassium, calcium, chromium, magnesium, sodium, manganese, iron	-	[52,69,78]
Syzygium malaccense (L.) Merr. & L.M. Perry		Peel or Pulp of Fruit	Protein, Lipids, dietary fibers	-	-	[67]
Vitis vinifera L.	Vitaceae	Grape raw	Proteins, lipids, Carbohydrates,	-	Vitamins : vitamin C, vitamin B, vitamin B2, vitamin B3, vitamin B5, vitamin B6, vitamin, B12, vitamin A, vitamin, vitamin K	[51]
		Leaves	Fat, Ash, Protein, crude fibre, carbohydrate	-	Vitamins C, Beta carotene, B1, B2, vitamin E, vitamin A	[52,69,78]
		Leaves	Fat, ash, protein, crude fibre, carbohydrate.	-	-	[52,69,78]
		Seeds	Fatty acids (Oil contained myristic acid (C14:0); palmitic acid (C16:0), stearic acid (C18:0), palmitoleic acid (C16:1), oleic acid (C18:1, linoleic acid (C18:2); linolenic acid (C18:3)	-	-	[68,69]

The table above indicates that the fruit plant species listed have macronutrients (proteins, carbohydrates, lipids and fatty acids), and micronutrients (mineral elements and vitamins) that, according to Mbadiko et al. [4], Mbemba [83], are essential for the development of the immune response.

Conclusion and Recommendations

The aim of this review was to compile data on the antiviral potential of some fruits commonly consumed in the world and particularly in the Democratic Republic of Congo. We believe that the fruit plants listed can be used for the management of certain viral diseases, particularly Covid-19, or for the search for antiviral compounds. Several compounds with antiviral properties derived from our plants are listed in this work. In addition, several of these compounds have been studied for their possible action against the new strain of Coronavirus (SARS-CoV-2) via molecular docking. However, further studies are needed to demonstrate the efficacy of the antiviral compounds in our fruit plants against the SARS-CoV-2 strain. Analysis of data on the nutrient composition of the plants surveyed also showed that consumption of most of the fruits of these plants can stimulate the immune response and thus protect an individual against virus diseases.

Conflicts of Interest

The authors declare no conflict of interest.

Acknowledgments

The authors are indebted to the reviewers for their valuable comments, which helped to improve the quality of this article.

ORCID

Mbadiko Clément Mutunda (0000-0002-9573-2487)

Matondo Aristote (0000-0002-6246-9803)

Kilembe Thambwe Jason (0000-0002-0028-8011)

Bongo Ngiala Gédéon (0000-0003-0710-0832)

Inkoto Clément Liyongo (0000-0003-0436-9633)

Lengbiye Emmanuel Moke (0000-0003-1783-0054)

Gbolo Benjamin Zoawe (0000-0001-8305-5901)

Falanga Mawi Clarisse (0000-0003-4695-4857)

Tshilanda Dorothée Dinagayi (0000-0002-0039-7680)

Tshibangu Damien Sha-Tshibey (0000-0003-3322-3385)

Mbemba Théophile Fundu (0000-0001-6627-6323)

Ngbolua Koto-Te-Nyiwa (0000-0002-0066-8153)

Mpiana Pius Tshimankinda (0000-0002-8590-6017)

Author Contributions

MCM, KNN- Research concept and design, MCM, MA, KTJ, BNG- Collection and/or assembly of data, MCM, ICL, LEM, GBZ, FMC–Data analysis and interpretation, MCM, TDD, MTF, MPT- Writing the article, MCM, TDD, TDST, MTF, NKN, MPT–Critical revision of the article, NKN, MTF, MPT– Final approval of the article.

References

1. Mangambu MJD, Mushagalusa KF, Ntokamunda NJ (2014) Contribution à l'étude phytochimique de quelques plantes médicinales antidiabétiques de la ville de Bukavu et ses environs (Sud-Kivu, R.D Congo). Journal of Applied Biosciences 75: 6211-6220.
2. Al Rawi AAS, Al Dulaimi AHSH, Marwa AA (2019) Antiviral Activity of Mangifera Extract on Influenza Virus Cultivated in Different Cell Cultures. Journal of Pure Applied Microbiology. 13(1): 455-458.
3. Pour PM, Sajad F, Sedigheh A, Hosein FM, Echeverría J (2019) The Signaling Pathways, and Therapeutic Targets of Antiviral Agents: Focusing on the Antiviral Approaches and Clinical Perspectives of Anthocyanins in the Management of Viral Diseases. Front Pharmacol 10: 1207.
4. Mbadiko CM, Inkoto CL, Gbolo BZ, Lengbiye EM, Jason KT, et al. (2020) Mini Review on the Phytochemistry, Toxicology and Antiviral Activity of Some Medically Interesting Zingiberaceae Species. Journal of Complementary and Alternative Medical Research 9(4): 44-56.
5. Mpiana PT, Ngbolua KN, Tshibangu DST, Kilembe JT, Gbolo BZ (2020) Aloe vera (L.) Burm. F. as a Potential Anti-COVID-19 Plant: A Mini-review of Its Antiviral Activity. European Journal of Medicinal Plants 31(8): 86-93.
6. Gupta A, Chaphalkar SR (2016) Virucidal potential of Prosopis spicigera and Mangifera indica on human peripheral blood mononuclear cells. Journal of Herbmed Pharmacology 5(4): 162-165.
7. Ngbolua KN, Mbadiko MC, Matondo A, Bongo NG, Inkoto LC, et al. (2020) Review on Ethno-botany, Virucidal Activity, Phytochemistry and Toxicology of Solanum genus: Potential Bio-resources for the Therapeutic Management of Covid-19. European Journal of Nutrition & Food Safety 12(7): 35-48.
8. Mukendi MT, Ngiala GB, Batoba KA, Yeto EBW, Ngbolua KN, et al. (2018) Fruits seasonality in selected markets at Mont-Ngafula district in Democratic Republic of the Congo: Biodiversity and food values. Tropical Plant Research 5(3): 275-285.
9. Radhakrishnan N, Lam KW, Norhaizan ME (2017) Molecular docking analysis of *Carica papaya* Linn constituents as antiviral Agent. International Food Research Journal 24(4): 1819-1825.
10. Ikeda K, Tsujimoto K, Uozaki M, Nishide M, Suzuki Y, et al. (2011) Inhibition of multiplication of herpes simplex virus by caffeic acid. Int J Mol Med 28: 595-598.
11. Baby J, Sankarganesh P, Koji I, Naoki Y (2015) *In vitro* study on cytotoxic effect and anti-DENV2 activity of *Carica papaya* L. leaf. Frontiers in Life Science 8(1): 18-22.
12. Yaakob H, Kadir L, Zainol N, Taher ZM, Shahar S et al. (2018) interaction of Carica papaya leaves Optimum Extract on Virus Dengue Infected Cells. Sci.Int.(Lahore) 30(3): 437-441.
13. Maroyi A (2014) Alternative Medicines for HIV/AIDS in Resource-Poor Settings: Insight from Traditional Medicines Use in Sub- Saharan Africa. Tropical Journal of Pharmaceutical Research 13(9): 1527-1536.
14. Yogiraj V, Goyal PK, Chauhan CS, Goyal A, Vyas B (2014) *Carica papaya* Linn: An Overview. International Journal of Herbal Medicine 2(5): 01-08.
15. Manisha D, Shyamapada M (2011) Coconut (Cocos *nucifera* L.: Arecaceae): In health promotion and diseasePrevention. Asian Pacific Journal of Tropical Medicine 4(3): 241-247.
16. Lima EBC, Sousa CNS, Meneses LN, Ximenes NC, Santos Júnior MA, et al. (2015) Cocos nucifera (L.) (Arecaceae): A phytochemical and pharmacological review. Braz J Med Biol Res 48(11): 953-964.
17. Ramaswam L, Rajendran R, Saraswathi U, Sughanya R, Geethadevi C (2015) Antimicrobial Properties of Cocos nucifera: A Review. CORD 31(1): 1-6.
18. Bernal FA, Coy-Barrera E (2015) Molecular Docking and Multivariate Analysis of Xanthones as Antimicrobial and Antiviral Agents. Molecules 20(7): 13165-13204.
19. Ibrahim MY, Hashim NM, Mariod AA, Mohan S, Abdulla MA, et al. (2016) ***α***- Mangostin from Garcinia mangostana Linn: An updated review of its pharmacological properties. Arabian Journal of Chemistry 9(3): 317-329.
20. Ansori ANM, Fadholly A, Hayaza S, Susilo RJK, Inayatillah B, et al. (2020) A Review on Medicinal Properties of Mangosteen (Garcinia mangostana L.). Research J Pharm and Tech 13(2): 974-982.
21. Sugiyanto Z, Yohan B, Hadisaputro S, Dharmana E, Suharti C, et al. (2019) Inhibitory Effect of Alpha-Mangostin to Dengue Virus Replication and Cytokines Expression in Human Peripheral Blood Mononuclear Cells. Natural Products and Bioprospecting 9: 345-349.
22. Wahyunia TS, Utsuboc CA, Hottaa H (2016) Promising Anti-Hepatitis C Virus Compounds from Natural Resources. Nat Prod Commun 11(8): 1193-1200.
23. Nugrahaa AS, Kellera PA (2011) Revealing Indigenous Indonesian Traditional Medicine: Anti-infective Agents. Nat Prod Commun 6(12): 1953-1966.
24. Abubakra MD, Mandalb CS, Banerjee SS (2013) Natural Compounds against Flaviviral Infections. Nat Prod Commun 8(10): 1487-1492.
25. Wozniak L, Skapska S, Marszałek K (2015) Review Ursolic Acid—A Pentacyclic Triterpenoid with a Wide Spectrum of Pharmacological Activities. Molecules 20: 20614-20641.
26. Yucharoen R, Anuchapreeda S, Tragoolpua Y (2011) Anti-herpes simplex virus activity of extracts from the culinary herbs *Ocimum* sanctum L, *Ocimum* basilicum L. and *Ocimum* americanum L. African Journal of Biotechnology 10(5): 860-866.
27. Kong L, Li S, Liao Q, Zhang Y, Sun R, et al. (2013) Oleanolic acid and ursolic acid: Novel hepatitis C virus antivirals that inhibit NS5B activity. Antiviral Res 98: 44-53.

28. Nurraihana H, Wan IWR, Abdul RN (2018) Nutritional and Pharmacological Properties of Agro-industrial by-Products from Commonly Consumed fruits. SDRP Journal of Food Science & Technology 3(4): 396-416.

29. Parvez GM (2016) Pharmacological Activities of Mango (*Mangifera Indica*): A Review. Journal of Pharmacognosy and Phytochemistry 5(3): 1-7.

30. Rechenchoski DZ, Faccin-Galhardi LC, Cunha AP, Ricardo NMPS, Nozawa C, et al. (2018) Antiviral potential of mangiferin against poliovirus. International Journal of Pharmacological Research 8(4): 34-39.

31. Shah KA, Patel MB, Patel RJ, Parmar PK (2010) *Mangifera Indica* (Mango). Review Article. Pharmacognosy Reviews 4(7): 42-48.

32. Otaviano MF, Fingolo CE, Kuster RM, Kaplan MAC, Romanos TV (2009) Atividade antiviral de *Musa acuminata* Colla, Musaceae. Rev. bras pharmacogn 19(3): 781-784.

33. Nurviani, Somowiyarjo S, Sulandari S, Subandiyah S (2018) The Inhibition of *Tobamovirus* by Using the Extract of Banana Flower *Penghambatan* Tobamovirus *dengan Ekstrak Bunga Pisang.* Jurnal Perlindungan Tanaman Indonesia 22(2): 181-185.

34. Ahmad SAA, Palanisamy DU, Tejo AB, Chew MF, Tham HW, et al. (2017) Geraniin extracted from the rind of Nephelium lappaceum binds to dengue virus type-2 envelope protein and inhibits early stage of virus replication. Virology Journal 229: 1-13.

35. Bhat R (2019) Bioactive Compounds of Rambutan (Nephelium lappaceum L.). Phytochemistry pp. 1-12.

36. Monrroy M, Arauz O, Garcıa RJ (2020) Active Compound Identification in Extracts of *N. lappaceum* Peel and Evaluation of Antioxidant Capacity. Journal of Chemistry 1-14.

37. Chiang LC, Ng LT, Cheng PW, Chiang W, Lin CC (2005) Antiviral activities of extracts and selected pure constituents of *Ocimum basilicum*. Clin Exp Pharmacol Physiol 32: 811-816.

38. Hernández-Hernández C, Aguilar CN, Rodríguez-Herrera R, Flores- Gallegos AC, Morlett-Chávez J, et al. (2019) Rambutan(*Nephelium lappaceum L.*):Nutritional and functional properties. Trends in Food Science & Technology 85: 201-210.

39. Thinkratok A (2011) Effects of the Crude Extract from the Fruit Rind of Rambutan (*Nephelium lappaceum* L.) on Obesity in Male Wistar Rats, Suranaree University of Technology, pp. 20.

40. Jabareen A, Huleihil M, Huleihel M (2013) Effect of Extracts of *Passiflora edulis* Leaves on Herpes Viruses Infection. J Virol Antivir Res 2(2): 1-6.

41. Bhuyan DJ, Perera SMAA, Low M, Basu A, Devi OA, et al. (2019) The Odyssey of Bioactive Compounds in Avocado (Persea americana) and Their Health Benefits. Antioxidants 8(10): 426.

42. Yu-Hsuan W, Chin-Kai T, Ho-Cheng W, Chih-Ku W, Chun-Kuang L, et al. (2019) Avocado (Persea americana) fruit extract (2R,4R)-1,2,4- trihydroxyheptadec-16-yne inhibits dengue virus replication via upregulation of NF-κB–dependent induction of antiviral interferon responses. Sci Rep 423: 1-10.

43. Behbahani M, Mohabatkar H, Soltani M (2013) Anti-HIV-1 Activities of Aerial Parts of Ocimum basilicum and its Parasite Cuscuta campestris. Journals of Antivirals & Antiretrovirals 5(3): 57-61.

44. Ngbolua KN, Ngiala GB, Liyongo CI, Ashande CM, Lufuluabo G, et al. (2019) A mini-review on the Phytochemistry and Pharmacology of the medicinal plant species *Persea americana* Mill. (Lauraceae). Discovery Phytomedicine 6(3): 102-111.

45. Siti K, Hendra K, Rizki A, Suhartati S, Soetjipto S (2020) Potential inhibitor of Covid-19 main protease (Mpro) from several medicinal plant compounds by molecular docking study. Preprints 1-14.

46. Samani ZN, Kopaei MR (2018) Effective Medicinal Plants in Treating Hepatitis B. International Journal of Pharmaceutical Sciences and Research 9(9): 3589-3596.

47. Badia-Boungou F, Sane F, Alidjinou KE, Hennebelle T, Roumy V, et al. (2019) Aqueous extracts of Syzygium brazzavillense can inhibit the infection with coxsackievirus B4 in vitro. J Med Virol 91(7): 1210-1216.

48. Jeon HR, Park JJH, Kim S, Kang U, Nam J, et al. (2013) Identification of a New Hexenoic Acid Glycoside and the RSV Principles from Vitis vinifera cv. Muscat of Alexandria. Bull Korean Chem Soc 34(6): 1906-1908.

49. Berardi V, Ricci F, Castelli M, Galati G, Risuleo G (2009) Resveratrol exhibits a strong cytotoxic activity in cultured cells and has an antiviral action against polyomavirus: potential clinical use. J Exp Clin Cancer Res 28(1): 96.

50. Lin SC, Ho CT, Chuo WH, Li S, Wang TT, et al. (2017) Effective inhibition of MERS-CoV infection by resveratrol. BMC Infect Dis 17(144):1-10.

51. Habiba AG (2007) Polyphénols des sarments et des rafles de la vigne (*vitis vinifera* l.) et du vin, purification, dosage et activités biologiques, Thèse de Doctorat, Badji Mokhtar-Annaba University & Université Badji Mokhtar-annabafaculté, pp. 123.

52. Orhan DD, Orhan N, Ozcelik B, Ergun F (2009) Biological activities of *Vitis vinifera* L. leaves. Turk J Biol 33: 341-348.

53. Gaafar AA, Asker MS, Ali MA, Salama ZA (2019) The Effectiveness of the Functional Components of Grape (*Vitis vinifera*) Pomace as Antioxidant, Antimicrobial, and Antiviral Agents. Jordan Journal of Biological Sciences 12(5): 625-635.

54. Sowa A, Zgórka G, SzykuBa A, Franiczek R, gbikowska B, et al. (2016) Analysis of Polyphenolic Compounds in Extracts from Leaves of Some *Malus domestica* Cultivars: Antiradical and Antimicrobial Analysis of These Extracts. Hindawi Publishing Corporation, BioMed Research International 2016: 1-12.

55. Weng JR, Lin CS, Laic HC, Line YP, Wange CY, et al. (2019) Antiviral activity of Sambucus FormosanaNakai ethanol extract and related phenolic acid constituents against human coronavirus NL63. Virus Research 273: 1-9.

56. Lien CC, Lean TN, Pei WCH, Win C, Chun CL (2005) Antiviral activities of extracts and selected pure constituents of *Ocimum basilicum*. Clin Exp Pharmacol Physiol 32: 811-816.

57. Al-Snai AE (2016) Nutritional value and pharmacological importance of citrus species grown in Iraq. IOSR Journal of Pharmacy 6(8): 76-108.

58. Olivero-Verbel J, Pacheco-Londono L (2002) Structure activity relationships for the anti-HIV activity of flavonoids. J Chem Inf Comput Sci 42(5): 1241-1246.

59. Naithani R, Mehta GR, Shukla D, Chandersekera NS, Moriarty R (2010) Antiviral Activity of Phytochemicals: A Current Perspective. Dietary Components and Immune Function 2010: 421-468.

60. Ediriweera MK, Tennekoon KH, Ranganath Samarakoon SR (2017) A Review on Ethnopharmacological Applications, Pharmacological Activities, and Bioactive Compounds of Mangifera indica (Mango). Review article. Evidence-Based Complementary and Alternative Medicine 2017: p. 24.

61. Sidhu JS, Zafar TA (2018) Bioactive compounds in banana fruits and their health benefits. Food Quality and Safety 2(4): 183-188.

62. Ngakegni-Limbili AC (2012) Etude de synergie des effets chimiques et biologiques des lipides de réserves et des huiles essentielles des fruits et graines saisonniers de la sous-région Afrique Centrale, Thèse de Doctorat, Université de Toulouse : 170.

63. Sukmandari NS, Dash GK, Jusof WHW, Hanaf M (2017) A Review on *Nephelium lappaceum* L. Research J Pharm and Tech 10(8): 2819-2827.

64. Ingale AG, Hivrale AU (2010) Pharmacological studies of *Passiflora* sp. and their bioactive compounds. African Journal of Plant Science 4(10): 417-426.

65. Adelusi IT, Ganiyu O, Ayodele Akinyemi JA (2018) *In vitro* Effects of *Persea americana* Aqueous Extracts Against Oxidants and Fe2+-Induced Oxidative Stress in Rats' Pancreas. Tropical Journal of Natural Product Research 2(6): 297-302.

66. Calderón-Montaño JM, Burgos-Morón E, Pérez-Guerrero C, López-Lázaro M (2011) A Review on the Dietary Flavonoid Kaempferol. Mini Rev Med Chem 11: 298-344.

67. Batista AG, Silva KJ, Cazarin CBB, Biasoto CCT, Sawaya ACHCF, et al. (2017) Red-jambo (Syzygium malaccense): Bioactive compounds in fruits and Leaves. LWT - Food Science and Technology 76 (2017): 284-291.

68. Kammerer D, Claus A, Carle R, Schieber AA (2004) Polyphenol Screening of Pomace from Red and White Grape Varieties (*Vitis vinifera* L.) by HPLC-DAD-MS/MS. J Agric Food Chem 52(14): 4360-4367.

69. Krithika V, Ravindra N, Pragalyaashree (2015) Functional properties of grape (*Vitis vinifera*) seed extract and possible extraction techniques - A review. Agri. Review 36(4): 313-320.

70. Utomo RY, Ikawati M, Meiyanto E (2020) Revealing the Potency of Citrus and Galangal Constituents to Halt SARS-CoV-2 Infection. Preprints p.1-8.

71. Williams JE (2001) Review of Antiviral and Immunomodulating Properties of Plants of the Peruvian Rainforest with a Particular Emphasis on Uña de Gato and Sangre de Grado. Altern Med Rev 6(6): 567-579.

72. Javed T, Ashfaq UA, Riaz SS, Rehman SS, Riazuddin SS (2011) In-vitro antiviral activity of Solanum nigrum against Hepatitis C Virus. Virology Journal 8(26): 1-7.

73. Al-Massarani SM, Gamal AA, Al-Musayeib NM, Mothana RA, Basudan AO, et al. (2013) Phytochemical, Antimicrobial and Antiprotozoal Evaluation of *Garcinia Mangostana* Pericarp and **α**-Mangostin, Its Major Xanthone Derivative. Molecules 18(9): 10599-10608.

74. Minh NP, Thanh Vo T, Viet Trung Q, Dat LT, Van Bay N, et al. (2019) Application Of Cmc, Xanthan Gum As Biodegradable Coating On Storage Of Rambutan (*Nephelium Lappaceum*) Fruit. Jounal of Pharmaceutical Science and Research, 11(3): 1063-1067.

75. Chidozie VN, Adoga GI, Chukwu OC, Chukwu ID, Adekeye AM (2014) Antibacterial and Toxicological Effects of the Aqueous Extract Mangifera indica stem bark on albino rats G.J.B.A.H.S (3): 237-245.

76. Novilla A, Djamhuri SD, Fauziah N, Maesaroh M, Balqis B, et al. (2016) Cytotoxic Activity of Mangosteen (*Garcinia mangostana* L.) Peel Extract and **α**-Mangostin toward Leukemia Cell Lines (HL-60 and K-562). Journal of Natural Remedies 16(2): 52-50.

77. Anjali P, Avijit M (2017) Carica papaya, A Magic Herbal Remedy. International Journal of Advanced Research 5(1): 2626-2635.

78. Joy NU, Raymond AA, Tochi JA (2019) Nutrient Composition of Carica Papaya Leaves Extracts. Food Sci Nutr Res 2(3): 274-282.

79. Itiann WRA (2002) Etude des activites biologiques et de la toxicite aigue de l'extrait aqueux des feuilles de mangifera indica L. (Anacardiaceae), Thèse de Doctorat, Universit& de Bamako, République du Mali, pp. 127.

80. Navarro M, Arnaez E, Moreira I, Quesada S, Azofeifa G, et al. (2019) Polyphenolic Characterization, Antioxidant, and Cytotoxic Activities of Mangifera indica Cultivars from Costa Rica. Foods 8(384): 1-26.

81. Ripa FA, Haque M, Nahar L, Islam M (2009) Antibacterial, Cytotoxic and Antioxidant Activity of *Passiflora Edulis Sims.* European Journal of Scientific Research 31(4): 592-598.

82. Zanetti LH, Murakami AE, Diaz-Vargas M, Guerra AFQG, Ospina-Rojas IC, et al. (2018) By-product of passion fruit seed (Passiflora edulis) in the diet of broilers. J Anim Sci 98: 109-118.

83. Mbemba FT (2020) Face à la Covid-19 : Quelle alimentation adopter en République Démocratique du Congo, Harmattan RDC, Editions L'Harmattan, France, p. 100.