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A Review of Bosnia and Herzegovina Medicinal Plants with Promising Antiviral Properties

Tutmić, L.[1], Parić, A.[1], Jerković-Mujkić, A.[1], Muratović, E.[1]*

[1] University of Sarajevo - Faculty of Science, Department of Biology, Laboratory for Research and Protection of Endemic Resources, Zmaja od Bosne 33-35, 71000 Sarajevo, Bosnia and Herzegovina
**edina.muratovic@pmf.unsa.ba*

Abstract

The study explored the antiviral potential of ethnobotanical plants in Bosnia and Herzegovina, aiming to identify plants with promising antiviral properties and commonly used plant organs and preparations. Three plant families, Lamiaceae, Compositae and Rosaceae showed significant antiviral potential based on the number of species mentioned in the literature. The most studied viruses were herpes simplex virus (HSV), influenza virus (Influenza), and SARS-CoV-2. Tea was the most popular herbal preparation, and aerial parts and leaves were the most frequently used for therapeutic applications. These findings highlight the potential of plants as natural sources of antiviral compounds, paving the way for further research and new therapeutic approaches.

Keywords: ethnobotany, plants, antiviral potential, viruses, plant parts, herbal preparations, Bosnia and Herzegovina.

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1. Introduction

Viral infections present a significant health problem due to the high rate of morbidity and mortality. Numerous viruses, such as human immunodeficiency virus (HIV), hepatitis A, B and C (HAV, HBV and HCV), and influenza virus, have been virulent and life-threatening pathogens for decades.

Viral infections have caused many pandemics throughout world history. The deadliest pandemic, the Spanish flu of 1918, infected around 500 million people worldwide and have killed 20 to 50 million. Other notable pandemics include the Ebola virus, between 2013 and 2016, resulting in 11,323 deaths (Trilla et al., 2008), as well as the Severe Acute Respiratory Syndrome (SARS) in 2003, the Middle East Respiratory Syndrome (MERS) in 2015 (Zumla et al., 2015), and in 2019 Coronavirus (COVID-19) pandemic, which has led to more than 776,471,644 infections and over 7,068,677 deaths (World Health Organization, 2024).

The major portion of diseases that do not have a cure are viral diseases (Choudhary et al., 2024). In recent decades, advanced scientific research has led to the discovery of many synthetic antiviral agents that effectively combat various viral infectious diseases. These synthetic agents have been reported to cause numerous adverse effects and become ineffective against new virus strains over time (Kurokawa et al., 2010). Even though more and more antiviral drugs have been approved in clinic studies, long-term use can easily lead to the emergence of drug resistance and side effects (Zhao et al., 2023). One of the global problems of viral infections is the cost of treatment, and there is a need to develop new strategies that will enable finding affordable and effective antiviral drugs (Bachar et al., 2021). The emergence of the severe acute respiratory syndrome-coronavirus (SARS-CoV)-2 pandemic has highlighted our ability to swiftly and resolutely respond to a potential outbreak (Tournier and Kononchik, 2021). As a result, the search for new antiviral agents is now focusing not only on synthetic combinations but also on plant-origin metabolites (Perera and Efferth, 2012).

Medicinal plants have been used for centuries for healing, although their use has not always been scientifically supported. Today, they form the basis of the system of traditional medicine. Traditional medicine includes health practices, approaches, knowledge and beliefs about herbal, animal and mineral drugs, spiritual treatments, and manual procedures applied individually or in combination to diagnose, treat or prevent disease or maintain health (World Health Assembly, 2003). This knowledge is consolidated and available to the public thanks to ethnobotanical research. In recent years, scientists, along with new technologies and research methods, have been discovering new bioactive components and therapeutic possibilities of plants,

contributing to the development of innovative solutions in the treatment and prevention of diseases. This constant progress in plant research enables the wider use of herbal products in modern medicine (Beressa et al., 2021, Najmi et al., 2022).

This study aimed to summarize data from the literature on the antiviral effects of plants that were/are traditionally used in Bosnia and Herzegovina, as well as investigate the relationship between the traditional use of these plants and their potential antiviral properties.

2. Material and Methods

In this retrospective analysis, previously published ethnobotanical studies were used to gain insight into the use of plants in traditional medicine in Bosnia and Herzegovina (Zovko, 1890; Glück, 1892; Fazlagić, 1894, 1895; Kulinović, 1898; Bratić, 1903, 1908; Medić, 1904 a, b; Dragićević, 1909; Filipović-Fabijanić, 1964; Filipović-Fabijanić, 1968; Filipović-Fabijanić, 1969/1970, 1971; Redžić, 2007, 2010; Šarić-Kundalić et al., 2010 a,b, 2011, 2015, 2016; Fereier et al., 2015; Ginko et al., 2023); as well as the study Muratović and Parić (2023) combined these studies to provide an overview of plant species used throughout history until today. Relevant databases, like Web of Science, Scopus, and ScienceDirect (Elsevier), were used to search for medicinal plants with antiviral activity using keywords such as "antiviral activity" and "bioactive compounds."

3. Results

Out of the total number of 145 ethnobotanically researched and documented plant species (Muratović and Parić, 2023), this paper focuses on 56 taxa scientifically proven to have antiviral potential in addition to ethnobotanical use (Table 1.). This selection provides a better understanding of plants that, based on traditional knowledge, were used to treat various diseases and showed significant potential in combating viral infections.

Based on the data in (Table 1.), research has been conducted on the antiviral properties of various plant families, and some of them were dominant. The most prominent family was Lamiaceae, with ten species investigated for their antiviral potential. The Asteraceae family takes second place with eight plant species, while Rosaceae ranks third with six species. The Fabaceae family follows them with three, and the rest of the families have two or one plant species each.

Table 1. Medicinal plants in traditional use in Bosnia and Herzegovina (Muratović and Parić, 2023) and their antiviral potential

Scientific Name	Family	Vernacular name	Part(s) of utilization	Therapeutic uses	Mode of utilization	Antiviral potential	References
Agrimonia eupatoria L.	Rosaceae	petrovac, turica, turika	aerial part	anti-haemorrhagic, anti-inflammatory, diarrhea, hepatics, rheumatism	infusion	HBV*	Kwon et al., 2005
Alchemilla vulgaris	Rosaceae	vrkuta, gospin plašt, plahtica	aerial part	anti-hemorrhagic, anti-inflammatory, antiseptic, dysmenorrhea, hormonal disorders	infusion	SARS-CoV-2	Suručić et al., 2022
Angelica archangelica L.	Apiaceae	anđelika	aerial part	analeptic, asthma, flatulence, migraine	infusion	HSV-1 CVB3	Rajtar et al., 2017
Anthyllis vulneraria L.	Fabaceae	ranjenik	aerial part	contusion, cough, skin disorders, wound	infusion	HSV-1 EVC	Suganda et al., 1983
Arctium lappa L.	Compositae	čičak, repuh	root, leaf, fruit	antipruritic, aperitif, arteriosclerosis, diabetes, diuretic, eczema, hepatic, hyperglycemia, psoriasis	infusion	HSV IAV	Dias et al., 2017
Artemisia vulgaris L.	Compositae	divlji pelin, komonjika, komunika, crnobilj, crni pelin, umit	young shoots	antianemic, antipyretic, antispasmodic, aperitif, diabetes, diarrhea, diuretic, gastritis, hepatic, laxative, rheumatism	infusion, tincture	HSV	Xiao, 2023

Scientific Name	Family	Vernacular name	Part(s) of utilization	Therapeutic uses	Mode of utilization	Antiviral potential	References
Berberis vulgaris L.	Berberidacae	žutika, babnja, breberika	root, flower, bark	antiemetic, arteriosclerosis, diuretic, hypertension, rheumatism	infusion	EV	Wang et al., 2017
Betula pendula Roth	Betulaceae	breza	leaf, bark, fresh sap	antiinfective, diarrhea, dermatitis, diuretic, hepatic, hypertension.	nfusion, juice	HSV HIV	Vladimirov et al., 2019; Heidary Navid et al.,
Carlina acaulis L.	Compositae	kravljak, sikavac	root	urinary infection, hypertension, hepatitis, antiseptic for skin diseases.	nfusion, fresh juice, infusion	SARS-CoV-2	Wnorowska et al., 2022
Centaurea benedicta (L.) L.	Compositae	blaženi čkalj	leaf	cancer of stomach, strengthen of liver and spleen.	Infusion, tincture	SARS-CoV-2	Alhadrami et al., 2021
Ceratonia siliqua L.	Fabaceae	rogač, rožićak, kaluber	fruit	sore throat, dysmenorrhea, gastritis, diarrhea	infusion	HSV	Darwish et al., 2021
Chelidonium majus L.	Papaveraceae	rosopas, zarastovača, zmijino mlijeko	aerial part	dermatitis, rheumatism.	juice from the stem	HSV HIV HPV	Monavari et al., 2011; Musidlak et al.2022;Salehi
Cornus mas L.	Cornaceae	drijenak, drijen, drijenjina	fruit, sap from a tree	antipyretic, diabetes, diarrhea, respiratory disease, vitamin C deficiensis.	juice, infusion	HSV HIV	Lavoie et al., 2017; Okuda 2005
Crataegus monogyna Jacq.	Rosaceae	glog, bijeli glog	leaf, flower, fruit	arteriosclerosis, cardiotonic, hypertension.	infusion	HSV 1	Orhan et al., 2007

Scientific Name	Family	Vernacular name	Part(s) of utilization	Therapeutic uses	Mode of utilization	Antiviral potential	References
Equisetum arvense L.	Equisetaceae	livadska preslica, preslica,	aerial part	anti-anemic, antiinfective, diabetes, diuretic, rheumatism.	infusion	IAV	Moradi et al., 2017
Fagus sylvatica L.	Fagaceae	bukva	leaf	antiinflammatory	infusion	HSV	Pujol et al., 2016
Ficus carica L.	Moraceae	smokva	leaf	diabetes	infusion	HSV HPV	Ay and Duran, 2018; Ghanbari
Filipendula vulgaris Moench	Rosaceae	kraljica polja	aerial part	circulation, cough, fever, rheumatism	infusion, fresh juice	HIV	James et al., 2003
Foeniculum vulgare Mill.	Apiacaeae	komorač	aerial part	antianemic, anti-inflammatory, antipyretic, diarrhea, hypertension.	nfusion, syrup	HSV IAV SARS-CoV-2	Ibrahim and Moussa, 2021; Orhan et
Fragaria vesca L.	Rosaceae	šumska jagoda	leaf, rhizome, fruit	anti-anemic, antitussive, arteriosclerosis, dyspepsia, gastritis, hypertension, vitamin C deficiensis.	infusion	IAV CVB1 EVC	Nikolaeva-Glomb et al., 2013
Geranium macrorrhizum L.	Geraniaceae	zdravac planinski	rhizome	menstruation disorders, stomach disorder.	infusion, decoction	HSV IAV	Choi et al., 2019; Serkedjieva al al., 1998

Scientific Name	Family	Vernacular name	Part(s) of utilization	Therapeutic uses	Mode of utilization	Antiviral potential	References
Glycyrrhiza glabra L.	Fabaceae	sladić	root	hepatitis, hysteria, stomach disorders, sore throat, stone and sand in the kidney.	infusion, extract in oil olive	HSV HIV HBV SARS-CoV-2	Sato et al., 1996; Gotoh et al., 1987; Takahara et al., 1994;
Hedera helix L.	Araliaceae	bršljan	leaf	anti-emetic, anti-inflammatory, diuretic, hypertension, rheumatism.	infusion	IAV	Hong et al., 2015
Helichrysum italicum (Roth) G. Don	Compositae	smilje	flower	antianemic, antipyretic, migraine.	infusion	HIV	Chien et al., 2004
Hypericum perforatum L.	Clusiaceae	kantarion, bogorodičina trava, ivanova trava	aerial part	analeptic, antianemic, antiinfective, antifungal, asthma, diarrhea, dysmenorrhea, gastritis, hepatic, migraine, rheumatism.	infusion, oil	SARS-CoV-2 HIV	Mohamed et al., 2022; Zhang et al., 2017
Juglans regia L.	Juglandaceae	orah	leaf, immature fruits	dermatitis, diabetes, gastritis, hypo-hyperthyroidism, rheumatism.	infusion, syrup, honey	HIV EVC CVB1 HAdV	D'Angeli et al., 2021

Scientific Name	Family	Vernacular name	Part(s) of utilization	Therapeutic uses	Mode of utilization	Antiviral potential	References
Juniperus communis L.	Cupressaceae	kleka, smreka	galbulus, yang shots	antianemic, antiinfective, anti-inflammatory, diabetes, dyspepsia, gastritis, hepatics, laxative, rheumatism, scurvy.	infusion, juice, tincture	IAV	Najar et al., 2022
Laurus nobilis L.	Lauraceae	lovor	leaf, fruit	antitussive, flatulence, gastritis.	infusion	HSV1 SARS-CoV-2	Khodja et al., 2023
Lavandula angustifolia Mill. subsp. *angustifolia*	Lamiaceae	despik, lavanda	aerial part	analeptic, cardiotonic, gastritis, hypertension, migraine, rheumatism	infusion, oil	IAV	Abou et al., 2021
Marrubium vulgare L.	Lamiaceae	obična marulja, očajnica, smrduša	aerial part	antiseptic	infusion	HSV	Fayyad et al., 2014
Matricaria chamomilla L.	Compositae	kamilica	leaf, flower	antianemic, anti-inflammatory, antipyretic, arthritis, antispasmodic, dermatitis, diarrhea, diuretic, flatulence, gastritis, hypertension, migraine.	infusion	HSV EVC	Suganda et al., 1983

Scientific Name	**Family**	**Vernacular name**	**Part(s) of utilization**	**Therapeutic uses**	**Mode of utilization**	**Antiviral potential**	**References**
Melissa officinalis L.	Lamiaceae	melisa, matičnjak, pčelinja ljubica, limunčić	aerial part	analeptic, antiviral, asthma, cardiotonic, dyspepsia, gastritis, hypertension, laxative.	infusion	HSV HIV SARS-CoV-2	Behzadi et al., 2023
Mentha pulegium L.	Lamiaceae	verem trava	aerial part	analeptic, anti-inflammatory, gastritis.	infusion	HSV	Parsania et al., 2017
Nigella damascena L.	Ranunculaceae	čurokot, mačkov brk	seed	analeptic, hepatic.	infusion	SARS-CoV-2	Imran et al., 2022
Origanum vulgare L.	Lamiaceae	divlji origano, mravinac, vranilova	aerial part	analeptic, antipyretic, dyspepsia, gastritis, hepatic.	infusion	SARS-CoV-2	Zhang et al., 2014
Petasites hybridus (L.) G. Gaertn. & al.	Compositae	lopuh, veliki čičak, repuh	root, leaf	rheumatism	infusion	SARS-CoV-2	Urda et al., 2022
Plantago media	Plantaginaceae	trputac,srednja bokvica	leaf	antianemic, anti-hemorrhagic, anti-inflammatory, antipyretic, diarrhea, gastritis, hepatics, rheumatism.	infusion	HSV HAdV	Zhakipbekov et al., 2023; Musarra-Pizzo et al., 2021

Scientific Name	**Family**	**Vernacular name**	**Part(s) of utilization**	**Therapeutic uses**	**Mode of utilization**	**Antiviral potential**	**References**
Polygonatum odoratum	Asparagaceae	pokosnica	rhizome	blooding from trachea, cough, hemorrhoids, leucorrhea, liver disorders, uterus disorders, wound.	resh juice, infusion	IAV	Pang et al., 2020
Primula veris	Primulaceae	jaglac, jaglika	aerial part	analeptic, migraine, rheumatism.	infusion	IAV	Eliopoulos et al., 2022
Prunella laciniata	Lamiaceae	bijela celinčica	aerial part	asthma, diarrhea, liver, strengthen of heart	decoction, infusion	HIV	Oh et al., 2011
Punica granatum	Lythraceae	nar	bark, fruit	diarrhea	infusion	HSV2 IAV	Arunkumar et al., 2018; Moradi et
Rosmarinus officinalis	Lamiaceae	ruzmarin, zimrad	leaf	analeptic, cardiotonic, gastritis, hepatics, rheumatism	infusion	HSV	Al-Megrin et al., 2020
Rubus idaeus	Rosaceae	malina	leaf	antiinfective, gastritis	infusion	IAV CVB1 EVC	Nikolaeva-Glomb et al., 2013
Ruta graveolens	Rutaceae	ruta	aerial part	cardiotonic, laxative, rheumatism	infusion	HSV1	Ebrahimi et al., 2021
Salvia officinalis	Lamiaceae	kadulja, žalfija	aerial part	anti-inflammatory, antipyretic, diabetes	infusion	IAV	Abou Baker et al., 2021

Scientific Name	Family	Vernacular name	Part(s) of utilization	Therapeutic uses	Mode of utilization	Antiviral potential	References
Sambucus ebulus	Viburnaceae	aptovina, apt, burjan	leaf, root, fruit	antipruritic	juice	HSV1	Ghaffari et al., 2021
Sinapis arvensis	Brassicaceae	gorušica, hardala	seed	asthma	with honey	HSV1	Sharifi-Rad et al., 2017
Taraxacum F. H. Wigg. sect. *Taraxacum*	Compositae	maslačak, žućanik	root, leaf, flower	antianemic, antispasmodic, diabetes, eczema, hemorrhoids, hepatic, hepatitis, laxative, rheumatism	infusion, honey	HCV	Rehman et al., 2016
Teucrium chamaedrys	Lamiaceae	dupčac, stupčac, mravak, suhovrh	aerial part	antibacterial, diabetes, diarrhea, gastritis	infusion	HSV	Todorov et al., 2015
Urtica dioica	Urticaceae	žara, kopriva	whole plant	analgesic, antianemic, antipyretic, arteriosclerosis, dermatitis, diabetes, diuretic, dysmenorrhea, hepatics, rheumatism	infusion	HIV	Uncini et al., 2005

Scientific Name	Family	Vernacular name	Part(s) of utilization	Therapeutic uses	Mode of utilization	Antiviral potential	References
Vaccinium myrtillus	Ericaceae	borovnica, vrisinje	leaf, fruit	antianemic, anti-inflammatory, arteriosclerosis, diabetes, diarrhea, dyspepsia, gastritis, vitamin C and E deficiencies	infusion, juice	IAV CVB1 EVC SARS-CoV-2	Nikolaeva-Glomb et al., 2013
Vaccinium vitis-idaea	Ericaceae	brusnica	leaf, fruit	antiinfective, diuretic, rheumatism	infusion	IAV	Nikolaeva-Glomb et al., 2013
Veronica officinalis	Plantaginaceae	čestoslavica, dobričica	leaf, flower	antipruritic, gastritis, rheumatism	infusion	IAV	Mazurkova et al., 2020
Viola odorata	Violaceae	ljubica mirisna	leaf, flower	antitussive	infusion	SARS-CoV-2	Adel Mehraban et al., 2023
Viscum album	Loranthaceae	imela bijela	aerial part	analeptic, cardiotonic, dysmenorrhea, hypertension	nfusion, tincture	HPIV	Karagöz et al., 2003
Vitex agnus-castus	Lamiaceae	fratarski biber, konopljika	aerial part, seed	against high potency, for nervous balance, hysteria, menstrual disorders	infusion, ecoctin, powder	HSV HIV	Islam et al., 2024

*Acronym of virus: HBV (*Hepatitis B virus*), HCV (*Hepatitis C virus*), SARS-CoV-2 (*Severe Acute Respiratory Syndrome Coronavirus 2*), HSV-1 and 2 (*Herpes simplex virus* 1 and 2), EV (*Enterovirus*). CVB1 and B3 (*Coxsackie virus B1* and *B3*), EVC (poliovirus -Enterovirus C), IAV (*Influenza A* virus), HIV (*Human immunodeficiency virus*), HPV 1 (*Human papilloma virus*), HPV (*Human papilloma virus 2),* HAdV *(Human adenovirus),* HPIV *(Human parainfluenza virus*)

The most common form of utilization (Table 1.) is infusion, for which 53 plant species are used. Infusion is prepared by pouring hot water over plant parts, and it is one of the simplest and most widespread ways of preparing medicinal plants. Nine plant species are used for fresh juice. It is frequently prepared from fresh parts of the plant, such as leaves, stems or roots, and is used due to the high concentration of bioactive substances. The tincture, which involves alcohol to extract the plant components, is prepared from four plant species. Three plant species are used for decoction (the plant material boiled in water), two for syrup, honey and oil, and one for honey. These data clearly showed that infusion dominates, while the other forms have less frequent usage.

The distribution of bioactive compounds varies in different parts of plants. According to (Table 1.), it was obvious that in folk medicine, the aerial part of plants is predominantly utilized (confirmed for 22 plant species). Additionally, leaves of 21 species are used in preparations, fruits of 10, and flowers and roots of seven species. Less commonly used plant organs, such as tree bark and rhizomes, were found to be employed for three taxa and young shoots for two. Finally, unripe fruits, seeds, fresh juice, tree sap and the whole plant were confirmed for only one plant species.

Based on the available literature data on the antiviral potential of plants (Table 1.), we selected the most relevant viruses against which these plants showed activity. Among the findings, 28 plant species showed antiviral potential against the herpes simplex virus (HSV-1 and HSV-2), 17 showed an inhibitory effect on the influenza virus, 13 on SARS-CoV-2, and 11 against the human immunodeficiency virus (HIV), etc.

In the reviewing literature, the Lamiaceae family showed the most pronounced antiviral potential on 13 different viruses, followed by Compositae, Rosaceae, Fabaceae, etc. (Table 1.).

4. Discussion

Regarding the antiviral properties of plant families, Lamiaceae, Compositae, and Rosaceae are the most extensively studied. It was expected since they are rich in taxa and contain various bioactive compounds known for their antiviral properties. The leaves of these families' members are sources of flavonoids and phenolic acids, such as 4-Hydroxybenzoic acid, vanillic acid, and chlorogenic acid (Sytar et al., 2018).

The plants from these families have been used in folk medicine for centuries, and modern research has confirmed their effectiveness in combating viruses. Behzadi et al. (2023) reported that Melissa officinalis has an antiviral effect against HSV, HIV,

SARS-CoV-2, CPV, HBV, and HCV (Table 1.). Additionally, its effectiveness as an alternative therapy for several viral infections has been confirmed by Muratović and Parić (2023). M. officinalis is rich in organic active compounds, mainly essential oils (including citronellal, menthol, eugenol, linalool, and geraniol) and polyphenols (including rosmarinic acid, caffeic acid, chlorogenic acid, salicylic acid, ellagic acid, and quercetin). Its significant antiviral effect is due to the presence of rosmarinic acid in its methanol extract (Chen et al., 2017).

Another example is Vaccinium myrtillus, a species with significant antiviral potential against various viruses such as poliovirus type 1 (PV-1), coxsackievirus B1 (CV-B1), human respiratory syncytial virus A2 (HRSV-A2), influenza virus A/H3N2, SARS-CoV-2, and Coxsackie virus (Nikolaeva-Glomb et al., 2014). This species contains phenolic compounds, including chlorogenic acid, quercetin and arbutin, which have outstanding antioxidant capacity both in vitro and in vivo. These compounds are present in different representatives of the Ericaceae family (Colak et al., 2017; Ștefănescu et al., 2019). The Juglans regia has a wide range of applications in daily life (Muratović and Parić, 2023). This taxon has been proven to have antiviral activity against HIV, Poliovirus, Coxsackievirus B1, Adenovirus, Sindbis virus (SINV), and herpes simplex virus (HSV) due to its active components quercetin, myricetin, and naringenin (Bhat et al., 2023). Additionally, Glycyrrhiza glabra has been found to have significant antiviral effects against HSV, HIV, HBV, SARS2, and H5N1 viruses due to its active compounds glycyrrhizin and glycyrrhetinic acid, which belong to the group of triterpenoids (Wang et al., 2015).

Although more than 200 human viruses have been discovered, antiviral medications are available only for a limited number of infections that target proteins encoded by a single virus (such as influenza A and B, hepatitis B and C, herpes, and HIV), providing a narrow spectrum of coverage (Karim et al., 2023). The emergence or re-emergence of viruses with epidemic or pandemic potential, such as Ebola, SAR-CoV-1, and SAR-CoV-2, has repeatedly reminded us of the importance of developing broad-spectrum antiviral drugs (Geraghty et al., 2021). In this context, our results highlight the diversity and complexity of antiviral potential among different plant families.

Table 2 shows the relationship between ethnobotanical research in Bosnia and Herzegovina and the research about the antiviral potential of selected plants. Local communities noticed that certain plant species help in the treatment of specific symptoms. Microbiological studies have proven that the plants used in traditional medicine also have antiviral potential and that the symptoms caused by these viruses can be identified with the symptoms recognized by folk medicine for the same plant species.

One of the examples is the already mentioned blueberry, which has proven antiviral potential against the SARS-CoV-2 virus, whose most common symptoms are hemorrhage, high temperature, diarrhea, anemia, sore throat, cough and diabetes (Table 2.). At the same time, it is important to emphasize that in the traditional medicine of B&H, this plant is used for antianemic, anti-inflammatory, arteriosclerosis, diabetes, diarrhea, dyspepsia, gastritis, vitamin C and E deficiency (Table 1.).

However, it is important to emphasize that the symptoms of viral infection are often subjective and can vary from person to person. For example, hepatitis B virus and hepatitis C virus can cause chronic infections. Viral hepatitis can cause a wide spectrum of clinical presentations from a benign form with quite mild or no symptoms to acute liver failure and sometimes liver cancer or death (Cheung and Kwo, 2020).

Various host factors collectively shape an individual's response to pathogens such as age, genetic factors, immune system function, nutritional status, microbiome, underlying health conditions as well as environmental factors including living conditions, socioeconomic status and exposure to pollutants and various other aspects (Hayward, 2023). Therefore, these results highlight the complexity of the relationship between traditional knowledge and modern scientific findings in the context of the treatment of viral infections.

Table 2. Antiviral potential of the plants with ethnobotanical use in Bosnia and Herzegovina

Virus (symptoms)	Plant species (Muratović et Parić 2023)	Reference
Herpes simplex virus (skin disorders, eczema, dermatitis, sore throat, inflammation, elevated temperature, migraine, asthma, diarrhea, gastritis)	*Angelica archangelica*, *Anthyllis vulneraria*, *Arctium lappa*, *Artemisia vulgaris*, *Betula pendula*, *Ceratonia siliqua* L, *Chelidonium majus*, *Cornus mas*, *Fagus sylvatica*, *Ficus carica*, *Foeniculum vulgare*, *Glycyrrhiza glabra*, *Laurus nobilis*, *Melissa officinalis*, *Matricaria chamomilla*, *Mentha pulegium*, *Plantago media*, *Punica granatum*, *Sinapis arvensis*, *Teucrium chamaedrys*	Xiao et al., 2024; Banerjee et al., 2007; McMillan et al., 1993; Napier et al., 2018; Zhang et al., 2022; Colemont et al., 1990

Influenza virus (high fever, anemia, diarrhea, cough)	*Arctium lappa*, *Foeniculum vulgare*, *Fragaria vesca*, *Hedera helix*, *Juniperus communis*, *Polygonatum odoratum* (Mill.), *Punica granatum*, *Rubus idaeus*, *Salvia officinalis*, *Vaccinium myrtillus*, *Vaccinium vitis-idaea*, *Veronica officinalis*	InformedHealth, 2006; Rice et al., 1998; Boktor et al., 2024
Severe acute respiratory syndrome coronavirus 2 (hemorrhages, high fever, diarrhea, anemia, sore throat, cough, diabetes)	*Alchemilla vulgaris*, *Foeniculum vulgare*, *Glycyrrhiza glabra*, *Hypericum perforatum*, *Laurus nobilis*, *Vaccinium myrtillus*, *Viola odorata*	Steenblock et al., 2023; Cornea et al., 2022; Bergamaschi et al., 2021; Juthi 2023; Waliszewska-Prosół et al., 2021; Rai et al., 2023
Human immunodeficiency virus (hypertension, diarrhea, dermatitis, fever and elevated temperature)	*Betula pendula*, *Chelidonium majus*, *Cornus mas*, *Filipendula vulgaris*, *Helichrysum italicum*, *Hypericum perforatum*, *Juglans regia*, *Prunella laciniata*, *Urtica dioica*	Nguyen et al., 2022; Garg and Snke, 2017; Harimenshi et al., 2022;
Poliovirus (flu-like symptoms, cough)	*Fragaria vesca*, *Matricaria chamomilla*, *Vaccinium myrtillus*	Wolbert et al., 2024
Coxsackie virus (dermatitis, diarrhea)	*Juglans regia, Vaccinium myrtillus*	Valestra et al., 2016; Trayer and Gore, 2020
Hepatitis B virus (hepatitis, stomach problems)	*Agrimonia eupatoria*, *Glycyrrhiza glabra*	Liu et al., 2022
Human papillomavirus (no data)	No data	No data
Adenovirus (gastrointestinal disturbances)	*Juglans regia*, *Plantago media*	Kumthip et al., 2019
Enterovirus (No data)	No data	No data
Hepatitis C virus (hepatitis)	*Taraxacum* sp.	Basit et al., 2023
Human parainfluenza virus (no data)	No data	No data

Among the plants that have been used throughout history in folk medicine and today are completely forgotten, there are the following: *Anagalis arvensis*, *Fritillaria meleagris*, *Galanthus nivalis*, *Hioscyamys niger*, *Rubia tinctorum* (Muratović and Parić, 2023). The antiviral effect of these plants was proven in different studies. Thus, the *Anagalis arvensis* has an antiviral potential against Herpes simplex and Poliovirus (Amoros et al., 1987), *Fritillaria meleagris* against the Influenza virus (Kim et al., 2020), *Galanthus nivalis* against Hepatitis C virus (Ashfaq et al., 2011), *Hioscyamys niger* against Respiratory Syndrome Coronavirus 2 (Kosari et al., 2021, 2024) and *Rubia tinctorum* against rotavirus (Sun et al., 2016).

5. Conclusions

In recent years, there has been a growing interest and need for antiviral drugs due to the latest pandemic. Consequently, medicinal plants are receiving increased attention. Research has demonstrated that the long-standing use of medicinal plants in folk medicine can offer valuable insights for further studies into their active

components. This study highlights the importance of a multidisciplinary approach, which can provide a broader perspective and better solutions for this and other issues.

6. References

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