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Potential anti-influenza effective plants used in Turkish folk medicine: A review

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ABSTRACT

Ethnopharmacological relevance: Due to the outbreaks such as SARS, bird flu and swine flu, which we frequently encounter in our century, we need fast solutions with no side effects today more than ever. Due to having vast ethnomedical experience and the richest flora (34% endemic) of Europe and the Middle East, Turkey has a high potential for research on this topic. Plants that locals have been using for centuries for the prevention and treatment of influenza can offer effective alternatives to combat this problem. In this context, 224 herbal taxa belonging to 45 families were identified among the selected 81 studies conducted in the seven regions of Turkey. However, only 35 (15.6%) of them were found to be subjected to worldwide *in vitro* and *in vivo* research conducted on anti-influenza activity. Quercetin and chlorogenic acid, the effectiveness of which has been proven many times in this context, have been recorded as the most common (7.1%) active ingredients among the other 56 active substances identified.

Aim of the study: This study has been carried out to reveal the inventory of plant species that have been used in flu treatment for centuries in Turkish folk medicine, which could be used in the treatment of flu or flu-like pandemics, such as COVID 19, that humanity has been suffering with, and also compare them with experimental studies in the literature.

Materials and methods: The investigation was conducted in two stages on the subject above by using electronic databases, such as Web of Science, Scopus, ScienceDirect, ProQuest, Medline, Cochrane Library, EBSCO, HighWire Press, PubMed and Google Scholar. The results of both scans are presented in separate tables, together with their regional comparative analysis.

Results: Data obtained on taxa are presented in a table, including anti-influenza mechanism of actions and the active substances. *Rosa canina* (58.7%) and *Mentha x piperita* (22.2%) were identified as the most common plants used in Turkey. Also, *Sambucus nigra* (11.6%), *Olea europaea* (9.3%), *Eucalyptus* spp., *Melissa officinalis,* and *Origanum vulgare* (7.0%) emerged as the most investigated taxa.

Conclusion: This is the first nationwide ethnomedical screening work conducted on flu treatment with plants in Turkey. Thirty-nine plants have been confirmed in the recent experimental anti-influenza research, which strongly shows that these plants are a rich pharmacological source. Also, with 189 (84.4%) taxa, detections that have not been investigated yet, they are an essential resource for both national and international pharmacological researchers in terms of new natural medicine searches. Considering that the production of antimalarial drugs and their successful use against COVID-19 has begun, this correlation was actually a positive and remarkable piece of data, since there are 15 plants, including *Centaurea drabifolia* subsp. *Phlocosa* (an endemic taxon), that were found to be used in the treatment of both flu and malaria.

1. Introduction

Plants have always been the primary choice for preventing and treating various diseases faced by human beings, and contain specific or broad-spectrum active compounds for almost any type of disease (Alaoui-Jamali, 2010). People living in Turkey have also benefited from plants in the prevention and treatment of various diseases for centuries. People living in rural areas still have an especially rich medicinal plant repertoire (Ertuğ, 2004). Although herbal cures such as rosehip tea, peppermint-lemon tea and garlic-lemon tea, which are used to prevent and treat flu outbreaks, are well known by the local people, the vast majority of them and their anti-influenza effects have not yet been

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adequately investigated *in vitro* by the related industries (Bekut et al., 2018).

In virus classification, influenza viruses are RNA viruses that comprise 4 of the 7 genera of the family Orthomyxoviridae (Kawaoka, 2006), while Human Rhinoviruses (HRVs) are within the genus Enterovirus and the family Picornaviridae (Jacobs et al., 2013). Nevertheless, the flu caused by influenza viruses and the common cold caused by Human Rhinovirus are very similar, although both are types of respiratory virus in terms of disease symptoms (CDC, 2019). In general, it is the most common cause of respiratory viral disease in spring, summer and autumn, while the flu virus is dominant in winter. On the other hand, flu or flu-like viruses are highly contagious and cause serious complications and outbreaks that erupt with a different genetic code each year and even life-threatening pandemics (Jacobs et al., 2013). Nowadays, COVID-19 is one of the most striking examples of a flu-like virus. Due to its fast transmission through direct contact with infected people and contaminated substances or droplets, thousands of patients are dying every day with a fever, cough, and shortness of breath, and, currently, there is no definitive treatment or vaccine, except for some available malaria medicines (Basiri, 2020). There is an urgent need to identify new naturally occurring antiviral molecules, as resistance to anti-influenza drugs appears to be prevalent to an alarming extent (Haidari et al., 2009). Herbal remedies have been used for centuries to treat flu symptoms, and essential oils derived from them have been prescribed as complementary and alternative treatments against influenza (Setzer, 2016). Therefore, to contribute to the treatment of influenza disease and bearing in mind their greater importance, we focused on plants whose successful anti-influenza effects have been tried and trusted by Turkish people for centuries.

Essentially, some antiviral medicines, such as Oseltamivir and Zanamivir, are available for treatment; however, the emergence of drug-resistant strains as a new type of virus is a serious concern (Watanabe and Kawaoka, 2015). In addition, vaccines are only around 50% effective in the elderly, where the highest mortality rates occur (Wang et al., 2006; Rajasekaran et al., 2013), and side effects, such as nausea, vomiting, neuropsychiatric events, abdominal pain, diarrhoea, sinusitis, headache and dizziness, are very common (Grienke et al., 2009). For this reason, natural active ingredients or traditional applications with proven effectiveness are accepted more in the world (Rajasekaran et al., 2013).

Empirical information and bio experiments based on the ethnomedical benefits of plants show that they have the potential to identify new antivirals that can be used against influenza. In particular, the results of research on plant-based antiviral activity and active ingredients against influenza viruses using purified plant chemicals are promising (Grienke et al., 2012). Some of them include determination of the antiviral and cytotoxic effect of quercetin 3-glucoside (Q3G) from *Dianthus superbus* on influenza virus infection and replication by Nile et al. (2020), revealing the neuraminidase inhibitory effect (on the Influenza Virus replication) of agathisflavone derived from the *Anacardium occidentale* by De Freitas et al. (2020), and discovering the inhibitory effect of pomegranate (*Punica granatum* L.) peel extract polymerase activity, RNA replication, and protein expression of the influenza virus by Moradi et al. (2020).

As Velavan and Meyer (2020) stated, the emergence of the COVID-19 flu-like pandemic with high epidemic and mortality rates in early 2020 shows that there is an urgent need for new, effective and various measures against this viral disease. Turkey has the potential for serious research on this topic due to having a very rich (34% of endemic) flora and folkloric experience in plant utilization that has existed for centuries (Güner et al., 2012). Notwithstanding, local research to date, such as detecting *Galanthus elwesii* and *Rheum ribes* had a strong antiviral effect against Herpes simplex virus and Sindbis virus among 16 plant influences (Hudson et al., 2000), and investigating the antiviral and cytotoxic effects of the *Salvia* species (Özçelik et al., 2011) have generally remained at the antiviral level.

In this study, the total list of plant taxa used in Turkish folk medicine against diseases caused by influenza viruses is presented for the first time. It also reveals which of these plants are researched worldwide for anti-influenza activity, along with their active compounds. Taxa that do not have a research record are an important resource for new drug researchers.

2. Materials and methods

2.1. Data collection

This research was conducted in two stages. While, in the first stage, a list of herbs that are used for the treatment of flu in Turkish folk medicine is presented, in the second stage, it was investigated whether there are experimental studies of "anti-influenza" effects of the plants from this list in the world literature. Among these studies those with active compound determination were especially preferred. Various electronic databases, such as Web of Science, Scopus, ScienceDirect, ProQuest, Medline, Cochrane Library, EBSCO, HighWire Press, PubMed and Google Scholar, have been scanned for both studies. In the interest of the plant inventory survey, the national studies conducted in all regions (Fig. 1) of Turkey were taken into account. Moreover, to achieve detailed coverage, the database of the Higher Education Council of Turkey National Thesis Center was also included in the research literature. The results of both scans are presented in Tables 3 and 4.

Only English and Turkish words were used in the search engines. If they exist, their English translations were reviewed for the studies conducted in different languages, such as Chinese, Korean and French. In this context, approximately 700 articles conducted between January 1977 and February 2020 throughout Turkey were excluded since they did not meet the inclusion criteria and a consensus has been provided among the 81 works on the determination of medicinal plants used by local people for centuries. The list of selected plants from these studies is presented in Table 1.

2.2. Data selection

The studies determined to be within the scope of plant screening were reviewed, compared and carefully selected according to the following criteria. Accordingly, a study should:

- be carried out in an area within the borders of Turkey.
- performed on ethnobotanical or ethnopharmacological concept layout.
- include scientific names and local names of the plants used.

In addition, the criterion for choosing the book sources was either the writer having an academic title or the work having been cited. If neither of these were in case, the work was not taken into consideration.

The screening of the resulting plants in the world literature was carried out considering the following criteria. Accordingly, a study should be:

- an experimental (*in vitro* or *in vivo*) study, not a review.
- included the scientific name of the plant in its title. In case of writing only the English name of the plant, it is obligatory to include the scientific name in the text.
- carried out under the headings of "anti-flu, anti-influenza or antiviral activities against influenza".

If it contains the active compound(s), it becomes preferable and the mechanism of action is recorded.

2.3. Data arrangement

Table 1 contains the scientific names of plants, their families, local

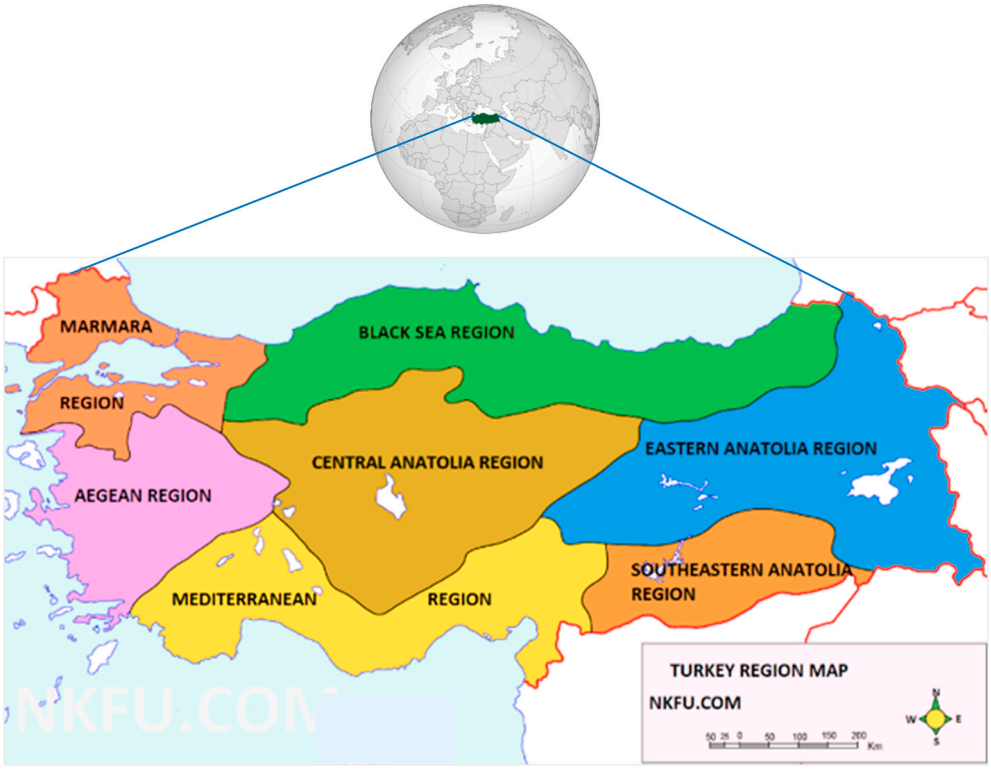

Fig. 1. Regional map of Turkey.

names, English common names, parts used, forms used, and references. The validation of the scientific names of the specified plant taxa was provided by the book Turkey Plant List (Vascular Plants) (Güner et al., 2012), the International Plant Names Index (IPNI: http://www.ipni.org) and the Plant List (http://www.theplantlist.org). English common names of the taxa are placed in the table using the following databases or search engines: EPPO Global Database (https://gd.eppo.int), Plants Database (http://garden.org/plants), USDA PLANTS (https://plants.sc.egov.usda.gov/java), Encyclopedia of Life (https://eol.org), Lebanon Flora (http://www.lebanon-flora.org), Springer Link (https://link.springer.com/article), Flora of Israel Online (http://flora.org.il), Altervista Flora Italiana (http://luirig.altervista.org/flora), and Plants of the World online (http://www.plantsoftheworldonline.org). Taxa for which common English names could not be found have been noted as endemic to Turkey, or containing Irano-Turanian elements.

Finally, the plants were arranged in alphabetical order according to family names. In order to prove the scientific validity of the ethnobotanical data obtained, the research data of the experimental studies regarding the taxa in the list, as found in the world literature, are shown in a separate table (Table 4). In this table, the mechanism of action, active compounds and used parts are also included, in addition to the researched taxa and their references. Great care has been taken to ensure that the findings obtained in these screening studies belong to experimental studies (*in vitro* or *in vivo*), not a review.

2.4. Comparative analysis

After obtaining the total list of plants with anti-influenza potential in Turkish folk medicine, a comparison was made to determine the similarity percentages in similar studies conducted in neighboring and nearby countries (Table 2). To avoid distraction from the subject integrity, not all studies in those countries were included in our comparison. Therefore, only the study with the richest content and the highest percentage of similarity from each country was included in the comparison list. Studies with a similarity percentage >10% were eliminated in the primary elections.

3. Results and discussion

The demand for new antimicrobial agents, especially antivirals, is constantly increasing. This demand arises from the lack of antiviral agents in the market and the emergence of resistant mutants to existing drugs (Vijayan et al., 2004). Throughout our existence, human beings have always been in search of healing from plants in the fight against winter diseases, but clinical studies have to this point been limited. Although the following work is relatively new in Turkey, they are promising for future study: Duman et al. (2018) elicited *in vitro* antiviral activity of *Ribes uva-crispa* L and *Ribes multiflorum* Kit ex Schult, which are naturally grown in Turkey, use the methanol and aqueous extracts of the leaves and fruits; Dogan et al. (2020) revealed anti-RSV effects of *Ribes uva-crispa* juicy fruit and leaf methanol extracts against the respiratory syncytial virus (RSV) (the cause of a worldwide viral infection), and emphasized their advantages to synthetic drugs; finally, Adem et al, (2020) found that natural polyphenols, such as hesperidin, routine, diosmin and apiin were more effective than nelfinavir in treating COVID-19. The plants (Table 3), which have been used by locals in Turkey for centuries for the prevention and treatment of influenza and its adverse effects - from colds to sudden deaths from respiratory failure - need to be investigated in this way. Today, much more research is needed, as outbreaks such as SARS, avian influenza, swine influenza and COVID-19 threaten the existence of human beings every year.

3.1. Regional analysis

Distribution of 81 studies by region was performed as follows: 13 in the Mediterranean (16.0%), 11 in Eastern Anatolia (13.6%), 10 in the Marmara and Aegean region (12.3%), 8 in the Black Sea (12%), 7 in Central and Southeastern Anatolia (11.1%), and 15 general studies across all regions (18.5%). The regional distribution of 921 total citations received was as follows: Mediterranean: 150 (16.3%), Eastern

Table 1
Eighty one carefully selected works from ethnomedicinal studies conducted in Turkey.

Selected Studies	Cited Taxa	Citation %	Region
Şenkardeş (2014)	39	17.4	Central Anatolia
Tuzlacı (2006)	34	15.2	All Regions
Baytop (1999)	33	14.7	All Regions
Ertuğ et al. (2004),	29	12.9	Aegean
Özhatay et al. (2009)	26	11.6	Marmara
Sargin (2015)	25	11.2	Mediterranean
Olgun (2019)	23	10.3	Eastern Anatolia
Polat et al. (2013)	23	10.3	Eastern Anatolia
Gökçe (2014)	22	9.8	All Regions
Kılıç (2019)	22	9.8	Southeastern Anatolia
Genç (2010)	21	9.4	All Regions
Köse (2019)	20	8.9	Black sea
Arıtuluk (2010)	19	8.5	Mediterranean
Sargin et al. (2015a)	19	8.5	Aegean
Cakilcioglu et al. (2011)	18	8.0	Eastern Anatolia
Demirci-Kayıran (2019)	18	8.0	Mediterranean
İşler (2017)	17	7.6	All Regions
Polat (2019)	17	7.6	Eastern Anatolia
Gürbüz et al. (2019)	16	7.1	Black sea
Kalafatçılar and Kalafatçılar (2010)	16	7.1	All Regions
Bulut and Tuzlacı (2015)	15	6.7	Marmara
Bulut et al. (2019)	15	6.7	Southeastern Anatolia
Güneş (2017)	15	6.7	Marmara
Günbatan et al. (2016)	14	6.3	Central Anatolia
Çiçek (2019)	13	5.8	Southeastern Anatolia
Karaköse and Karaköse (2017)	13	5.8	Black sea
Ozturk et al. (2017)a	13	5.8	Southeastern Anatolia
Sargin and Büyükcengiz (2019)	13	5.8	Mediterranean
Tuzlacı and Doğan (2010)	13	5.8	Eastern Anatolia
Tuzlacı and Erol (1999)	13	5.8	Mediterranean
Ertuğ (2004)	11	4.9	Aegean
Güneş and Özhatay (2011)	11	4.9	Eastern Anatolia
Kılıç (2016)	11	4.9	Eastern Anatolia
Kilic and Bagci (2013)	11	4.9	Eastern Anatolia
Guzel and Guzelsemme (2018)	10	4.5	Mediterranean
Ozturk et al. (2017b)	10	4.5	Mediterranean
Saraç (2005)	10	4.5	All Regions
Tetik et al. (2013)	10	4.5	Eastern Anatolia
Yeşilyurt et al. (2017b)	10	4.5	Marmara
Akgül et al. (2016)	9	4.0	Central Anatolia
Bulut et al. (2017a)	9	4.0	Aegean
Cansaran and Kaya (2010)	9	4.0	Black sea
Güner and Selvi (2016)	9	4.0	Marmara
Nacakcı and Dutkuner (2015)	9	4.0	Mediterranean
Özçelik et al. (2016)	9	4.0	Mediterranean
Akan and Bakır-Sade (2015)	8	3.6	Southeastern Anatolia
AkBulut et al. (2019)	8	3.6	Aegean
Kurt and Karaoğul (2018)	8	3.6	Black sea
Paksoy et al. (2016)	8	3.6	Central Anatolia
Sargin et al. (2013)	8	3.6	Aegean
Yılmaz (2019)	8	3.6	Aegean
Demirci and Özhatay (2012)	7	3.1	Southeastern Anatolia
Kaval et al. (2014)	7	3.1	Eastern Anatolia
Kocabaş and Gedik (2016)	7	3.1	Mediterranean
Maranki and Maranki (2016)	7	3.1	All Regions
Tuzlacı and Eryaşar-Aymaz (2001)	7	3.1	Marmara
Ugulu et al. (2009)	7	3.1	Aegean
Tanker et al. (1998)	7	3.1	All Regions
Dalar et al. (2018)	6	2.7	Eastern Anatolia
Güneş et al. (2018)	6	2.7	Mediterranean
Kocabas et al. (2017)	6	2.7	Mediterranean
Bağcı et al. (2016)	5	2.2	Central Anatolia
Bulut and Tuzlacı (2013)	5	2.2	Aegean
Bulut et al. (2017b)	5	2.2	Aegean
Koçyiğit and Özhatay (2006)	5	2.2	Marmara
Özer et al. (2005)	5	2.2	All Regions
Sargin et al. (2015b)	5	2.2	Mediterranean
Uzun and Kaya (2016)	5	2.2	Central Anatolia
Akgul et al. (2018)	4	1.8	Southeastern Anatolia
Bulut (2016)	4	1.8	Marmara
Ergül-Bozkurt and Terzioğlu (2017)	4	1.8	Black sea
Tuzlacı and Tolon (2000)	4	1.8	Marmara
Yeşilada (2012)	4	1.8	All Regions
Yeşilyurt et al. (2017a)	4	1.8	Black sea
Kartal and Güneş (2017)	3	1.3	Marmara
Bozyel and Merdamert-Bozyel (2020)	2	0.9	All Regions
Ekşi et al. (2020)	2	0.9	All Regions
Han and Bulut (2015)	2	0.9	Central Anatolia
Karamanoğlu (1977)	2	0.9	All Regions
Saraçoğlu (2014)	2	0.9	All Regions
Sağıroğlu et al. (2013)	1	0.4	Black sea

Anatolia: 141 (15.3%), Aegean: 109 (11.8%), Marmara: 98 (10.6%), Central and Southeastern Anatolia: 82 (8.9%), Black Sea: 75 (8.1%), and general studies covering all regions: 184 (20.0%). The reason why the studies conducted in the Mediterranean and Eastern Anatolia regions were highly cited may be due to the fact that there are more plant options, which is the result of having a higher rate of biodiversity and endemism in these regions (Güner et al., 2012) compared to others, that the locals can use in the treatment of influenza. In addition, the topographic structure of the region, and the fact that the region is isolated from city centers in winter conditions (Doğanay and Orhan, 2016) may have been a factor for the people living in these rural areas to choose mostly natural treatment methods.

3.2. Data analysis of ethnomedicinal plants used in flu treatment in Turkey

It has been determined that 224 plants, selected from 81 studies composing of 57 articles, 13 books, seven theses, three chapters and one congress report in total, belonging to 43 families. These plant taxa most commonly belong to the Lamiaceae (88 taxa, 39.3%), Compositae (32 taxa, 14.3%), Rosaceae (21 taxa, 9.4%), Malvaceae (13 taxa, 5.8%), and other families (70 taxa, 31.3%). The most preferred outcome of the Lamiaceae family may be due to the Turkish people's preference for flu treatment, as it is the family that contains the highest dosage of essential oils (Askun et al., 2012). The second family, Compositae, is known as Turkey's most common family (Güner et al., 2012). Infusions prepared from taxa with capitula flower structures such as its representative Chamomile are widely used by local people. Therefore, this was an expected result.

According to studies conducted in different regions of Turkey (Fig. 1), the most common genera are *Sideritis* (16 taxa, 7.1%), *Salvia* (12 taxa, 5.4%), *Thymus* (12 taxa, 5.4%), and *Origanum* (10 taxa, 4.5%). This finding may indicate that these genus members are more effective in anti-influenza treatment than other genera. In addition, they are the most favored medicinal tea for the locals of Turkey, and even without natural nationwide distribution, it is possible to find these products in almost every public market, herbal and spice shop (Ertuğ, 2004; Dogan, 2012). Some species, such as thyme (*Thymus* spp.), melissa (*Melissa officinalis*), lavender (*Lavandula angustifolia*), cassidony (*Lavandula stoechas*) and sage (*Salvia officinalis*), are today being grown in home gardens, balconies or on small farms by rural people for folk medicine use, or for trade and household income (Güneş, 2017; Ekşi et al., 2020). like thyme, melissa, lavender, and sage, Among the identified plants, 145 were wild (64.7%), 49 were wild and cultivated (21.9%), 27 were endemic (12.1%) and 3 (*Allium cepa, Allium sativa* and *Malus domestica*)

Table 2
Similarity percentages of neighboring studies (sorted by descending order according to the similarity index).

Countries	Regions	Total taxa used for influenza	Similar Taxa #	Similarity %	References
Iraq	Sulaymaniyah (Northern)	20	15	75.0	Ahmed (2016)
Bosnia and Herzegovina	Javor Mountain	15	11	73.3	Savić et al. (2019)
Cyprus	All	26	19	73.1	Karousou and Deirmentzoglou (2011)
Bulgaria	All	18	13	72.2	Kozuharova et al. (2013)
Romania	Dobruja (South-Eastern)	24	17	70.8	Pieroni et al. (2014)
Kosovo	Southern	20	14	70.0	Mustafa et al. (2015)
Croatia	Knin	18	12	66.7	Varga et al. (2019)
Georgia	Caucasus	20	13	65.0	Bussmann et al. (2016)
Syria	Aleppo	14	9	64.3	Alachkar et al. (2011)
Iran	Sirjan in Kerman	14	9	64.3	Nasab and Khosravi (2014)
Albania	Alps	30	18	60.0	Mustafa et al. (2012)
Greece	Thessaloniki (Northern)	74	44	59.5	Hanlidou et al. (2004)
Serbia	South-eastern	36	20	55.6	Jarić et al. (2015)
Macedonia	Sharr Mountains	20	9	45.0	Rexhepi et al. (2013)
Jordan	Northern Badia	14	6	42.9	Alzweiri et al. (2011)
Israel	All	21	8	38.1	Lev and Amar (2000)
Montenegro	Prokletije Mountains	22	7	31.8	Menković et al (2011)

were cultivated (1.3%). These parameters are shown in a column in Table 3; wild taxa as “W", cultivated “C", cultivated & wild “CW” and endemic “E". Most of the plant pieces used are aerial parts (41.1%), flowers/flowering branches/petals (30.8%), leaves (25.0%), fruits (17.4%), seeds/cones (8.5%), roots/bulbs/tubers (6.7%), and other parts (stems, buds, barks, whole parts, resins, tars, cupula, bracts, fruit stalks, essential oils and fixed oils) (14.3%). Those parts were mostly used as infusions (78.6%), decoction/boiling (19.2%), raw eating/swallowing/salad (12.9%), molasses/jam/syrup/juice (7.6%), lotion/drop/cataplasm/vapor compression (6.3%) and other consumption types (roasting, mouthwash, tincture, mixture and pastes) (5.4%) and powdered for spice use (3.1%). The taxa having with the most usage types are *Citrus* spp (7 types, 3.1%), *Rosa canina* and *Rubus sanctus* (5 types, 2.2%) and *Vitis vinifera* (4 types, 1.8%), while the taxa with the maximum number of consumption parts belong to *Rosa canina* and *Tilia tomentosa* (6 parts, 2.7%), and *Juniperus oxycedrus* (5 parts, 2.2%). Additionally, *Rosa canina* (with 5 different types of use and 6 different parts) have appeared as the most efficient plants in terms of the total of both part and usage type (Table 3).

3.3. Comparative evaluation of the data with studies of nearby countries

16 taxa, such as *Rosa canina* (with 46 references and 56.8%) and *Mentha x piperita* (with 17 references and 21.0%) (Fig. 2, red color), have been identified as the most frequently cited plants. The reason why these herbs are highly cited may be a reflection of their stronger protective and therapeutic effects against flu; this may be the result of the experience gained in Turkish folk medicine for centuries. We would obviously see this when comparing similar studies between 17 geographically close countries (Fig. 2, blue color). The emergence of the data presented in Table 2 in a similar manner as in Fig. 2 confirms the superior efficacy of these plants, with 76.7% similarity.

As a matter of fact, similar results were obtained from studies conducted in 17 neighboring countries, comparing with the taxon list presented in the study, including especially *Rosa canina* (11 countries with 64.7%), *Sambucus nigra* (8 countrIes with 47.1%) and *Mentha x piperita* (6 countries with 35.3%). While the similarity was seen mostly in Iraq (75.0%), Bosnia and Herzegovina (73.3%), and Cyprus (73.1%), the least similarity was seen in Montenegro (31.8%) and Israel (38.1%). This may due to the fact that, besides the resemblance of landforms, climate and vegetation, we lived together with the cultures of those countries during the Ottoman period for about 500 years. The reason for the low similarity in Israel and Montenegro may be due to the geographical distance as well as the difference of social-cultural habits, religious rituals, topography and flora (Table 2). It was not very surprising that *Matricaria chamomilla* emerged as the plant used most in influenza treatment in 12 countries (70.6%) since the spreading area of this plant is very wide and it is very easy for the public to access and use (Fig. 2).

3.4. Comparative analysis with studies in the global literature

Experimental research studies carried out in the world in terms of anti-influenza activities have been determined only for 35 out of 224 taxa (15.6%). Still, among these studies, the active substances were detected for only 18 taxa (8.0%); for the remaining 17 taxa (7.6%), it was observed that they had not been specified (Table 4). In Table 4, only “the parts used in research” were given as an idea for these taxa for which active gradients had been “not specified”. It is noteworthy that no investigation has been conducted for 189 (84.4%) taxa yet (they are highlighted in bold in Table 3). Among these 35 taxa, the most common active chemicals are quercetin and chlorogenic acid (7.1%), mentofin (5.4%) and 1,8-cineole (3.6%). The most preferred mechanisms in research are inhibition of viral replication by inhibiting viral nucleoprotein synthesis or polymerase and neuraminidase activity (40.4% out of the 47 mechanisms in total), blocking the receptor site of the viruses by inhibition of neuraminidase, reducing the hemagglutination, or blocking hemadsorption (31.9%), inhibition of the virus-induced cytopathic effect by blocking hemadsorption (21.3%), and stimulating and boosting of the immunity (6.4%). The reason that the six taxa at the end of the list are shown as a line separated from the alphabetical sequence is that there was no significant result for virus inactivation in the experimental studies conducted for them (Table 4).

According to screening results found in the global literature, the most preferred plants in experimental anti-influenza studies are *Sambucus nigra* (14.3%, out of 35 taxa), *Olea europaea* (11.4%), followed by *Eucalyptus camaldulensis, E. globules, Melissa officinalis and Origanum vulgare* (8.6%). The reason for this may be that these plants are easily accessible in nature or from the virtual market environment, and can be obtained for less money. Additionally, eucalyptus trees in Turkey are also known as “malaria trees”, as the infusion prepared from its leaves is used against malaria in traditional medicine (Baytop, 1999; Ertuğ, 2004). Although its effectiveness against COVID-19 has not been fully proven by clinical trials, the widespread use and mass production of chloroquine and similar malaria drugs are permitted in many countries, and positive results continue to be achieved (Millán-Oñate et al., 2020; Touret and de Lamballerie, 2020). This correlation of data has been positive and unexpected because there are fourteen more plants, including *Centaurea drabifolia* subsp *floccosa* (an endemic taxon), which have been detected in this study to be used in the treatment of malaria. These fifteen plants are presented in Table 3 by adding the "*" sign to the end of their scientific names.

The percentage of compatibility of the plant parts belonging to these

Table 3
The list of plant taxa used against influenza in Turkish folk medicine.

Families	Sc. names	W/C/E	English names	Parts	Preparations	References
Adoxaceae	***Sambucus ebulus* L.**	W	European dwarf elder	Aerial parts	Decoction	Baytop (1999), Tuzlacı and Tolon (2000), Gürbüz et al. (2019)
Adoxaceae	*Sambucus nigra* L.	W	Elderberry, European elder	Leaves, Flowers, Fruits	Infusion	Özhatay et al. (2009), Ugulu et al. (2009), Kalafatçılar and Kalafatçılar (2010), Yeşilada (2012), Karaköse and Karaköse (2017), Ozturk et al. (2017b)
Amaranthaceae	***Amaranthus retroflexus* L.**	W	Redroot pigweed, red-rooted pigweed	Leaves	Infusion	Arıtuluk (2010), Polat et al. (2013), Sargin et al. (2013), Yeşilyurt et al. (2017b), Gürbüz et al. (2019), Olgun (2019)
Amaranthaceae	***Chenopodium album* L.**	W	Lamb's quarters	Aerial parts	Decoction	Baytop (1999), Şenkardeş (2014), Kılıç (2016)
Amaryllidaceae	*Allium cepa* L.	C	Onion, bulb onion, common onion	Bulbs, Leaves	Eaten raw, Boiling, Juice with some honey	Cansaran and Kaya (2010), Polat et al. (2013), Gökçe (2014), Saraçoğlu (2014), Günbatan et al. (2016), Maranki and Maranki (2016), Paksoy et al. (2016), Uzun and Kaya (2016), Köse (2019), Ekşi et al. (2020)
Amaryllidaceae	*Allium sativum* L.	C	Garlic, onion, shallot, leek, chive, Chinese onion	Leaves, Bulbs, Flowers	Eaten raw or a tablespoon of a tincture prepared with the bulbs, lemon and vinegar is drunk 2–3 times a day	Tuzlacı (2006), Sargin et al. (2013), Gökçe (2014), Şenkardeş (2014), Köse (2019), Ekşi et al. (2020)
Anacardiaceae	***Rhus coriaria* L.**	CW	Tanner's sumach, Sicilian sumac	Leaves, Fruits	Infusion, Spice	Tuzlacı and Erol (1999), Tuzlacı and Eryaşar-Aymaz (2001), Akgül et al. (2016)
Apiaceae	***Cuminum cyminum* L.**	CW	Cumin	Seeds	Spice	Baytop (1999), Güneş et al. (2018)
Apiaceae	*Pimpinella anisum* L.	CW	Anise, aniseed	Seeds	Infusion after powdering	Genç (2010), Akgül et al. (2016), Ugulu et al. (2009)
Apiaceae	***Prangos platychlaena* Boiss.**	E	No English name	Leaves	Infusion after powdering	Tuzlacı and Doğan (2010), Olgun (2019)
Asparagaceae	***Asparagus acutifolius* L.**	CW	Wild asparagus	Aerial parts	Infusion	Demirci and Özhatay (2012), Polat et al. (2013), Sargin et al. (2013, 2015a), Demirci-Kayıran (2019), Polat (2019)
Berberidaceae	***Berberis crataegina* DC.**[a]	W	Pipperidge	Roots, Stems	Decoction	Sezik et al. (1992), Arıtuluk (2010)
Brassicaceae	***Eruca vesicaria* (L.) Cav.**	CW	Rocket, garden rocket	Leaves	Eaten raw, Salad	Akan and Bakır-Sade (2015), Demirci-Kayıran (2019)
Brassicaceae	***Erysimum* × *cheiri* (L.) Crantz**	CW	Wallflower	Flowers	Infusion	Baytop (1999), Sargin et al. (2013)
Brassicaceae	***Lepidium sativum* L.**	CW	Garden cress	Aerial parts	Infusion	Baytop (1999), Ugulu et al. (2009), Gökçe (2014), Bulut and Tuzlacı (2015)
Brassicaceae	***Raphanus raphanistrum* subsp. *sativus* (L.) Domain**	CW	Radish	Tubers	Eaten after mixing with some honey	Sargin et al. (2013), Günbatan et al. (2016), Güneş (2017)
Cactaceae	***Opuntia ficus-indica* (L.) Mill.**	CW	Prickly pear, cactus pear, barbary fig	Stems, Fruits	Cataplasm	Baytop (1999), Sargin and Büyükcengiz (2019)
Cannabaceae	***Celtis tournefortii* Lam.**	CW	Oriental hackberry	Fruits	Decoction	Polat et al. (2013), Polat (2019), Olgun (2019)
Caprifoliaceae	***Knautia orientalis* L.**	W	Oriental widow flower	Flowers	Infusion after drying	Güneş and Özhatay (2011), Güneş (2017)
Caprifoliaceae	***Morina persica* L.**	W	Whorl flower	Flowers	Infusion	Şenkardeş (2014), Ozturk et al. (2017a)
Compositae	***Achillea aleppica* DC.**	W	Sweet yarrow	Aerial parts	Infusion	Şenkardeş (2014), Kılıç (2019)
Compositae	***Achillea arabica* Kotschy**	W	Arabian milfoil	Fruits	Eaten raw, Infusion	Tuzlacı and Erol (1999), Kılıç (2016)
Compositae	***Achillea cretica* L.**	W	Cretan milfoil	Flowering branches	Infusion	Bulut et al. (2017b), Yılmaz (2019)
Compositae	***Achillea millefolium* L.**	W	Common yarrow	Leaves, Flowers	Infusion	Baytop (1999), Özhatay et al. (2009), Akan and Bakır-Sade (2015)
Compositae	***Achillea nobilis* L. subsp. *sipylea* (O.Schwarz) Basler**	W	Noble yarrow	Aerial parts, Flowers	Infusion	Bulut and Tuzlacı (2015), Sargin et al. (2015a, 2015b), Güner and Selvi (2016), Ozturk et al. (2017b)
Compositae	***Anthemis cotula* L.**	W	Dog fennel, stinking chamomile	Aerial parts	Infusion	Güneş and Özhatay (2011), Akgül et al. (2016), Kılıç (2016), Güneş et al. (2018), Polat (2019), Demirci-Kayıran (2019), Kılıç (2019)
Compositae	***Anthemis fumariifolia* Boiss.**	E	No English name	Flowers, Flowers	Infusion	Şenkardeş (2014), Kılıç (2016)
Compositae	***Anthemis haussknechtii* Boiss. & Reut.**	W	No English name	Aerial parts	Infusion	Akgul et al. (2018), Kılıç (2019)
Compositae	***Arctium minus* (Hill) Bernh.**	W	Lesser burdock, little burdock, wild rhubarb	Leaves, Roots	Decoction	Baytop (1999), Günbatan et al. (2016)
Compositae	***Artemisia absinthium* L.**	W	Wormwood, grand wormwood, absinthe, absinthium	Flowers, Leaves, Flowering branches, Aerial parts	Infusion after drying	Tuzlacı and Erol (1999), Kılıç (2016)
Compositae	***Bellis perennis* L.**	W	Common daisy	Flowers	Infusion	

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Table 3 (*continued*)

Families	Sc. names	W/C/E	English names	Parts	Preparations	References
						Özçelik et al. (2016), Karaköse and Karaköse (2017), Köse (2019)
Compositae	***Centaurea drabifolia* subsp. *floccosa* (Boiss.) Wagenitz & Greuter**[a]	E	No English name	Flowers	Infusion, Eaten raw by chewing	Ezer and Avcı (2004), Arıtuluk (2010)
Compositae	***Centaurea iberica* Trevir. ex Spreng.**[a]	W	Iberian knapweed, Iberian star-thistle	Leaves	The juice extracted by crushing the leaves is drunk twice a day	Tuzlacı (2006), Çiçek (2019)
Compositae	***Centaurea jacea* L.**	W	Brown knapweed	Aerial parts	Infusion	Ergül-Bozkurt and Terzioğlu (2017)
Compositae	***Centaurea solstitialis* L.**[a]	W	Yellow star-thistle, golden starthistle	Aerial parts	Infusion	Tuzlacı and Doğan (2010), Şenkardeş (2014), Bulut and Tuzlacı (2013)
Compositae	***Cota austriaca* (Jacq.) Sch.Bip.**	W	Austrian mayweed	Aerial parts	Infusion	Şenkardeş (2014), Kılıç (2019)
Compositae	*Cota tinctoria (*L.) J.Gay	W	Golden marguerite, yellow chamomile	Flowers	Infusion	Ertuğ et al. (2004), Şenkardeş (2014), Bulut and Tuzlacı (2015), Günbatan et al. (2016), Kılıç (2016), Özçelik et al. (2016), Karaköse and Karaköse (2017), Kurt and Karaoğul (2018)
Compositae	***Crepis vesicaria* L.**	W	Beaked hawk's-beard	Flowers, Flowers	Infusion	Özhatay et al. (2009)
Compositae	***Helianthus annuus* L.**	CW	Common sunflower	Leaves, Flowers, Fruits	Infusion, Decoction, Medicinal bath	Baytop (1999), Cansaran and Kaya (2010), Kalafatçılar and Kalafatçılar (2010), Sargin et al. (2013), Ozturk et al. (2017a)
Compositae	***Helichrysum arenarium* (L.) Moench**	W	Dwarf everlast, immortelle	Flowers	Decoction	Tuzlacı and Erol (1999), Akgül et al. (2016), Bağcı et al. (2016), Günbatan et al. (2016)
Compositae	***Lactuca serriola* L.**	W	Prickly lettuce	Aerial parts	Infusion	Bulut and Tuzlacı (2013), Şenkardeş (2014)
Compositae	***Matricaria aurea* (Loefl.) Sch.Bip.**	W	Golden mayweed	Aerial parts	Infusion	Akgul et al. (2018), Kılıç (2019)
Compositae	*Matricaria chamomilla* L.	W	Chamomile, German chomile	Aerial parts, Flowering branches, Flowers	Infusion	Özer et al. (2005), Özhatay et al. (2009), Kalafatçılar and Kalafatçılar (2010), Sargin et al. (2013, 2015a), Nacakcı and Dutkuner (2015), Akgül et al. (2016), Güneş (2017), İşler (2017), Demirci-Kayıran (2019)
Compositae	***Pallenis spinosa* (L.) Cass.**	W	Spiny starwort	Flowering branches, Seeds	Infusion	Ertuğ (2004), Sargin et al. (2015a)
Compositae	*Silybum marianum* (L.) Gaertn.	W	Milk thistle, Marian thistle	Stems, Fruits	Eaten raw after peeling, Infusion	Baytop (1999), Sargin et al. (2015a), Demirci-Kayıran (2019), Kılıç (2019)
Compositae	***Tanacetum aureum* (Lam.) Greuter & al.**	W	Golden feverfew	Whole parts	Decoction	Güneş and Özhatay (2011)
Compositae	***Tanacetum cadmeum* (Boiss.) Heywood**	E	No English name	Fruits	Eaten raw, Infusion	Tuzlacı and Erol (1999), Kocabas et al. (2017)
Compositae	***Tanacetum parthenium* (L.) Sch.Bip.**	W	Feverfew, bachelor buttons	Flowers, Flowers	Infusion	Şenkardeş (2014), Günbatan et al. (2016), Karaköse and Karaköse (2017)
Compositae	***Tripleurospermum callosum* (Boiss. & Heldr.) E.Hossain**	E	No English name	Flowers	Infusion	Cansaran and Kaya (2010), Günbatan et al. (2016)
Compositae	***Tripleurospermum parviflorum* (Willd.) Pobed.**	W	No English name	Flowers	Infusion	Arıtuluk (2010), Şenkardeş (2014)
Compositae	***Tussilago farfara* L.**	W	Coltsfoot	Aerial parts, Flowering branches, Leaves	Infusion	Sargin et al. (2015a), Kılıç (2016), Bulut et al. (2017a)
Compositae	***Xeranthemum annuum* L.**	W	Annual everlasting	Aerial parts	Decoction	Özhatay et al. (2009), Tuzlacı and Doğan (2010)
Cornaceae	***Cornus mas* L.**[a]	CW	Cornelian cherry	Fruits	Eaten raw, Decoction, Jam	Koçyiğit and Özhatay (2006), Polat et al. (2013), Köse (2019)
Cupressaceae	***Juniperus drupacea* Labill.**	W	Syrian juniper	Fruits, Seeds, Cones	Decoction, Mixture	Ertuğ (2004), Sargin (2015), Kocabaş and Gedik (2016)
Cupressaceae	***Juniperus oxycedrus* L.**	W	Cade, cade juniper, prickly juniper	Fruits, Seeds, Leaves, Tars, Cones	Decoction, Infusion	Tuzlacı and Erol (1999), Tuzlacı (2006), Şenkardeş (2014), Nacakcı and Dutkuner (2015), Sargin (2015), Sargin et al. (2015b), Günbatan et al. (2016)
Dioscoreaceae	***Dioscorea communis* (L.) Caddick & Wilkin**	W	Black bryony, lady's-seal, black bindweed	Flowering branches, Stems	After boiling, Roasted with onions	Sargin et al. (2013, 2015a), Bulut and Tuzlacı (2015), Gürbüz et al. (2019)
Elaeagnaceae	***Hippophae rhamnoides* subsp. *caucasica* Rousi**	W	Sanddorn, sea bucktorn	Fruits	Infusion, Syrup, jam	Baytop (1999), Şenkardeş (2014)
Euphorbiaceae	***Euphorbia macroclada* Boiss.**[a]	W	No English name	Latex of Stem	Dropped onto a piece of bread, then swallowed.	Şenkardeş (2014), Kılıç (2019)
Fagaceae		W	Valonia oak	Cupula, Seeds	Decoction	Baytop (1999), Sargin et al. (2013, 2015a), Akan and Bakır-Sade (2015)

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Table 3 (*continued*)

Families	Sc. names	W/C/E	English names	Parts	Preparations	References
	***Quercus ithaburensis* subsp. *macrolepis* (Kotschy) Hedge & Yalt.**					
Gentianaceae	***Centaurium erythraea* Rafn**	W	Common centaury, European centaury	Flowering branches	Infusion	Tuzlacı and Eryaşar-Aymaz (2001), Özhatay et al. (2009), Demirci-Kayıran (2019)
Hypericaceae	*Hypericum perforatum* L.	CW	St. John's Wort	Flowering branches, Aerial parts	Infusion	Tuzlacı and Tolon (2000), Tuzlacı and Eryaşar-Aymaz (2001), Tuzlacı (2006), Özhatay et al. (2009), Şenkardeş (2014), Sargin et al. (2015a), Güner and Selvi (2016), Güneş (2017), Kartal and Güneş (2017), Yeşilyurt et al. (2017b), Köse (2019)
Iridaceae	***Iris caucasica* Hoffm.**	W	Caucasean Iris	Aerial parts	Infusion	Tuzlacı and Doğan (2010), Polat (2019)
Iridaceae	***Iris sari* Schott ex Baker**	E	Tall bearded iris	Flowers	Infusion	Tuzlacı and Doğan (2010), Kılıç (2016)
Lamiaceae	***Ballota nigra* L.**	W	Black horehound	Leaves, Aerial parts	Infusion	Özhatay et al. (2009), Arıtuluk (2010)
Lamiaceae	***Clinopodium acinos* (L.) Kuntze**	W	Basil-thyme	Aerial parts	Infusion	Özhatay et al. (2009), Kartal and Güneş (2017)
Lamiaceae	***Clinopodium dolichodontum* (P.H. Davis) Bräuchler & Heubl**	W	No English name	Aerial parts, Flowering branches	Infusion	Sargin (2015), Ozturk et al, (2017a), Sargin and Büyükcengiz (2019)
Lamiaceae	***Cyclotrichium origanifolium* (Labill.) Manden. & Scheng.**	W	Marjoram, leaved calamint	Aerial parts	Infusion, Juice after crashing, Gargle	Sargin (2015), Bağcı et al. (2016), Ozturk et al, (2017b)
Lamiaceae	***Lavandula angustifolia* Mill.**	CW	Lavender, true lavender	Leaves	Infusion	Baytop (1999), Bozyel and Merdamert-Bozyel (2020)
Lamiaceae	***Lavandula pedunculata* subsp. *cariensis* (Boiss.) Upson & S.Andrews**	W	Turkish lavender, French lavender	Flowering branches	Infusion	Baytop (1999), Ertuğ (2004), Arıtuluk (2010)
Lamiaceae	***Lavandula stoechas* L.**	CW	Spanish lavender, topped lavender	Leaves, Flowering branches	Infusion	Tuzlacı (2006), Bulut and Tuzlacı (2015), Sargin et al. (2015a), Özçelik et al. (2016), Bozyel and Merdamert-Bozyel (2020)
Lamiaceae	***Marrubium rotundifolium* Boiss.**	E	Silver edged horehound	Aerial parts	Cataplasm	Arıtuluk (2010), Sargin et al. (2015a), Yeşilyurt et al. (2017a)
Lamiaceae	*Melissa officinalis* L.	CW	Lemon balm	Aerial parts	Infusion	Özhatay et al. (2009), Güneş (2017), Demirci-Kayıran (2019)
Lamiaceae	***Mentha longifolia* (L.) L.**	W	Horsemint, Asian mint	Leaves	Infusion	Kilic and Bagci (2013), Gökçe (2014), Sargin et al. (2015a), Günbatan et al. (2016), Özçelik et al. (2016), Yeşilyurt et al. (2017b), Gürbüz et al. (2019)
Lamiaceae	***Mentha longifolia* subsp. *typhoides* (Briq.) Harley**	W	Horse mint	Aerial parts	Eaten raw, Infusion	Güneş and Özhatay (2011), Demirci and Özhatay (2012), Polat et al. (2013), Şenkardeş (2014), Kılıç (2016), Bulut et al. (2017a), Yeşilyurt et al. (2017b), Polat (2019), Kılıç (2019), Çiçek (2019), Olgun (2019)
Lamiaceae	***Mentha pulegium* L.**	W	Pennyroyal, pennyrile, squaw mint	Leaves	Infusion	Gökçe (2014), Sargin et al. (2015a), Güner and Selvi (2016), Yeşilyurt et al. (2017b), Akbulut et al. (2019), Köse (2019), Yılmaz (2019)
Lamiaceae	***Mentha spicata* L.**	W	Garden mint, spearmint, curly mint, mint, common mint	Aerial parts	Infusion	Tuzlacı and Eryaşar-Aymaz (2001), Tuzlacı (2006), Cakilcioglu et al. (2011), Polat et al. (2013), Tetik et al. (2013), Gökçe (2014), Paksoy et al. (2016), Yeşilyurt et al. (2017b), Güneş (2017), Güneş et al. (2018), Polat (2019), Köse (2019)
Lamiaceae	*Mentha x piperita* L.	CW	Peppermint	Leaves	Infusion with/without lemon juice, Spices	Saraç (2005), Ugulu et al. (2009), Genç (2010), Kalafatçılar and Kalafatçılar (2010), Tetik et al. (2013), Şenkardeş (2014), Sargin et al. (2015a), Sargin and Büyükcengiz (2019), Günbatan et al. (2016), Bulut et al. (2017b), Güneş (2017), Yeşilyurt et al. (2017a, 2017b), Bulut et al. (2019), Demirci-Kayıran (2019), Gürbüz et al. (2019), Kılıç (2019)
Lamiaceae	***Micromeria myrtifolia* Boiss. & Hohen.**	W	No English name	Aerial parts	Infusion, Spices	Bulut and Tuzlacı (2015), Kocabaş and Gedik (2016), Güzel and Güzelsemme (2018), Çiçek (2019), Sargin and Büyükcengiz (2019)
Lamiaceae	***Micromeria nervosa* (Desf.) Benth.**	W	No English name	Aerial parts	Infusion	Ertuğ (2004), Bulut et al. (2017b)
Lamiaceae	***Ocimum basilicum* L.**	CW	Basil, great basil	Aerial parts	Infusion	Arıtuluk (2010), Polat et al. (2013), Tetik et al. (2013), Polat (2019)
Lamiaceae		E	No English name	Aerial parts	Infusion	Polat (2019)

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Table 3 (*continued*)

Families	Sc. names	W/C/E	English names	Parts	Preparations	References
	Origanum acutidens (Hand.-Mazz.) Ietsw.					
Lamiaceae	***Origanum hypericifolium* O.Schwarz & P.H.Davis**	E	No English name	Aerial parts	Infusion	Bulut et al. (2017a), Yılmaz (2019)
Lamiaceae	***Origanum majorana* L.**	W	Sweet marjoram, marjoram	Flowering branches	Infusion	Ertuğ et al. (2004), Bulut and Tuzlacı (2015), Sargin (2015), Sargin et al. (2013, 2015a), Sargin and Büyükcengiz (2019), Demirci-Kayıran (2019)
Lamiaceae	***Origanum onites* L.**	W	Pot marjoram, Cretan oregano	Aerial parts	Infusion with/without Sage leaves	Ertuğ (2004), Ertuğ et al. (2004), Tuzlacı (2006), Ugulu et al. (2009), Genç (2010), Kalafatçılar and Kalafatçılar (2010), Sargin et al. (2013, 2015a), Gökçe (2014), Nacakcı and Dutkuner (2015), Akbulut et al. (2019), Yılmaz (2019)
Lamiaceae	***Origanum saccatum* P.H. Davis**	E	No English name	Aerial parts, Flowering branches	Infusion	Sargin (2015), Sargin and Büyükcengiz (2019)
Lamiaceae	***Origanum syriacum* subsp. *bevanii* (Holmes) Greuter & Burdet**	W	No English name	Aerial parts, Flowering branches	Infusion	Sargin (2015), Sargin et al. (2015b), Sargin and Büyükcengiz (2019), Guzel and Guzelsemme (2018), Demirci-Kayıran (2019)
Lamiaceae	*Origanum vulgare* L.	W	Ornamental oregano	Aerial parts	Infusion	Ertuğ et al. (2004), Özhatay et al. (2009), Cakilcioglu et al. (2011), Polat et al. (2013), Gökçe (2014), Bulut and Tuzlacı (2015), Çiçek (2019)
Lamiaceae	***Origanum vulgare* subsp. *gracile* (K.Koch) Ietsw.**	W	Russian oregano	Leaves, Flowering branches, Aerial parts	Infusion	Ertuğ et al. (2004), Cakilcioglu et al. (2011), Kilic and Bagci (2013), Ozturk et al, (2017a), Tuzlacı and Doğan (2010), Olgun (2019)
Lamiaceae	***Origanum vulgare* subsp. *hirtum* (Link) Ietsw.**	W	Greek oregano	Aerial parts	Infusion	Ertuğ et al. (2004), Tuzlacı and Eryaşar-Aymaz (2001), Cakilcioglu et al. (2011), Gökçe (2014), Bulut (2016)
Lamiaceae	***Origanum vulgare* subsp. *viridulum* (Martrin-Donos) Nyman**	W	Winter marjoram	Flowering branches	Infusion	Ertuğ et al. (2004), Cakilcioglu et al. (2011), Gökçe (2014), Karaköse and Karaköse (2017)
Lamiaceae	***Phlomis armeniaca* Willd.**[a]	W	No English name	Flowers, Aerial parts	Infusion	Şenkardeş (2014), Dalar et al. (2018), Çiçek (2019), Olgun (2019)
Lamiaceae	***Prunella vulgaris* L.**	W	Common selfheal, self-heal	Flowering branches	Infusion	Baytop (1999), Ergül-Bozkurt and Terzioğlu (2017), Karaköse and Karaköse (2017)
Lamiaceae	*Rosmarinus officinalis* L.	CW	Rosemary	Leaves, Stems	Infusion	Ertuğ et al. (2004), Tuzlacı (2006), Yeşilada (2012), Saraçoğlu (2014), Bulut and Tuzlacı (2015), Güner and Selvi (2016), Maranki and Maranki (2016), Kocabas et al. (2017), Kurt and Karaoğul (2018), Akbulut et al. (2019)
Lamiaceae	***Salvia absconditiflora* Greuter & Burdet**	E	No English name	Aerial parts, Leaves, Flowers	Cataplasm with dough	Demirci and Özhatay (2012), Sargin (2013), Şenkardeş (2014), Sargin et al. (2015a), Ozturk et al, (2017a), Kılıç (2019)
Lamiaceae	***Salvia aramiensis* Rech.f.**	W	Aramenian salve	Leaves	Infusion	Guzel and Guzelsemme (2018)
Lamiaceae	***Salvia candidissima* Vahl**	W	Silver sage	Leaves	Infusion	Tuzlacı and Doğan (2010), Olgun (2019)
Lamiaceae	*Salvia fruticosa* Mill.	W	Greek sage, Turkish sage	Aerial parts, Essential oil	Infusion, Lotion	Tanker et al. (1998), Ertuğ (2004), Ertuğ et al. (2004), Tuzlacı (2006), Bulut (2016)
Lamiaceae	***Salvia multicaulis* Vahl**	W	Many-stemmed sage	Aerial parts	Infusion, Decoction	Tetik et al. (2013), Çiçek (2019), Olgun (2019)
Lamiaceae	*Salvia officinalis* L.	CW	Culinary sage, golden sage, garden sage	Aerial parts	Infusion	Tanker et al. (1998), Ertuğ et al. (2004), Kalafatçılar and Kalafatçılar (2010), Cakilcioglu et al. (2011), Yeşilada (2012), Akan and Bakır-Sade (2015), Maranki and Maranki (2016), Kurt and Karaoğul (2018), Demirci-Kayıran (2019)
Lamiaceae	***Salvia palaestina* Benth.**	W	Palestinian sage	Aerial parts	Infusion	Kocabas et al. (2017), Bulut et al. (2019), Kılıç (2019)
Lamiaceae	*Salvia sclarea* L.	W	Clary sage, clary, clary wort	Flowering branches, Leaves	Infusion	Tuzlacı and Doğan (2010), Demirci-Kayıran (2019)
Lamiaceae	***Salvia syriaca* L**	W	Syrian sage	Leaves, Flowers	Infusion	Kilic and Bagci (2013), Şenkardeş (2014)
Lamiaceae	***Salvia tomentosa* Mill.**	W	Balsamic sage	Aerial parts	Infusion, Steam compress	Tuzlacı and Erol (1999), Tuzlacı and Eryaşar-Aymaz (2001), Ertuğ et al. (2004), Sargin et al. (2013, 2015a), Güner and Selvi (2016), Özçelik et al. (2016), Bulut et al. (2017a), Guzel and Guzelsemme (2018)
Lamiaceae	***Salvia verticillata* L.**	W	Lilac sage	Leaves	Infusion	Köse (2019), Olgun (2019)

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Table 3 (*continued*)

Families	Sc. names	W/C/E	English names	Parts	Preparations	References
Lamiaceae	***Salvia viridis* L.**	W	Horminum sage	Leaves, Flowers	Infusion	Paksoy et al. (2016), Güneş (2017)
Lamiaceae	***Satureja cuneifolia* Ten.**	W	Apulian savory	Aerial parts	Infusion, Decoction	Ertuğ et al. (2004), Sargin et al. (2013, 2015a), Güneş (2017), Kartal and Güneş (2017)
Lamiaceae	***Satureja hortensis* L.**	W	Summer savory	Aerial parts	Infusion	Ertuğ et al. (2004), Cakilcioglu et al. (2011), Kilic and Bagci (2013), Polat et al. (2013), Tetik et al. (2013), Güneş (2017), Çiçek (2019), Olgun (2019)
Lamiaceae	***Satureja thymbra* L.**	W	Thyme-leaved savory	Aerial parts, Flowering branches, Essential oil	Infusion, Spice, Lotion	Ertuğ et al. (2004), Nacakcı and Dutkuner (2015), Sargin (2015); Sargin et al. (2015a)
Lamiaceae	***Satureja wiedemanniana* (Avé-Lall.) Velen.**	W	No English name	Aerial parts	Infusion	Cansaran and Kaya (2010), Han and Bulut (2015)
Lamiaceae	***Sideritis arguta* Boiss. & Heldr.**	E	No English name	Leaves, Flowers	Infusion	Akbulut et al. (2019), Yılmaz (2019)
Lamiaceae	***Sideritis dichotoma Huter***	E	No English name	Aerial parts	Infusion	Cansaran and Kaya (2010)
Lamiaceae	***Sideritis erythrantha* Boiss. & Heldr.**	E	No English name	Aerial parts	Infusion, Gargle	Ertuğ et al. (2004), Sargin (2015), Sargin et al. (2015b), Ozturk et al, (2017b)
Lamiaceae	***Sideritis germanicopolitana* Bornm.**	E	No English name	Aerial parts	Infusion	Han and Bulut (2015), Günbatan et al. (2016)
Lamiaceae	***Sideritis huber-morathii* Greuter & Burdet**	E	No English name	Aerial parts	Infusion	Guzel and Guzelsemme (2018)
Lamiaceae	***Sideritis leptoclada* O. Schwarz & P.H.Davis**	E	No English name	Aerial parts	Infusion	Bulut et al. (2017a), Yılmaz (2019)
Lamiaceae	***Sideritis libanotica* Labill.**	W	No English name	Leaves, Flowers	Infusion	Arıtuluk (2010), Akbulut et al. (2019)
Lamiaceae	***Sideritis libanotica* subsp. *linearis* (Benth.) Bornm.**	W	No English name	Aerial parts	Infusion	Arıtuluk (2010), Nacakcı and Dutkuner (2015), Demirci and Özhatay (2012)
Lamiaceae	***Sideritis montana* L.**	W	Mountain ironwort	Aerial parts	Infusion	Ertuğ et al. (2004), Paksoy et al. (2016), Özhatay et al. (2009)
Lamiaceae	***Sideritis perfoliata* L.**	W	No English name	Aerial parts	Infusion	Bulut and Tuzlacı (2015), Kocabaş and Gedik (2016), Bulut et al. (2017a), Ozturk et al, (2017b), Guzel and Guzelsemme (2018)
Lamiaceae	***Sideritis rubriflora* Hub.-Mor.**	E	No English name	Aerial parts	Infusion, Gargle	Sargin (2015), Sargin et al. (2015b)
Lamiaceae	***Sideritis scardica* Griseb.**	W	Shepherd's tea	Aerial parts	Infusion	Ertuğ et al. (2004), Özhatay et al. (2009), Güneş (2017)
Lamiaceae	***Sideritis sipylea* Boiss.**	E	No English name	Aerial parts	Infusion	Ertuğ et al. (2004), Sargin et al. (2013, 2015a)
Lamiaceae	***Sideritis syriaca* subsp. *nusairiensis* (Post) Hub.-Mor.**	E	No English name	Aerial parts	Infusion	Şenkardeş (2014), Kocabaş and Gedik (2016), Guzel and Guzelsemme (2018)
Lamiaceae	***Sideritis tmolea* P. H. Davis**	E	No English name	Aerial parts, Flowers	Infusion	Baytop (1999), Ertuğ et al. (2004), Arıtuluk (2010), Sargin et al. (2013, 2015a)
Lamiaceae	***Sideritis vulcanica* Hub.-Mor.**	E	No English name	Aerial parts	Infusion	Ertuğ et al. (2004), Polat (2019), Olgun (2019)
Lamiaceae	***Stachys annua* (L.) L.**	W	Annual yellow	Aerial parts	Infusion	Şenkardeş (2014), Karaköse and Karaköse (2017)
Lamiaceae	***Stachys lavandulifolia* Vahl**	W	Lamb's ear	Aerial parts	Infusion	Polat et al. (2013), Sargin (2015), Sargin and Büyükcengiz (2019), Polat (2019), Olgun (2019)
Lamiaceae	***Teucrium chamaedrys* L.**	W	Midget	Aerial parts	Infusion	Tuzlacı (2006), Tuzlacı and Doğan (2010), Kaval et al. (2014)
Lamiaceae	***Teucrium chamaedrys* subsp. *sinuatum* (Celak.) Rech.f.**	W	No English name	Aerial parts	Infusion	Polat et al. (2013), Kaval et al. (2014), Polat (2019)
Lamiaceae	*Teucrium polium* L.[a]	W	Hulwort, felty germander, mountain germander	Aerial parts	Infusion	Tuzlacı and Erol (1999), Tuzlacı (2006), Koçyiğit and Özhatay (2006), Özhatay et al. (2009), Tuzlacı and Doğan (2010), Cakilcioglu et al. (2011), Kilic and Bagci (2013), Polat et al. (2013), Kaval et al. (2014), Şenkardeş (2014), Günbatan et al. (2016), Dalar et al. (2018), Polat (2019), Bulut et al. (2019), Kılıç (2019), Çiçek (2019), Olgun (2019)
Lamiaceae	*Thymbra capitata* (L.) Cav.	W	Spanish oregano, cone-head thyme	Aerial parts, Flowering branches, Essential oil	Infusion, Lotion, Spice	Ertuğ et al. (2004), Sargin (2015), Sargin et al. (2015a), Yılmaz (2019)
Lamiaceae	***Thymbra sintenisii* Bornm. & Azn.**	W	No English name	Aerial parts	Infusion	Ozturk et al, (2017)a, Bulut et al. (2019)
Lamiaceae	***Thymbra spicata* L.**	W	Thyme spiked		Infusion, Lotion, Spice	

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Table 3 (*continued*)

Families	Sc. names	W/C/E	English names	Parts	Preparations	References
				Aerial parts, Flowers		Ertuğ et al. (2004), Tuzlacı (2006), Bulut and Tuzlacı (2013, 2015), Sargin et al. (2013, 2015a; 2015b), Özçelik et al. (2016), Sargin and Büyükcengiz (2019), Akan and Bakır-Sade (2015), Sargin (2015), Güner and Selvi (2016), Kocabaş and Gedik (2016), Kılıç (2019)
Lamiaceae	***Thymus cilicicus* Boiss. & Balansa**	W	Cilician thyme	Aerial parts	Infusion	Tuzlacı (2006), Genç (2010), Gökçe (2014), Özçelik et al. (2016), İşler (2017), Guzel and Guzelsemme (2018)
Lamiaceae	***Thymus haussknechtii* Velen.**	E	No English name	Leaves	Infusion	Tuzlacı (2006), Genç (2010), Cakilcioglu et al. (2011), Kilic and Bagci (2013), Tetik et al. (2013), Gökçe (2014), Paksoy et al. (2016), İşler (2017)
Lamiaceae	***Thymus kotschyanus* Boiss. & Hohen.**	W	No English name	Aerial parts	Infusion	Tuzlacı (2006), Genç (2010), Cakilcioglu et al. (2011), Polat et al. (2013), Kaval et al. (2014), Kocabaş and Gedik (2016), İş ler (2017), Kocabas et al. (2017), Polat (2019), Bulut et al. (2019)
Lamiaceae	***Thymus longicaulis* C. Presl**	W	Creeping thyme	Flowering branches, Aerial parts	Infusion	Tuzlacı (2006), Genç (2010), Gökçe (2014), Günbatan et al. (2016), İşler (2017), Akbulut et al. (2019), Gürbüz et al. (2019)
Lamiaceae	***Thymus longicaulis* subsp. *chaubardii* (Rchb.f.) Jalas**	W	No English name	Aerial parts	Infusion	Ertuğ et al. (2004), Tuzlacı (2006), Ö zhatay et al. (2009), Arıtuluk (2010), Genç (2010), Bulut and Tuzlacı (2015), İşler (2017)
Lamiaceae	***Thymus migricus* Klokov & Des.-Shost.**	W	No English name	Leaves	Infusion	Ertuğ et al. (2004), Tuzlacı (2006), Genç (2010), Tuzlacı and Doğan (2010), Güneş and Özhatay (2011), İşler (2017)
Lamiaceae	***Thymus nummularius* M. Bieb.**	W	No English name	Flowering branches	Infusion	Ertuğ et al. (2004), Tuzlacı (2006), Genç (2010), İşler (2017), Karaköse and Karaköse (2017)
Lamiaceae	***Thymus praecox* subsp. *jankae* (Celak.) Jalas**	W	No English name	Leaves	Infusion	Ertuğ et al. (2004), Tuzlacı (2006), Arıtuluk (2010), Genç (2010), Günbatan et al. (2016), İşler (2017)
Lamiaceae	***Thymus revolutus* Celak.**	E	No English name	Aerial parts	Infusion	Tuzlacı (2006), Genç (2010), Kocabas et al. (2017), Sargin and Büyükcengiz (2019)
Lamiaceae	***Thymus sipyleus* Boiss.**	W	No English name	Aerial parts	Infusion	Tuzlacı (2006), Cansaran and Kaya (2010), Genç (2010), Gökçe (2014), Şenkardeş (2014), Paksoy et al. (2016), Polat (2019)
Lamiaceae	***Thymus transcaucasicus* Ronniger**	W	No English name	Whole parts	Infusion	Tuzlacı (2006), Genç (2010), Güneş and Özhatay (2011), Gökçe (2014), İşler (2017)
Lamiaceae	***Thymus zygioides* Griseb.**	W	No English name	Aerial parts, Flowering branches	Infusion	Tuzlacı (2006), Özhatay et al. (2009), Genç (2010), Sargin et al. (2013, 2015a), Gökçe (2014), Bulut and Tuzlacı (2015), İş ler (2017)
Lamiaceae	***Vitex agnus-castus* L.**	W	Chaste tree, Abraham's balm	Seeds	Decoction, Swallowing	Tuzlacı (2006), Akan and Bakır-Sade (2015), Sargin (2015), Güner and Selvi (2016), Demirci-Kayıran (2019)
Lamiaceae	***Ziziphora capitata* L.**	W	No English name	Aerial parts	Infusion	Kilic and Bagci (2013), Kocabas et al. (2017), Kılıç (2019)
Lamiaceae	***Ziziphora clinopodioides* Lam.**	W	Blue mint bush	Aerial parts	Infusion	Ertuğ et al. (2004), Tuzlacı and Doğan (2010), Sargin et al. (2013, 2015a)
Lamiaceae	***Ziziphora taurica* M.Bieb.**	W	No English name	Aerial parts	Infusion	Baytop (1999), Ertuğ et al. (2004), Sargin et al. (2013, 2015a)
Lamiaceae	***Ziziphora taurica* subsp. *cleonioides* (Boiss.) P.H. Davis**	E	No English name	Aerial parts	Infusion	Ertuğ (2004), Ertuğ et al. (2004), Arıtuluk (2010), Sargin et al. (2013, 2015a)
Lamiaceae	***Ziziphora tenuior* L.**	W	No English name	Aerial parts	Infusion	Ertuğ (2004), Sargin et al. (2013), Dalar et al. (2018)
Lauraceae	***Laurus nobilis* L.**	CW	Laurel, true laurel, bay, royal bay, sweet bay, Grecian laurel	Leaves, Seeds	Infusion of the leaves with/without quince leaves after drying and pulverizing, Decoction of the seeds	Tuzlacı (2006), Nacakcı and Dutkuner (2015), Kurt and Karaoğul (2018), Gürbüz et al. (2019), Köse (2019)
Leguminosae	***Ceratonia siliqua* L.**	CW	Carob, carob tree	Fruits	Eaten raw, Boiling, Molasses	Kurt and Karaoğul (2018), Sargin and Büyükcengiz (2019)
Leguminosae	*Glycyrrhiza glabra* L.	CW	Licorice, liquorice	Leaves, Roots	Infusion after pulverizing	Özer et al. (2005), Saraç (2005), Genç (2010), Sargin et al. (2013, 2015a), Gökçe (2014), Kurt and Karaoğul (2018), Kılıç (2019)
Leguminosae	***Trifolium repens* L.**	W	Dutch clover	Aerial parts	Infusion	Cakilcioglu et al. (2011), Kilic and Bagci (2013), Ozturk et al, (2017b)

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Table 3 (*continued*)

Families	Sc. names	W/C/E	English names	Parts	Preparations	References
Lythraceae	*Punica granatum* L.	CW	Pomegranate	Fruits	Eaten raw, Juice	Baytop (1999), Kocabaş and Gedik (2016), Demirci-Kayıran (2019)
Malvaceae	***Alcea calvertii* (Boiss.) Boiss.**	W	No English name	Aerial parts	Infusion, Decoction	Akan and Bakır-Sade (2015), Kılıç (2016), Ozturk et al, (2017a)
Malvaceae	***Alcea excubita* Iljin**	W	No English name	Flowers, Leaves	Infusion	Tuzlacı and Doğan (2010), Kılıç (2016)
Malvaceae	***Alcea pallida* (Willd.) Waldst. & Kit.**	W	Hollyhock, eastern hollyhock	Flowers, Fruits, Aerial parts	Infusion, Decoction	Arıtuluk (2010), Bulut et al. (2017a)
Malvaceae	*Alcea rosea* L.	W	Garden hollyhock, rose mallow	Leaves, Flowers, Roots	Infusion	Şenkardeş (2014), Akgül et al. (2016), Demirci-Kayıran (2019)
Malvaceae	***Alcea setosa* (Boiss.) Alef.**	W	Bristly hollyhock	Flowers, Fruits	Infusion	Akgul et al, (2018), Kılıç (2019)
Malvaceae	***Alcea striata* Alef.**	W	No English name	Flower, Fruits	Infusion	Akgul et al, (2018), Kılıç (2019)
Malvaceae	***Althaea officinalis* L.**	CW	Common marsh	Buds, Flowers	Infusion	Baytop (1999), Genç (2010), Kalafatçılar and Kalafatçılar (2010), Sargin et al. (2015b), Demirci-Kayıran (2019)
Malvaceae	***Malva neglecta* Wallr.**	W	Cheeseplant, dwarf mallow	Aerial parts	Infusion, Decoction	Tuzlacı and Erol (1999), Cakilcioglu et al. (2011), Kilic and Bagci (2013), Polat et al. (2013), Tetik et al. (2013), Kaval et al. (2014), Şenkardeş (2014), Dalar et al. (2018), Olgun (2019)
Malvaceae	***Malva sylvestris* (L.) Mill.**[a]	W	Large-flowered mallow, high mallow	Aerial parts	Roasted with rice, radish, onion and butter, Infusion	Tuzlacı and Erol (1999), Özer et al. (2005), Özhatay et al. (2009), Polat et al. (2013), Nacakcı and Dutkuner (2015), Sargin et al. (2015a), Dalar et al. (2018), Demirci-Kayıran (2019), Köse (2019)
Malvaceae	***Tilia cordata* Mill.**	W	Bast, small-leaved linden	Leaves, Fruits	Decoction with cinnamon and cloves	Saraç (2005), Kalafatçılar and Kalafatçılar (2010), Gökçe (2014), Şenkardeş (2014), Akgül et al. (2016), Maranki and Maranki (2016), İşler (2017), Yeşilyurt et al. (2017b)
Malvaceae	***Tilia platyphyllos* Scop.**	W	Broad-leaved lime	Flowers, Bracts	Infusion	Saraç (2005), Kalafatçılar and Kalafatçılar (2010), Bulut and Tuzlacı (2013), Gökçe (2014), Maranki and Maranki (2016), Bulut et al. (2017b), İşler (2017)
Malvaceae	***Tilia rubra* subsp. *caucasica* (Rupr.) V.Engl.**	W	No English name	Flowers, Leaves, Barks	Infusion, Decoction	Saraç (2005), Tuzlacı (2006), Cansaran and Kaya (2010), Gökçe (2014), Bulut and Tuzlacı (2015), Güner and Selvi (2016), Uzun and Kaya (2016), Maranki and Maranki (2016), İşler (2017), Karaköse and Karaköse (2017), Köse (2019)
Malvaceae	***Tilia tomentosa* Moench**	CW	European white lime, silver lime, silver linden	Leaves, Flowers, Fruits, Barks, Bracts, Roots	Infusion, Decoction	Tuzlacı and Tolon (2000), Tuzlacı and Eryaşar-Aymaz (2001), Saraç (2005), Özhatay et al. (2009), Sargin et al. (2013), Gökçe (2014), Bulut and Tuzlacı (2015), Akgül et al. (2016), Maranki and Maranki (2016), Bulut et al. (2017a), İşler (2017), Yeşilyurt et al. (2017a, 2017b), Guzel and Guzelsemme (2018), Kurt and Karaoğul (2018), Gürbüz et al. (2019)
Moraceae	*Ficus carica* L.[a]	CW	Fig, common fig	Fruits, Leaves	Eaten after drying, Infusion	Sargin et al. (2013, 2015a), Köse (2019)
Moraceae	*Morus alba* L.	CW	White mulberry	Fruits	Syrup	Cakilcioglu et al. (2011), Şenkardeş (2014), Olgun (2019)
Myrtaceae	*Eucalyptus camaldulensis* Dehnh.	CW	Murray red gum, red gum, river red gum, long-beak eucalyptus	Leaves, Essential oils	The 2% infusion is sweetened with honey and drunk 2–3 glasses a day. Medicinal bath, frankincense	Karamanoğlu (1977), Tanker et al. (1998), Baytop (1999), Ertuğ (2004), Saraç (2005), Genç (2010), Kalafatçılar and Kalafatçılar (2010), Ozturk et al. (2017a)
Myrtaceae	*Eucalyptus globulus* Labill.	CW	Blue gum, southern blue gum	Leaves, Essential oils	The 2% infusion is sweetened with honey and drunk 2–3 glasses a day. Medicinal bath, frankincense	Karamanoğlu (1977), Tanker et al. (1998), Baytop (1999), Saraç (2005), Genç (2010), Kalafatçılar and Kalafatçılar (2010), Kurt and Karaoğul (2018)
Nitrariaceae	*Peganum harmala* L.	W	Harmal piganum	Seeds	Infusion	Yeşilyurt et al. (2017a), Bulut et al. (2019), Demirci-Kayıran (2019)
Oleaceae	***Fraxinus ornus* subsp. *cilicica* (Lingelsh.) Yalt.**	E	No English name	Stems, Barks	Infusion	Demirci and Özhatay (2012), Ozturk et al, (2017a)
Oleaceae	*Olea europaea* L.[a]	CW	Olive, common olive	Fixed oils	Cataplasm with one tablespoon molasses, tarhana and flour	Tuzlacı (2006), Nacakcı and Dutkuner (2015), Sargin et al. (2015a), Köse (2019)
Orchidaceae	***Dactylorhiza osmanica* (Klinge) P.F.Hunt & Summerh.**	E	No English name	Tubers	Infusion (with some milk after powdering)	Şenkardeş (2014), Sargin (2015), Sargin and Büyükcengiz (2019)
Orchidaceae	***Orchis anatolica* Boiss.**	W	Orchid	Tubers	Infusion, Spice (after powdering)	Baytop (1999), Sargin (2015), Ozturk et al, (2017b)
Papaveraceae	***Papaver orientale* L.**	W	Great scarlet poppy	Seeds	Roasted with garlic	Tanker et al. (1998), Baytop (1999), Güneş and Özhatay (2011)

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Table 3 (*continued*)

Families	Sc. names	W/C/E	English names	Parts	Preparations	References
Papaveraceae	*Papaver rhoeas* L.	W	Flanders poppy	Flowers	Infusion	Tanker et al. (1998), Ugulu et al. (2009), Bulut et al. (2017b)
Pedaliaceae	***Sesamum indicum* L.**	CW	Sesame, common sesame	Seeds	Crushed and mixed with boiled grape juice, Eaten raw	Baytop (1999), Bağcı et al. (2016), Güneş (2017)
Pinaceae	***Abies cilicica* (Antoine & Kotschy) Carrière**	W	Spring grove, cilica fir, hunnewell	Cones, Resins, Buds, Branches	Decoction	Baytop (1999), Ozturk et al. (2017a)
Pinaceae	***Pinus nigra* J.F.Arnold**	W	Black pine	Resins, Tars, Essential oils	Decoction, Medicinal bath, frankincense	Tanker et al. (1998), Arıtuluk (2010), Kalafatçılar and Kalafatçılar (2010), Cakilcioglu et al. (2011), Bağcı et al. (2016), Özçelik et al. (2016), Gürbüz et al. (2019)
Pinaceae	***Pinus sylvestris* L.**	CW	Redwood, Scots fir	Buds, Resins, Cones, Essential oils	Decoction, Medicinal bath, frankincense	Kalafatçılar and Kalafatçılar (2010), Karaköse and Karaköse (2017), Gürbüz et al. (2019)
Plantaginaceae	***Plantago major* L.**[a]	W	Rat's-tail plantain	Leaves	Infusion	Özhatay et al. (2009), Cakilcioglu et al. (2011), Olgun (2019)
Plantaginaceae	***Plantago major* subsp. *intermedia* (Gilib.) Lange**	W	No English name	Aerial parts, Leaves	Infusion after drying	Arıtuluk (2010), Sargin et al. (2015a), Yeşilyurt et al. (2017a)
Polygonaceae	*Portulaca oleracea* L.	W	Common purslane, fatweed	Aerial parts	Eating raw, Boiling, Roasting	Şenkardeş (2014), Kılıç (2019), Köse (2019), Olgun (2019), Yılmaz (2019)
Polygonaceae	***Rumex crispus* L.**	W	Curled dock	Roots	Cataplasm	Tuzlacı (2006), Arıtuluk (2010), Sargin et al. (2015a), Yeşilyurt et al. (2017a)
Polygonaceae	***Rumex patientia* L.**	W	Garden patience	Leaves	Decoction	Tuzlacı (2006), Güneş and Özhatay (2011), Ozturk et al, (2017b)
Polygonaceae	***Rumex scutatus* L.**	W	Shield dock	Leaves	Infusion	Tuzlacı (2006), Cansaran and Kaya (2010), Ozturk et al, (2017a)
Ranunculaceae	***Adonis annua* L.**	W	Annual pheasant's eye	Flowers	Infusion after drying	Baytop (1999), Güneş (2017)
Ranunculaceae	***Helleborus orientalis* Lam.**	W	Lenten-rose	Roots	Eaten raw	Tuzlacı and Tolon (2000), Koçyiğit and Özhatay (2006)
Ranunculaceae	***Nigella arvensis* L.**	CW	Wild fennel, field fennel flower	Flowers, Seeds	Infusion after drying and crashing	Güneş (2017)
Ranunculaceae	*Nigella sativa* L.	CW	Black cumin	Seeds	Eating raw, Infusion after crashing	Bulut et al. (2017a), Kurt and Karaoğul (2018)
Rosaceae	*Crataegus monogyna* Jacq.	CW	Hawtorn, may	Fruits	Eaten raw, Infusion	Cakilcioglu et al. (2011), Şenkardeş (2014), Sargin et al. (2015a), Olgun (2019)
Rosaceae	***Crataegus orientalis* Pall. ex M.Bieb.**	CW	Oriental hawtorn	Fruits	Eaten raw, Infusion	Arıtuluk (2010), Polat et al. (2013), Ş enkardeş (2014), Ozturk et al, (2017b)
Rosaceae	***Crataegus pentagyna* Waldst. & Kit. ex Willd.**	W	Small-flowered black hawtorn	Flowers	Infusion	Özhatay et al. (2009), Koçyiğit and Özhatay (2006)
Rosaceae	*Cydonia oblonga* Mill	CW	Quince	Leaves, Fruits	Infusion, Cataplasm (with some thyme and tarhana flour), Eaten raw	Cansaran and Kaya (2010), Bulut and Tuzlacı (2013), Polat et al. (2013), Sargin et al. (2013), Şenkardeş (2014), Özçelik et al. (2016), Paksoy et al. (2016), Uzun and Kaya (2016), Güneş (2017), Yeşilyurt et al. (2017a, 2017b), Gürbüz et al. (2019), Köse (2019), Çiçek (2019), Olgun (2019)
Rosaceae	***Eriobotrya japonica* (Thunb.) Lindl.**	CW	Loquat	Leaves	Infusion with Cydonia leaves and Tilia flowers	Baytop (1999), Gürbüz et al. (2019)
Rosaceae	*Malus domestica* Borkh.	C	Apple	Fruits	Eaten raw, Juice	Baytop (1999), Olgun (2019)
Rosaceae	***Mespilus germanica* L.**[a]	CW	Medlar, medlar tree	Leaves, Fruits	Infusion Eaten raw	Tuzlacı (2006), Özhatay et al. (2009), Ş enkardeş (2014), Köse (2019)
Rosaceae	***Potentilla speciosa* Willd.**	W	No English name	Roots	Decoction	Demirci and Özhatay (2012), Ozturk et al, (2017a), Güneş et al. (2018)
Rosaceae	***Prunus avium* (L.) L.**	CW	Sweet cherry	Fruits stalks	Paste (from tarhana flour and rye seeds, honey or molasses)	Sargin et al. (2015a), Çiçek (2019), Gürbüz et al. (2019)
Rosaceae	***Prunus cerasifera* Ehrh.**	CW	Cherry plum	Fruits	Eaten raw, Infusion, Decoction	Özhatay et al. (2009), Tetik et al. (2013), Çiçek (2019)
Rosaceae	***Prunus laurocerasus* L.**	W	Laurel cherry	Leaves	Infusion with Cydonia leaves	Baytop (1999), Bulut (2016), Gürbüz et al. (2019)
Rosaceae	***Prunus mahaleb* L.**	CW	Mahaleb cherry	Leaves	Infusion	Baytop (1999), Bulut and Tuzlacı (2013), Bulut et al. (2019)
Rosaceae	***Prunus spinosa* L.**	W	Sloe, blackthorn	Fruits	Eaten raw, Decoction	Özhatay et al. (2009), Yeşilyurt et al. (2017b)
Rosaceae	***Rosa* × *damascena* Herrm.**	CW	Rose, damask rose	Fruits	Infusion	Baytop (1999), Ozturk et al, (2017a), Guzel and Guzelsemme (2018)
Rosaceae	***Rosa* × *dumalis* Bechst.**	CW	Glaucous northern dog rose	Fruits, Leaves	Decoction, Infusion	Polat et al. (2013), Polat (2019), Olgun (2019)
Rosaceae	***Rosa boissieri* Cr.p.**[a]	W	Rose	Leaves, Fruits	Infusion Decoction	Tuzlacı (2006), Olgun (2019)
Rosaceae	***Rosa canina* L.**[a]	CW	Dog rose, briar rose, common briar	Fruits, Leaves, Flowers, Petals, Roots, Stems	Eaten raw, Infusion, Decoction, Jam, Marmalate	Tuzlacı and Erol (1999), Saraç (2005), Koçyiğit and Özhatay (2006), Özhatay et al. (2009), Ugulu et al. (2009), Genç (2010), Kalafatçılar and Kalafatçılar

(*continued on next page*)

Table 3 (*continued*)

Families	Sc. names	W/C/E	English names	Parts	Preparations	References
						(2010), Tuzlacı and Doğan (2010), Cakilcioglu et al. (2011), Güneş and Özhatay (2011), Demirci and Özhatay (2012), Yeşilada (2012), Bulut and Tuzlacı (2013), Kilic and Bagci (2013), Polat et al. (2013), Sargin et al. (2013, 2015a; 2015b), Tetik et al. (2013), Kaval et al. (2014), Şenkardeş (2014), Bulut and Tuzlacı (2015), Nacakcı and Dutkuner (2015), Akgül et al. (2016), Bağcı et al. (2016), Bulut (2016), Güner and Selvi (2016), Ozturk et al, (2017a), Paksoy et al. (2016), Uzun and Kaya (2016), Bulut et al. (2017a, 2017b), Ergül-Bozkurt and Terzioğlu (2017), Karaköse and Karaköse (2017), Yeşilyurt et al. (2017b), Dalar et al. (2018), Güneş et al. (2018), Guzel and Guzelsemme (2018), Polat (2019), Akbulut et al. (2019), Çiçek (2019), Demirci-Kayıran (2019), Gürbüz et al. (2019), Kılıç (2019), Köse (2019), Sargin and Büyükcengiz (2019)
Rosaceae	***Rosa hemisphaerica* Herrm.**	W	Sulphur rose	Fruits	Eaten raw, Decoction	Şenkardeş (2014), Uzun and Kaya (2016)
Rosaceae	***Rosa xanthina* Lindl.**	W	Yellow rose	Fruits	Decoction, Jam	Güneş and Özhatay (2011)
Rosaceae	***Rubus canescens* DC.**	W	Woolly blackberry	Leaves	Infusion	Özhatay et al. (2009), Kalafatçılar and Kalafatçılar (2010), Polat et al. (2013), Polat (2019), Akbulut et al. (2019)
Rosaceae	***Rubus sanctus* Schreb.**	W	Holy bramble	Fruits, Roots, Flowers	Eaten raw or after drying, Decoction, Infusion, Jam, Marmalate	Ertuğ (2004), Kalafatçılar and Kalafatçılar (2010), Şenkardeş (2014), Sargin et al. (2015a), Güneş et al. (2018), Kılıç (2019), Çiçek (2019), Olgun (2019)
Rutaceae	***Citrus* spp.**	CW	Oranges, lemons, grapefruits, pomelos, limes	Fruits, Pericarps	Dropped in teas and soups, Juice (sweetened with sugar), Gargle, Eaten fresh, Jam, Marmalade, Hot mush (externally)	Baytop (1999), Ertuğ (2004), Saraç (2005), Genç (2010), Sağıroğlu et al, (2013), Gökçe (2014), Akan and Bakır-Sade (2015), Gürbüz et al. (2019), Köse (2019)
Sapindaceae	***Aesculus hippocastanum* L.**	CW	Horse-chestnut, conker tree	Seeds	Peeled, minced, then swallowed	Baytop (1999), Gürbüz et al. (2019), Köse (2019)
Scrophulariaceae	***Scrophularia chrysantha* Jaub. & Spach**	W	Figwort	Whole parts	Decoction after drying	Güneş and Özhatay (2011)
Solanaceae	***Physalis alkekengi* L.**	W	Bladder cherry	Fruits	Eaten raw, Decoction	Karaköse and Karaköse (2017), Ozturk et al, (2017b)
Urticaceae	*Urtica dioica* L.	W	Stinging nettle, perennial nettle, tall nettle, common nettle	Aerial parts (without flowering)	Infusion	Tuzlacı and Erol (1999), Kilic and Bagci (2013), Polat et al. (2013), Özer et al. (2005), Tetik et al. (2013), Kaval et al. (2014), Şenkardeş (2014), Sargin et al. (2015a), İşler (2017), Ozturk et al, (2017a), Yeşilyurt et al. (2017a, 2017b), Kılıç (2019)
Urticaceae	***Urtica urens* L.**	W	Small nettle	Aerial parts	Infusion	Tuzlacı and Erol (1999), Özer et al. (2005), Cakilcioglu et al. (2011), Şenkardeş (2014), İşler (2017), Yeşilyurt et al. (2017b)
Violaceae	***Viola sieheana* W.Becker**	W	No English name	Flowers	Infusion	Özhatay et al. (2009), Karaköse and Karaköse (2017)
Violaceae	***Viola suavis* M.Bieb.**	W	Russian violet	Aerial parts	Infusion	Ergül-Bozkurt and Terzioğlu (2017)
Vitaceae	*Vitis vinifera* L.	CW	Common grapevine, grapevine, table grape	Fruits, Seeds	Eaten raw or dried, Cataplasm (with tarhana flour), Molasses	Tuzlacı (2006), Polat et al. (2013), Sargin et al. (2013, 2015a), Kılıç (2019), Köse (2019)

W: Wild plans, C: Cultured plants, WC: Wild and cultured plants, E: Endemic plants.
Boldly highlighted taxa (which are 189 in total and their anti-influenza effects have not been investigated experimentally yet).
[a] The plants that were also identified to be used in the treatment of malaria.

35 (15.6%) taxa found between the investigation results in the world literature and ethnobotanical results of the study was found to be 92.9%. This result may prove the fact that for centuries, the locals have been equally justified in their preferences of plant usage.

3.5. Comparative evaluation of active compounds

Taxa containing quercetin, which has a typical polyphenol structure with anti-influenza activity, are *Hypericum perforatum, Morus alba* and *Papaver rhoeas* (Kim et al., 2010; Liu et al., 2016; Kim and Chung, 2018) (Table 4). It is not accidental that we detected quercetin and chlorogenic acid as the most common active gradients in our screening records, because these compounds are found to be the most effective compounds used in the treatment of influenza. Supporting these findings, Kumar et al. (2003) stated in a study of mice that quercetin (Fig. 3A) may be useful as a drug to reduce oxidative stress caused by influenza virus

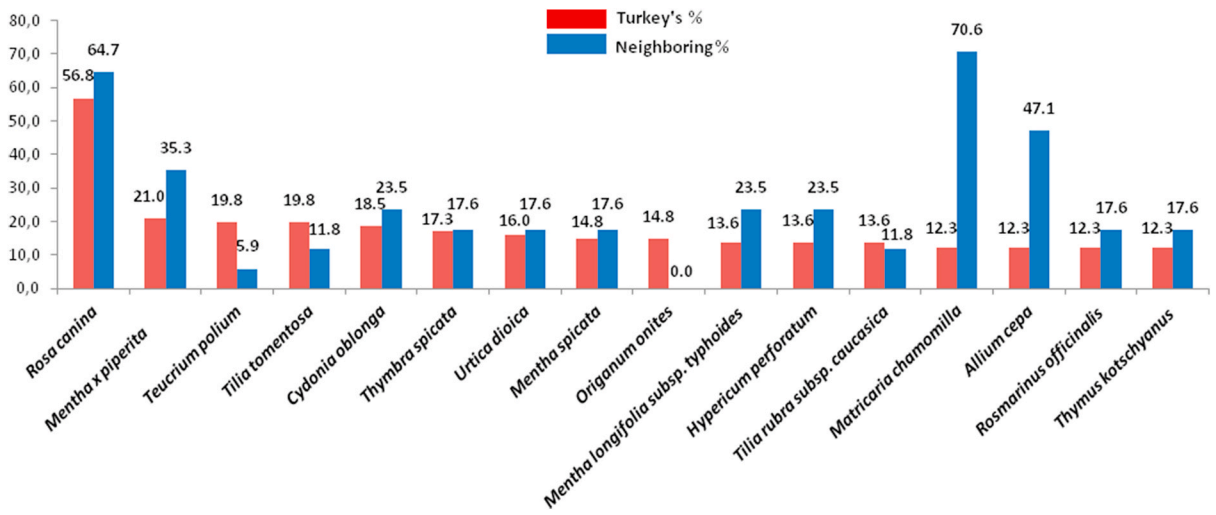

Fig. 2. The most frequently cited plants in Turkey and neighboring countries.

infection in the lungs, and to protect them from the toxic effects of free radicals. In another study, Wu et al. (2016) stated that quercetin, which shows inhibitory activity in the early stage of influenza infection, offers a future therapeutic option for developing effective, safe and affordable natural products for the treatment and prophylaxis of influenza virus infections. Moreover, Nile et al. (2020), in an investigation of the antiviral and cytotoxic effects of quercetin 3-glucoside (Q3G) from *Dianthus superbus*, Q3G (Fig. 3B) found that this substance showed strong antiviral activity against influenza A and B viruses. Therefore, they emphasized that it could be developed and used as a natural anti-influenza drug.

On the other hand, chlorogenic acid (CHA) is a caffeoylquinic acid constituent (Fig. 3C) found in many vegetables and fruits traditionally used in Turkish folk medicine, such as *Cydonia oblonga, Crataegus monogyna, Morus alba, Hypericum perforatum, Eucalyptus globules* (Baytop, 1999; Ding et al., 2017; Kim and Chung, 2018). Indeed, many researchers including Ding et al. (2017) and Ren et al. (2019) have pointed out that CHA acts as a neuraminidase blocker to inhibit influenza A virus at both *in vitro* and *in vivo* levels, thus they stated that CHA is potentially beneficial in the treatment of influenza.

Among the researches, the taxa containing the most active compounds in terms of anti-influenza activity were *Glycyrrhiza glabra* (11 chemicals with 31.4% out of the 35), *Papaver rhoeas* (7; 20.0%), *Morus alba* (5; 14.3%) *and Punica granatum* (4; 11.4%) (Table 4). *Glycyrrhiza glabra* (licorice) is among the oldest and most popular traditional herbal medicines worldwide (Grienke et al., 2014). Also, its roots are one of the most frequently used parts for treating respiratory tract infections in Turkish folk medicine (Baytop, 1999; Ertuğ, 2004). Hence, the roots may have appeared to have the greatest number of active ingredients in the screening. This result overlaps with the findings of Grienke et al. (2014) because they had emphasized that the accumulation of the plant components exhibits 3D similarities to known flu Neuraminidase inhibitors (which are key enzymes in viral replication and the first-line drug target to fight influenza) according to their basis of a shape-focused virtual screening. Therefore, this finding may be pointing out that this plant is more effective and specific than other taxa in terms of anti-influenza activity.

3.6. Ecotic plants

In addition, 9 medicinal exotic herbs were detected to have been traditionally used in the treatment of influenza and sold in herbal and public markets. *Zingiber officinale* (ginger), *Curcuma longa* (turmeric), *Syzygium aromaticum* (cloves), *Piper nigrum* (black pepper) and *Cinnamomum verum* (cinnamon) are examples of these plants. Information on which parts, methods, and how often these plants are used in flu treatment is given in Table 5. The citrus species presented in Table 3 are actually exotic species. For several centuries, they have mainly exhibited a distribution in the Aegean and Mediterranean coasts in Turkey's flora. *Citrus limon* (lemon), *C. sinensis* (orange), *C. reticulata* (tangerine), *C. paradisi* (grapefruit) and *C. x aurantium* (citrus) are among these types. *Eucalyptus camaldulensis* and *E. globulus* (Eucalyptus trees), another plant that has settled in the flora, are of Australian origin and have been used in forestry, roadside landscaping, drying of the marshes and folk medicine practices, such as combating malaria, since the Ottoman era (Özgün, 2013).

The point we should especially emphasize here is that, while herbal products to be released for the treatment of influenza are determined by World Health Organisation (WHO) and the European Phytotherapy Scientific Cooperative (ESCOP), and controlled by the Turkish government, these standard practices are not yet available for fresh or dried plant taxa that are traditionally consumed and sold in public markets and herbalist shops in Turkey. Besides, it can never be ignored that medicinal plants are very successful in preventing and treating influenza if used according to the prescriptions specified in their pharmacopoeia. Thus, it is necessary to record traditional-empirical practices with proven trial-and-error methods urgently, to demonstrate their activities and active ingredients *in vitro* or *in vivo* studies, and to enlighten the public by adding optimal tariffs to their pharmacopoeia by the relevant official standard institutions.

In our study, it was also determined that 27 endemic plants were used effectively in influenza treatment and collected from nature. The unconscious collection of endemic and endangered species in the red list of the International Association for Nature Conservation (IUCN) should be more carefully monitored using laws, media and educational tools and methods, and the necessary precautions should be urgently taken.

4. Conclusion

Although the first choice for influenza control and reducing the effects of epidemics is a vaccine, it is also known that it is not the fastest and most effective option since modifications in viral proteins require annual adaptation of the influenza vaccine formulation, as noted by Nachbagauer and Palese (2020). Considering the side effects and complications of antiviral medicines, the search for more effective remedies for fast-spreading pandemic influenza strains continues intensively all over the world today.

Due to their easy production, low cost, water-solubility, low toxicity and selective effects, medicinal plants, especially herbal essential oils and antiviral compounds found in their aqueous extracts are the most

Table 4
Worldwide anti-influenza activity research results of the taxa detected in the study.

Plant species	Active compounds identified (and used parts)	Mechanism of action	References
Alcea rosea L.	Not specified (Aerial parts)	Elicits antiviral innate immune responses in serum, bronchoalveolar lavage fluid, small intestinal fluid, and the lungs	Kim et al. (2018)
Allium cepa L.	Not specified (Bulbs)	Decreases Hemagglutination Assay (HA) titers and destroys the avian influenza virus subtype H9N2, and the propagation of the virus	Ahmadi et al. (2018)
Allium sativum L.	Allicin (Bulbs)	Inhibits viral nucleoprotein synthesis and polymerase activity	Chavan et al. (2016),
Crataegus monogyna Jacq.	Chlorogenic acid (Fruits)	Inhibits neuraminidase activity and blocks the release of newly formed virus particles from infected cells	Ding et al. (2017)
Cydonia oblonga Mill	Chlorogenic acid, 3-Caffeoylquinic acid (Fruits)	Inhibit influenza viral activity and no effect on hemagglutination inhibition	Hamauzu et al. (2005)
Eucalyptus camaldulensis Dehnh.	Not specified (Leaves)	Inhibit virus replication completely	Sadatrasul et al. (2017)
Eucalyptus camaldulensis Dehnh.	1,8-cineole (Leaves, Essential oil)	Increase the production of influenza-specific serum immunoglobulin (Ig) G2a antibodies, stimulate mucosal secretive IgA (s-IgA) responses at the nasal cavity, improve the expression of respiratory tract intraepithelial lymphocytes (IELs) in the upper respiratory tract, and promote dendritic cell (DC) maturation and the expression of co-stimulatory molecules	Li et al. (2017)
Eucalyptus camaldulensis Dehnh.	Mentofin (Leaves, Essential oil)	Inactivate Avian Influenza Virus (AIV)	Barbour et al. (2010)
Eucalyptus globulus Labill.	1,8-cineole (Leaves, Essential oil)	Increase the production of influenza-specific serum immunoglobulin (Ig) G2a antibodies, stimulate mucosal secretive IgA (s-IgA) responses at the nasal cavity, improve the expression of respiratory tract intraepithelial lymphocytes (IELs) in the upper respiratory tract, and promote dendritic cell (DC) maturation and the expression of co-stimulatory molecules	Li et al. (2017)
Eucalyptus globulus Labill.	Mentofin (Leaves, Essential oil)	Inactivate Avian Influenza Virus (AIV)	Barbour et al. (2010)
Eucalyptus globulus Labill.	Citronellol and Eugenol (Leaves, Essential oil) 1,8-Cineole and α-Thujone (Leaves)	Inhibits the hemagglutinin activity, but not the Neuraminidase activity	Vimalanathan and Hudson (2014)
Glycyrrhiza glabra L.	3,4-dihydro-8,8-dimethyl-2H,8H-benzo dipyran-3-ol, Biochanin B, Glabrol, Glabrone, Hispaglabridin B, Licoflavone B, Licorice glycoside B, Licorice glycoside E, Liquiritigenin, Liquiritin, Prunin (Roots)	Inhibit Neuraminidase (NA) activity	Grienke et al. (2014)
Hypericum perforatum L.	Hypericin (Flowers)	Inhibits virus-induced cytopathic effect; ie: Lung consolidation and lessening of lung virus titers.	Pu et al. (2009)
Hypericum perforatum L.	Isoquercetin (Flowers)	Inhibit the replication of both influenza A and B viruses at the lowest effective concentration	Kim et al. (2010)
Hypericum perforatum L.	Chlorogenic acid and Quercetin (Flowers)	Taken together, it was proposed that chlorogenic acid and quercetin could be employed as the effective lead compounds for anti-influenza A H1N1 due to having strong binding abilities with neuraminidase.	Liu et al. (2016)
Malus domestica Borkh.	5-Caffeoylquinic acid (Fruits)	Inhibit influenza viral activity and no effect on hemagglutination inhibition	Hamauzu et al. (2005)
Matricaria chamomilla L.	Borneol (Flowers-Essential oil)	Inhibit the replication of the influenza virus A (H1N1)	Sokolova et al. (2017)
Melissa officinalis L.	Not specified (Leaves)	Inhibit the HA (hemagglutinin) activity, but not the NA (Neuraminidase) activity	Jalali et al. (2016)
Melissa officinalis L.	Not specified (Leaves)	Inhibit replication of AVI through the different virus replication phase, especially throughout the direct interaction with the virus particles	Pourghanbari et al. (2016)
Melissa officinalis L.	Tannin (Leaves)	Aqueous extracts of the melissa plant blocked hemadsorption by parainfluenza viruses, but the tannin of this plant has no effect on influenza A and B viruses in hemagglutination and hemadsorption.	Kucera and Herrmann (1967)
Mentha x piperita L.	Menthone and Pulegone (Leaves)	Show good antiviral effects in infected mice.	Qi et al. (2012)
Mentha x piperita L.	Mentofin (Leaves, Essential oil)	Inactivate Avian Influenza Virus (AIV)	Barbour et al. (2010)
Morus alba L.	Cyanidin-3-rutinoside, Rutin, Cyanidin-3-glucoside, Quercetin, Chlorogenic acid (Fruit juice and seeds)	Exhibit 1.3 log inhibition in the pre- and cotreatment of the virus against FL04, a type B virus. Also exhibited significant DPPH radical scavenging and ferric ion-reducing activities in a dose-dependent manner.	Kim and Chung (2018)
Nigella sativa L.	Not specified (Seeds)	Enhance immune responsiveness and suppress pathogenicity of influenza viruses in turkeys	Umar et al. (2016)
Olea europaea L.	Not specified (Leaves)	Blokes the receptor site of the viruses	Mehmood et al. (2018)
Olea europaea L.	Not specified (Leaves)	Shows significant antiviral activity. Olive oil was included in formulations to ameliorate its potential cytotoxic effects.	Vimalanathan and Hudson (2012)
Olea europaea L.	Not specified (Fruits)	Both in influenza A/H1N1 and HRV14, replication cycle and progeny virus production were significantly decreased after the	Tseliou et al. (2019)

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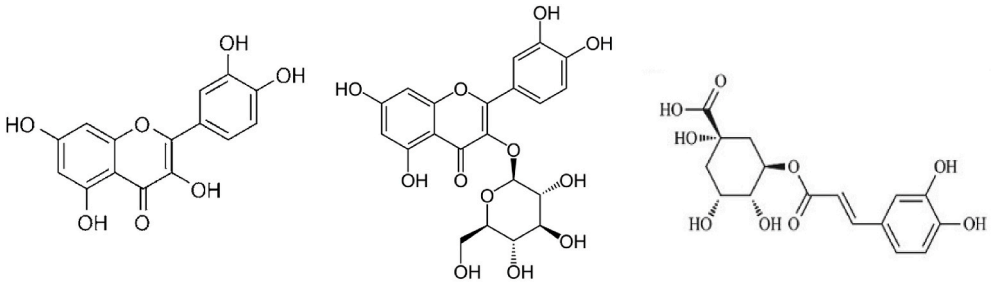
Table 4 (*continued*)

Plant species	Active compounds identified (and used parts)	Mechanism of action	References
		treatment with CAPeo (An essential oil combination based on three aromatic plants (*Thymbra capitata, Origanum dictamnus* and *Salvia fruticosa* in extra-virgin olive oil)	
Origanum vulgare L	β-carotene and Linoleic acid (Aerial parts)	Decrease influenza virus activation by inhibiting the hemagglutination	Mancini et al. (2009)
Origanum vulgare L.	Carvacrol (Essential oil)	Shows significant antiviral activity. Olive oil was included in formulations to ameliorate its potential cytotoxic effects.	Vimalanathan and Hudson (2012)
Origanum vulgare L.	Not specified (Essential oil) Linalool (Essential oil) Linalool (Essential oil)	Reduce visible cytopathic effects of influenza A/WS/33 virus activity by > 52.8%.	Choi (2018)
Papaver rhoeas L.	Kaempferol-3-sophoroside, Kaempferol-3-neohesperidoside, Kaempferol-3-sambubioside, Kaempferol-3-glucoside, Quercetin-3-sophoroside, Luteolin, Chelianthifoline (Pollen)	Display noncompetitive inhibition of H3N2 neuraminidase and reduce the severity of virally induced cytopathic effects	Lee et al. (2016)
Peganum harmala L.	Not specified (Seeds)	Inhibit cytopathic effect of influenza virus	Moradi et al. (2017)
Pimpinella anisum L.	Not specified (Essential oil) Linalool (Essential oil) Linalool (Essential oil)	Reduce visible cytopathic effects of influenza A/WS/33 virus activity by > 52.8%.	Choi (2018)
Portulaca oleracea L.	Not specified (Aerial parts)	Suppress the production of circulating H1N1 and H3N2 and inhibit the binding of virus to cells and decrease the viral load within 10 min to prevent viral infection	Li et al. (2019)
Punica granatum L.	Not specified (Seeds)	Inhibit cytopathic effect of influenza virus	Moradi et al. (2017)
Punica granatum L.	Ellagic acid, Caffeic acid, Luteolin, and Punicalagin (Fruit juice)	Suppress replication of influenza A virus and inhibit viral RNA replication and agglutination of chicken red blood cells by influenza virus	Haidari et al. (2009)
Salvia fruticosa Mill.	Not specified (Aerial parts-Essential oil)	Both in influenza A/H1N1 and HRV14, replication cycle and progeny virus production were significantly decreased after the treatment with CAPeo (An essential oil combination based on three aromatic plants (*Thymbra capitata, Origanum dictamnus* and *Salvia fruticosa* in extra-virgin olive oil)	Tseliou et al. (2019)
Salvia officinalis L.	Citronellol and Eugenol (Leaves, Essential oil) 1,8-Cineole and α-Thujone (Leaves)	Inhibits the hemagglutinin activity, but not the Neuraminidase activity	Vimalanathan and Hudson (2014)
Salvia sclarea L.	Not specified (Essential oil) Linalool (Essential oil) Linalool (Essential oil)	Reduce visible cytopathic effects of influenza A/WS/33 virus activity by > 52.8%.	Choi (2018)
Sambucus nigra L.	Not specified (Fruits)	Reduce hemagglutination and inhibit the replication of human influenza viruses	Zakay-Rones et al. (1995)
Sambucus nigra L.	Not specified (Fruits)	Reduce visible cytopathic effects and inhibit at an early point in infection, probably by rendering the virus non-infectious	Chen et al. (2014)
Sambucus nigra L.	Not specified (Fruits)	Decrease virus titer and inhibit viral protein synthesis or virus particle release.	Shahsavandi et al. (2017)
Sambucus nigra L.	Not specified (Fruits)	Suppress viral replication in the bronchoalveolar lavage fluids and increase the level of the IFV-specific neutralizing antibody in the serum	Kinoshita et al. (2012)
Sambucus nigra L.	Not specified (Fruits)	Exhibit a specific neuraminidase-inhibiting effect	Krawitz et al. (2011)
Silybum marianum (L.) Gaertn.	Silymarin (Seeds)	Reduces cytopathic effect (CPE) and inhibits viral mRNA synthesis with no cytotoxicity	Song and Choi (2011)
Thymbra capitata (L.) Cav.	Carvacrol (Essential oil)	Shows significant antiviral activity. Olive oil was included in formulations to ameliorate its potential cytotoxic effects.	Vimalanathan and Hudson (2012)
Thymbra capitata (L.) Cav.	Apigenin, Thymol (Aerial parts-Essential oil)	Both in influenza A/H1N1 and HRV14, replication cycle and progeny virus production were significantly decreased after the treatment with CAPeo (An essential oil combination based on three aromatic plants (*Thymbra capitata, Origanum dictamnus* and *Salvia fruticosa* in extra-virgin olive oil)	Tseliou et al. (2019)
Urtica dioica L.	Lectin (Roots)	Inhibit mannosidases in host cells rendered the progeny viruses more sensitive to the mannose-binding agents and even to the N-acetylglucosamine-binding Urtica dioica agglutinin	Van der Meer et al. (2007)
Vitis vinifera L.	Not specified (Fruits)	Exhibit the prevention of the virus infectivity and the antioxidant activities (DPPH scavenging capacity and superoxide anion radical scavenging capacity)	Bekhit et al. (2011)
Cota tinctoria (L.) J. Gay[a]	Not specified (Aerial parts)	No correlation was found between antiviral activity and fatty acid contents of the extracts.	Orhan et al. (2009)
Ficus carica L.[a]	Not specified (Fruits)	The results indicated that the prepared emulsions could elicit a little degree of immunity, but they could not inhibit the anamnestic response and infection.	Najjari et al. (2015)
Olea europaea L.[a]	Not specified (Fruits)	The results indicated that the prepared emulsions could elicit a little degree of immunity, but they could not inhibit the anamnestic response and infection.	Najjari et al. (2015)
Origanum acutidens (Hand.-Mazz.) Ietsw.[a]	Carvacrol (Flowers-Essential oil)	None of the extracts inhibited the reproduction of influenza A/Aichi virus in MDCK cells	Sökmen et al. (2004)
Rosmarinus officinalis L.[a]	Carnosic acid (Aerial parts)	Inhibit both A- and B- type hRSV, while it does not affect the replication of influenza A virus	Shin et al. (2013)
Teucrium polium L.[a]	Not specified (Aerial parts)	No significant effects on influenza virus infectivity	Derakhshan et al. (2015)

[a] The taxa that have no significant result for virus inactivation.



(A) (B) (C)

Fig. 3. The chemical structures of quercetin (A), quercetin 3-glucoside (B) and chlorogenic acid (C).

Table 5
Exotic plants used for influenza treatment in Turkish folk medicine.

Families	Sc. Names	Local names	English names	Parts	Preparations	Homeland	References
Combretaceae	*Terminalia chebula* Retz.	Kara halile, karahalile	Black myrobalan	Unripe Fruits	Decoction or infusion (after pulverizing)	South Asia	Baytop (1999), Akan and Bakır-Sade (2015)
Lauraceae	*Cinnamomum verum* J.Presl	Tarçın, darçın	Cinnamon, true cinnamon tree	Bark	Decoction or infusion (after pulverizing) with/without cloves	South and Southeast Asia	Baytop (1999), Kocabaş and Gedik (2016), Gürbüz et al. (2019)
Lythraceae	*Lawsonia inermis* L.	Kına, kına otu	Hina, henna tree, mignonette tree, Egyptian privet	Leaves	Infusion of 1% is used in the treatment of lung inflammation. To reduce fever in infants, it is mixed with dried mint, honey and eggs and applied externally to the baby's chest and back.	Northeast Africa	Baytop (1999), Günbatan et al. (2016), Demirci-Kayıran (2019)
Myrtaceae	*Syzygium aromaticum* (L.) Merr. & L.M. Perry	Karanfil	Cloves	Flower buds, Essential oil	Pastille, Infusion, Frankincense	Maluku Islands	Baytop (1999), Sargin et al. (2013)
Piperaceae	*Piper nigrum* L.	Kara biber, karabiber	Black pepper	Unripe Fruits	Infusion prepared with mint (*Mentha* × *piperita*) is consumed after the addition of honey.	India	Baytop (1999), Güneş (2017), Gürbüz et al. (2019)
Rubiaceae	*Cinchona pubescens* Vahl	Kınakına, kınakına ağacı	Red cinchona, quina	Bark	15–30 g of liqueur or wine, containing sulfate salts, is drunk 3 times a day.	Central and South America	Baytop (1999)
Zingiberaceae	*Zingiber officinale* Roscoe	Zencefil	Ginger	Rhizomes	Dried and pulverized rhizomes are used as an infusion or eaten by mixing with honey	South Asia	Baytop (1999), Sargin et al. (2013), Akan and Bakır-Sade (2015), Kocabaş and Gedik (2016), Gürbüz et al. (2019), Demirci-Kayıran (2019)
Zingiberaceae	*Alpinia officinarum* Hance	Havlıcan, havlucan	Lesser galangal	Rhizomes	Decoction or infusion (after pulverizing)	Southeast Asia	Baytop (1999), Sargin et al. (2013), Akan and Bakır-Sade (2015), Kurt and Karaoğul (2018)
Zingiberaceae	*Curcuma longa* L.	Zerdeçal, Hint safranı, safran kökü, sarıboya, zerdeçav	Turmeric	Rhizomes	Decoction or infusion (after pulverizing) with/without lemon and zingiber. Eaten a coffee spoonful with some honey, twice a day	Indian subcontinent and Southeast Asia	Baytop (1999), Akan and Bakır-Sade (2015)

studied natural ingredients in recent times (Grienke et al., 2009). Therefore, natural products such as traditional herbs show great promise in the development of potentially effective new antiviral drugs. Particularly, recent studies on phytochemicals, such as quercetin, chlorogenic acid, mentofin, and linalool abundantly found in many plants and vegetables, eliminate the efforts and huge costs of finding lots of antiviral vaccines that need to be renewed every year and allow us to be more optimistic about the successful management of the next influenza outbreaks.

Turkey has remarkable potential for serious research on this topic due to having vast ethnomedicinal experience and the richest flora of Europe and the Middle East. This study, conducted in this regard, is the first nationwide ethnomedical screening study conducted on flu treatment with plants in Turkey. In particular, we would like to emphasize that the most common detected genus members, such as *Sideritis* (16 taxa; 7.1%), *Salvia* (12; 5.4%), *Thymus* (12; 5.4%), and *Origanum* (10; 4.5%) may be more efficient in terms of the anti-influenza targeting than other genera for the interest of the sectors that are researching new natural drug sources.

Through this study, we strongly recommend these 35 (15.6%) plants, which have proved their high anti-influenza activities and inhibition potentials in the experimental studies, to be subject to clinical research and for widespread use in the near future. Also, with 189 (84.4%) taxa detections that have not been investigated yet, it is an important resource for both national and international pharmacological researchers. Clinical research and evaluation studies required for standard compliance for human use, starting especially with the fifteen plant taxa whose use records against both malaria and influenza were presented in this study, can be begun. With a possible mass production of one or more malaria-like drugs, a significant contribution can be provided to the indigenous people living in that region and to the national economy. Therefore, more experimental studies are urgently needed to understand

the true value of these plants. Based on the data to be obtained, we believe that the future extension of anti-influenza studies, including plant taxa that are frequently used in Turkish folk medicine, would be a more effective option.

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