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ARTEMISIA PROCERIFORMIS L. (ARTEMISIA ABROTANUM): LITERATURE REVIEW ON CHEMICAL COMPOSITION AND BIOLOGICAL ACTIVITY

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Abstract. The genus of *Artemisia* is the largest plant genera with about 500 species, which has potential sources of new natural biological active products and chemical structures. *Artemisia proceriformis* L. is one of the better-known medicinal species of this genus and it has an important position in the European and Asian medicine. The aim of this study is to review the chemical composition and biological activity of *A. proceriformis*. *Results.* In this review, we have compiled data of recent literature on essential oil and extracts compositions and their biological activities. These data were obtained from international databases, such as SciFinder and PubChem. The component composition of essential oil's *A. proceriformis* varies depending on the place of growing and collection. However, it was found that the main components of this essential oil were α-thujone, β-thujone, 1.8-cineol, 1.4-cineole, aromadendrene, isogermacrene D, davanone, trans-piperitol, 2-hydroxy-1,8-cineole, β-eudesmol and camphor. Also, according to literature, this essential oil was showed antimicrobial, anticancer and antioxidant activities. The main secondary metabolites of *A. proceriformis* belonging to the group flavonoids, sesquiterpene lactones, phenolic acids, coumarines and due to this can show different types of bioactivities. *Scientific novelty*. As a result of the review, it can be concluded that there is no data on the component composition of extracts

of *A. proceriformis* growing in Kazakhstan. *Practical value.* In this review we have combined the data into the table and made this data more accessible.

Key words: *Artemisia proceriformis*, *Artemisia abrotanum*, mugwort, wormwood, sagebrush, essential oils, secondary metabolites, biological activity

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Аннотация. *Artemisia* тұқымдасы – 500-ге жуық түрі бар ірі өсімдік тұқымдасының бірі, және жаңа биологиялық белсенді қосылыстар мен химиялық құрылымдардың табиғи көзі болып табылады. *Artemisia proceriformis* L. осы тұқымдастың ең танымал дәрілік түрінің бірі, еуропалық және азиялық медицинада маңызды орны бар өсімдік. Бұл зерттеудің мақсаты – *A. proceriformis* химиялық құрамы мен биологиялық белсенділігіне шолу жасау. *Нәтижелері.* Бұл шолуда біз эфир майлары мен сығындыларының құрамы және олардың биологиялық белсенділігі туралы соңғы әдебиет деректерін жинадық. Бұл деректер SciFinder және PubChem сияқты халықаралық дерекқорлардан алынды. *A. proceriformis* эфир майының компоненттік құрамы өсу және жиналу орнына байланысты өзгереді. Алайда, бұл эфир майының негізгі компоненттері α-туйон, β-туйон, 1,8-цинеол, 1,4-цинеол, аромадендрен, изогермакрен D, даванон, транс-пиперитол, 2-гидрокси-1,8-цинеол, β-эудесмол және камфора екені анықталды. Сондай-ақ, әдебиеттерге сәйкес, бұл эфир майы микробқа қарсы, ісікке қарсы және антиоксиданттық белсенділікті көрсетті. *A. proceriformis*-тің негізгі екіншілік метаболиттері флавоноидтар, сесквитерпендік лактондар, фенол қышқылдары, кумариндер тобына жатады және осыған байланысты олар биологиялық белсенділіктің әртүрлі

түрлерін көрсетеді. *Ғылыми жаңалығы.* Жасалған шолу нәтижесінде Қазақстанда өсетін *A. proceriformis* сығындыларының химиялық құрамы туралы деректер жоқ деген қорытынды жасауға болады. *Практикалық құндылығы.* Бұл шолуда біз деректерді кесте түрінде жүйелендірдік және деректерді қолжетімді еттік. Бұл материалдар осы өсімдік түрін одан әрі зерттеуді жеңілдетуге көмектеседі және жаңа биологиялық белсенді қосылыстарды іздеу үшін пайдалы болады.

Түйін сөздер: *Artemisia proceriformis*, *Artemisia abrotanum*, кәдімгі жусан, сүректі жусан, бұталы жусан, эфир майлары, екіншілік метаболиттер, биологиялық белсенділік

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ARTEMISIA PROCERIFORMIS L. *(ARTEMISIA ABROTANUM):* ОБЗОР ЛИТЕРАТУРЫ ПО ХИМИЧЕСКОМУ СОСТАВУ И БИОЛОГИЧЕСКОЙ АКТИВНОСТИ

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Аннотация. Род *Artemisia* является крупнейшим родом растений, насчитывающим около 500 видов, который имеет потенциальные источники новых природных биологически активных продуктов и химических структур. *Artemisia proceriformis* L. является одним из наиболее известных лекарственных видов этого рода и занимает важное место в европейской и азиатской медицине. Целью данного исследования является обзор химического состава и биологической активности *A. proceriformis*. *Результаты.* В данном обзоре мы собрали данные недавней литературы по составам эфирных масел и экстрактов, и их биологической активности. Эти данные были получены из международных баз данных, таких как SciFinder и PubChem. Компонентный состав эфирного масла *A. proceriformis* варьируется в зависимости от места произрастания и сбора. Однако было установлено, что основными компонентами этого эфирного масла являются α-туйон, β-туйон, 1,8-цинеол, 1,4-цинеол, аромадендрен, изогермакрен D, даванон, транс-пиперитол, 2-гидрокси-1,8-цинеол, β-эудесмол и камфора. Также, согласно литературным данным, это эфирное масло проявило антимикробную, противораковую и антиоксидантную активность. Основные вторичные

метаболиты *A. proceriformis* относятся к группе флавоноидов, сесквитерпеновых лактонов, фенольных кислот, кумаринов и благодаря этому они могут проявлять различные виды биоактивности. *Научная новизна.* В результате сделанного обзора можно заключить, что данные о компонентном составе экстрактов *A. proceriformis*, произрастающего в Казахстане, отсутствуют. *Практическая ценность.* В данном обзоре мы объединили данные в таблицу и сделали эти данные более доступными. Эти материалы могут помочь упростить дальнейшие исследования этого вида растений и будут полезны для поиска новых биологически активных соединений.

Ключевые слова: *Artemisia proceriformis*, *Artemisia abrotanum*, полынь обыкновенная, полынь древовидная, полынь кустарниковая, эфирные масла, вторичные метаболиты, биологическая активность

Introduction. *Artemisia* genus is one of the largest plant genera to the *Asteraceae* family, with about 500 species distributed mostly South Asia, North America and European countries (Abad, et al., 2012) These species are called by the common names mugwort, wormwood and sagebrush (Bora, et al., 2011). This well-known medicinal plant genus has been used traditionally in a form of infusions, tinctures and decoctions. Hydro/alcoholic liquid *Artemisia* species extracts improve digestion, stimulate the appetite and are used for dyspepsia, acid gastritis, gastrointestinal tract diseases, liver diseases, the gall bladder, insomnia, malaria, influenza and to treat upper respiratory tract maladies. Additionally, they have been employed in the treatment of bronchial asthma, rheumatism, eczema, dysentery, rheumatism, anemia, jaundice, obesity, meteorism, migraine, hypertension and tuberculosis. Central Asia's folk medicine uses the infusion of *Artemisia* species flowers for ulcerative colitis, an inflammatory process in the cecum, hemorrhoids, bad breath, epilepsy and several other diseases (Koul, et al., 2018, Nurlybekova, et al., 2022). *Artemisia* species has a great economic and medicinal perspective due to the fact of the isolation of artemisinin, which is the main phytochemical of *Artemisia annua* L., is represented as an antimalarial drug (Zaman, et al., 2021).

Scientists from Kazakhstan are actively studying the chemical composition and biological activity of essential oils (Suleimen, et al., 2022, Suleimen, et al., 2022) and extracts (Jalmakhanbetova, et al., 2021, Suleimen, et al., 2022, Suleimen, et al., 2022, Suleimen, et al., 2022) of a number of wormwoods of the Kazakhstani flora.

One of the better-known medicinal species of this genus in Europe and Asia is *Artemisia proceriformis* (*Artemisia abrotanum*). This species occurs in the South-Eastern part of Asia and in the countries of Central and North-Western Europe. This species also has its natural habitats in Asia Minor, Central Asia, and Arabian Peninsula (Melzig, et al., 2019).

Object of the study. *A. proceriformis* (southernwood) is a shrubby perennial plant, the height and width 3-5 feet, it consists of yellowish-white flowers, and has a fragrance similar to cola or tangerine (Amirmohammadi, et al., 2014) (Fig.1). *A. proceriformis* was traditionally used as an antiseptic, astringent, emmenagogue, antidiabetic, expectorant, febrifuge, stomachic, antimalarial, anti-inflammatory, vermifuge, and spasmolytic and

used for treating upper respiratory tract disease, antibacterial, antifungal, cancer, cough, and fever (Sureshn, et al., 2011).

Fig. 1. Artemisia proceriformis L. (Artemisia abrotanum)

Methodology. The goal of this study is to review the chemical composition and biological activity of *A. proceriformis* for further research of this plant. In this review, we have compiled data of recent literature on essential oil and extracts compositions and their biological activities. These data were obtained from international databases, such as SciFinder and PubChem. The component composition of essential oils is presented as predominant components, and the data on the biological activity of these essential oils are also given. The secondary metabolites of extracts and their biological activities are compiled as a table.

Results main content. Essential oil content and it's biological activity of *Artemisia proceriformis*.

The main components present in *A. proceriformis* have focused mainly on the essential oil. The content and concentration of essential oil are variable and depend on the cultivation site, weather conditions, period of plant collection and other various factors.

According to the literatures, the main components of *A. proceriformis* essential oil's from Kazakhstan were α-thujone (66.3%), β-thujone (23.4%) and 1.8-cineol (3.1%) (Suleimenov, et al., 2010, Sampietro, et al., 2016), the essential oil obtained from the this herb growing in Lithuania were 1.4-cineole (4.1–13.1%), lavandulylbutanoate (0.8–4.7%), aromadendrene, (2.4–7.4%), isogermacrene D (5.2–15.7 %) (Saunoriute, et al., 2020), and 2-hydroxy-1,8-cineole, β-eudesmol, and camphor were the main components of this spiece from Egypt (Khalid, et al., 2020). Romanian scientists have

determined that the main component of the essential oil of this plant was davanone and its derivatives, trans-piperitol and estragole (Obistioiu, et al., 2014).

The essential oil of this plant from Iraq had a potent antimicrobial and anticancer effect. The authors attribute this fact due to its essential oil constituents: borneol, cymene, camphor, terpineol, eucalyptol, and aromadendrene (Almahdawy, et al., 2017). *A. proceriformis* essential oil's, collected in Yemen, showed antioxidant activity by the reducing power method and the TBARS method (Al-Zubairi, et al., 2017).

It should be noted that Kazakh chemists have developed a method for isolating and purifying valuable α-thujone and β-thujone from the essential oil of *A. proceriformis* (Patent No 7102 KZ, 2022).

Secondary metabolites from Artemisia proceriformis and their bioactivities. A broad variety of bioactivities of *Artemisia* species owes to the presence of several active secondary metabolites, such as lignans, sesquiterpenoids, flavonoids, coumarins, glycosides, caffeoylquinic acids, sterols and polyacetylenes (Penkala-Gaw, et al., 2013, Watsan, et al., 2002). Sesquiterpene lactones, which are typical for *Artemisia*, are extremely diverse and plentiful and exhibit a wide range of therapeutic effects: anticancer, antimalarial, anti-inammatory, immunomodulatory, antiulcerogenic, antibacterial, antifungal and antiviral effects (Ivanescu, et al., 2015).

Among secondary metabolites of *A. proceriformis*, compounds with phenolic structures can be distinguished. Some data indicate the presence of phenolic acids. This compounds present in the leaves of *A. proceriformis* growing in Saudi Arabia, was dominated by rosmarinic, chlorogenic, caffeic and isochlorogenic acids (Baiceanu, et al., 2015). These metabolites were isolated mainly from alcoholic (methanol, ethanol) extracts. Detailed data on secondary metabolites and their biological activity are given in Table 1, 2.

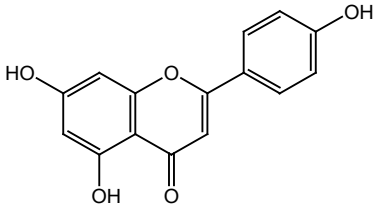
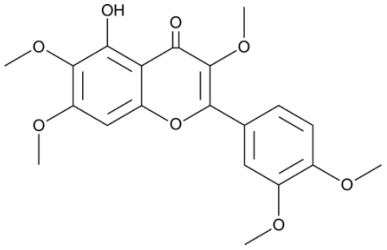
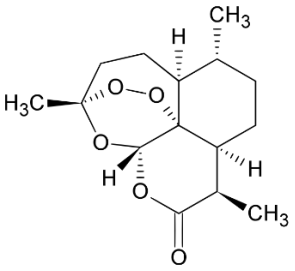
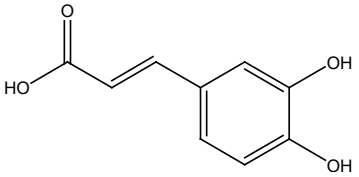
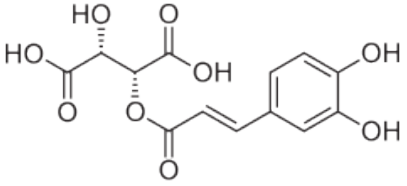
Table 1 – Secondary metabolites of *A. proceriformis* and their bioactivities

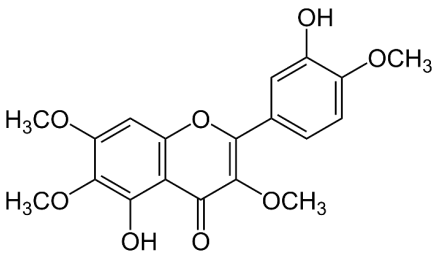
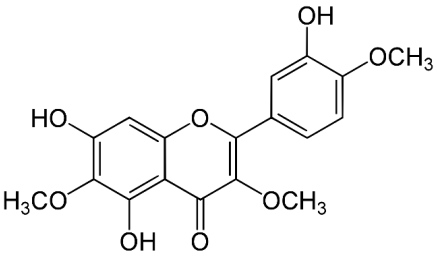
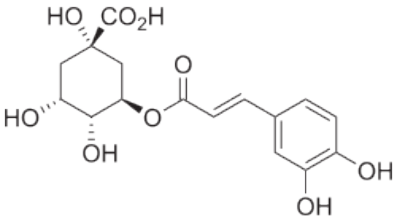
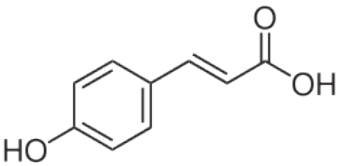
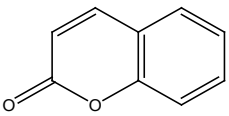
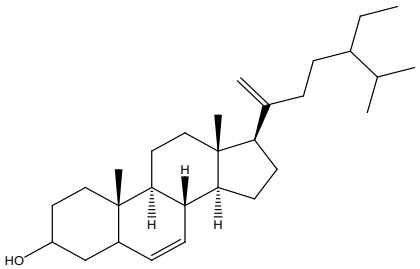
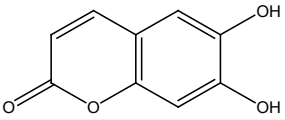
NN	Group of compounds	Compounds	Activity
1	Flavonoids	1.Rutoside (Ruminska, et al., 1990).	1. Antimicrobial, antifungal and anti-allergic agent (Al-Dhabi, et al., 2015).
		1. Apigenin; 2. Artemisetin; 3. Hyperoside; 4. Isoquercitrin; 5. Kaempferol; 6. Quercetol; 7. Luteolin; 8. Myricetin; 9. Patuletin (Baiceanu, et al., 2015)	1.Antioxidant, anti-inflammatory and chemoprevention activity (Cadona, et al., 2020); 2. - 3.Anti-inflammatory, antidepressant and anticancer effects (Xeu, et al., 2023); 4.Chemoprotective effects, both in vitro and in vivo, against oxidative stress, cancer, cardiovascular disorders, diabetes and allergic reactions (Valentova, et al., 2014); 5. Antioxidant and antibacterial agent, as well as a plant metabolite (CID 520863, 2022); 6.Possesses antioxidant properties and is used in the protection against various diseases such as osteoporosis, lung cancer and cardiovascular disease (David, et al., 2016); 7.Anticancer, anti-inflammatory, antioxidant, anti-allergic and antimicrobial activity (Shukla, et al., 2019); 8.Anti-inflammatory, antitumor, antibacterial, antiviral, antioxidant (Xiaominting, et al., 2021).

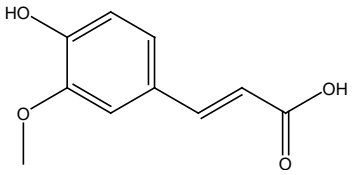
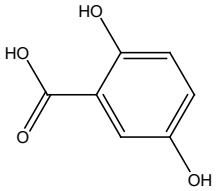
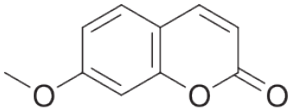
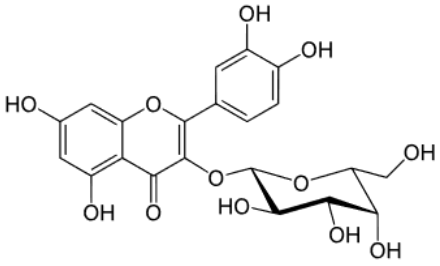
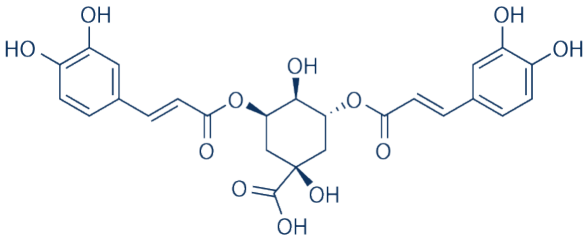
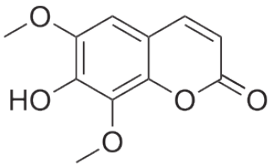
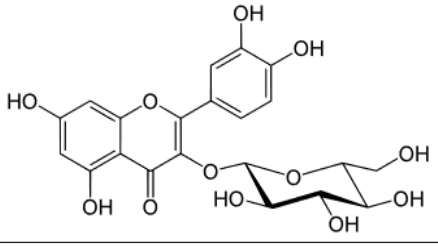
		1. Quercetin (Baiceanu, et al., 2015).	1.Possesses antioxidant properties and is used in the protection against various diseases such as osteoporosis, lung cancer and cardiovascular disease (David, et al., 2016).
		1.Centaureidine; 2.Casticin (Remberg, et al., 2004)	-
2	Sesquiterpene lactones	1.Santonin (Tunon, et al., 2006); 2.Artemisinin (Baiceanu, et al., 2015)	1. Anthelmintic (Sakipova, et al., 2017) and antipyretic activity (Mabtin, et al., 1988); 2.Antimalarial agent (Ferreira, et al., 2010).
3	Phenolic acids	1. Ferulic acid; 2. Gentisic acid; 3. Caftaric acid; 4. p-Coumaric acid; 5. Sinapic acid (Baiceanu, et al., 2015); 6. Chlorogenicacid (Ruminska, et al., 1990, Baiceanu, et al., 2015, Ozarowski, et al., 1987, Elansary, et al., 2020); 7. Isochlorogenic acid; 8. Protocatechuic acid; 9. Rosmarinic acid; 10. Syryngic acid; 11. Vanillic acid (Elansary, et al., 2020); 12. Caffeic acid (Ruminska, et al., 1990, Baiceanu, et al., 2015, Ozarowski, et al., 1987, Elansary, et al., 2020).	1. Antioxidant, anti-inflammatory, anticancer, antiallergic, and antiviral effects (Pyrzynska, et al., 2024); 2. Antiinflammatory, antigenotoxic, hepatoprotective, neuroprotective, antimicrobial, and antioxidant (Farshad, et al., 2019); 3. Antioxidant, anti-inflammatory, antimutagenic and anticarcinogenic, hepatoprotective (Mohamed, et al., 2020); 4. Antioxidant, anti-inflammatory, antimutagenic, antiulcer, antiplateletand anticancer (Pei, et al., 2016); 5. Antioxidant, antimicrobial, anti-inflammatory, anticancer, and antianxiety activity (Niciforovic, et al., 2014); 6,7. Antioxidant, liver and kidney protection, anti-bacterial, anti-tumor, regulation of glucose metabolism and lipid metabolism, anti-inflammatory, protection of the nervous system, and action on blood vessels (Wang, et al., 2022) 8. Antioxidant and anti-inflammatory (Liu, et al., 2002); 9. Anti-inflammation, anti-oxidation, anti-diabetes, anti-tumor, anti-virus, neuroprotection, hepatoprotection (Guan, et al., 2022); 10. Antioxidant, antimicrobial, anti-inflammatory and antiendotoxic (Srinivasulu, et al., 2018); 11. Antimicrobial, antioxidant, anti-inflammantory (Matejczyk, et al., 2024); 12. Antioxidant, anti-inflammatory and anticarcinogenic (Espindola, et al., 2019).
4	Coumarines	1. Isofraxidine (Sakipova, et al., 2017); 2. Umbelliferone (David, et al., 2016, Sakipova, et al., 2017); 3. Scopoletin (CID 5280863, 2022); 4. Herniarin (Sakipova, et al., 2017)]; 5. Esculetin (David, et al., 2016, Sakipova, et al., 2017); 6. Coumarin (David, et al., 2016).	1. Antioxidant, cardioprotective, weight loss, anti-osteoarthritis, antimalarial, and neuroprotective effects (Majnooni, et al., 2020); 2. Anti-inflammatory, anti-hyperglycaemic, molluscicidal and anti-tumor (Mazimba, et al., 2017); 3. Antimicrobial, anticancer, anti-inflammation, anti-angiogenesis, anti-oxidation, antidiabetic, antihypertensive, hepatoprotective, and neuroprotective properties and immunomodulatory effects (Gao, et al., 2024); 4. Antioxidant, cytotoxic (Jasim, et al., 2023); 5. Antitussive, anti-inflammatory, antioxidant, antibacterial, and antitumor (Liang, et al., 2017); 6. Anticoagulant, antimicrobial, anti-inflammatory, neuroprotective, antidiabetic, anticonvulsant and antiproliferative (Annunziata, et al., 2020).

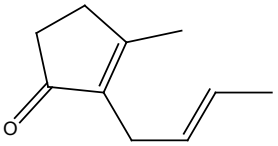
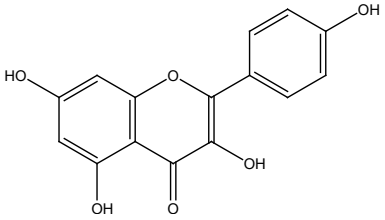
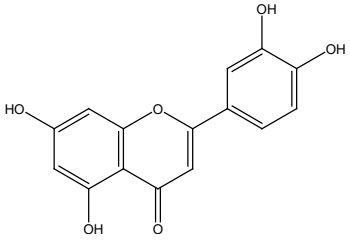
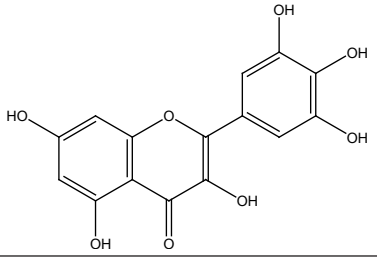
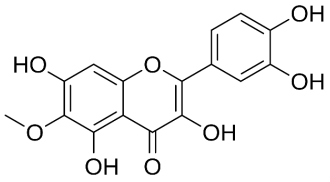
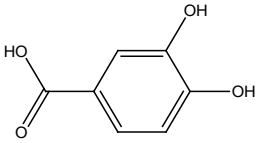
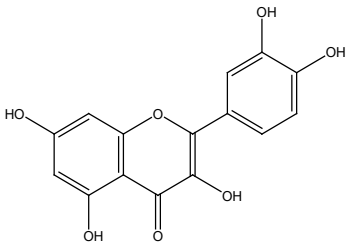
5	Sterols	24β-ethylcholesta-6(7),20(21)-dien-3β-ol (Serkenov, et al., 2014)	-
6	Alkaloids	Abrotine (Ur Rashid, et al., 2019)	-
7	Other compounds	*cis*-Jasmone (Tunon, et al., 2006)	-

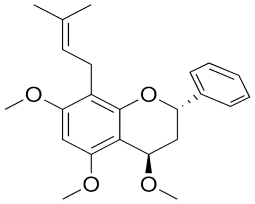
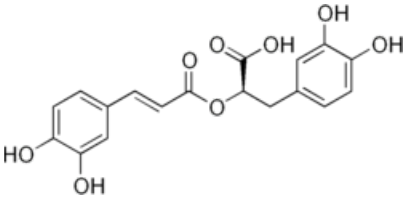
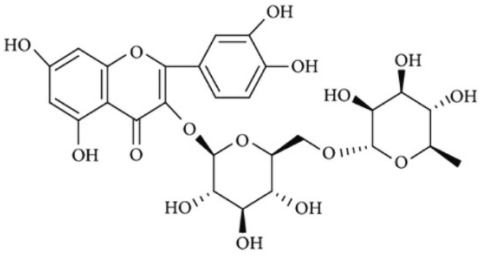
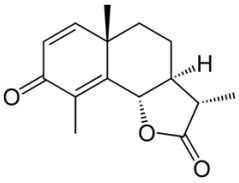
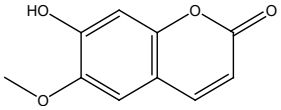
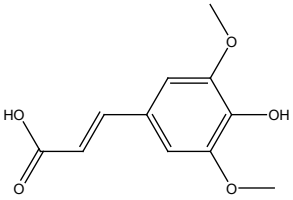
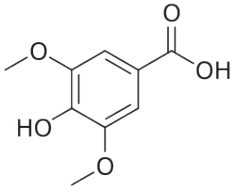
Table 2 – The structural formulas of compounds found in *A. proceriformis* extracts

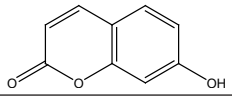
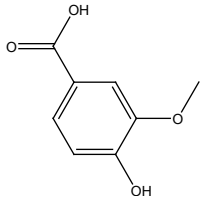
NN	Name of compound	Structural formula
1	Abrotine	Structurally unknown alkaloid
2	Apigenin	
3	Artemisetin	
4	Artemisinin	
5	Caffeic acid	
6	Caftaric acid	

7	Casticin	
8	Centaureidine	
9	Chlorogenicacid	
10	p-Coumaric acid	
11	Coumarin	
12	β -ethylcholesta-6(7),20(21)-dien-3β-ol	
13	Esculetin	

14	Ferulic acid	
15	Gentisic acid	
16	Herniarin	
17	Hyperoside	
18	Isochlorogenic acid	
19	Isofraxidine	
20	Isoquercitrin	

21	cis-Jasmone	
22	Kaempferol	
23	Luteolin	
24	Myricetin	
25	Patuletin	
26	Protocatechuic acid	
27	Quercetin	

28	Quercetol	 Quercetol B
29	Rosmarinic acid	
30	Rutoside	
31	Santonin	
32	Scopoletin	
33	Sinapic acid	
34	Syryngic acid	

35	Umbelliferone	
36	Vanillic acid	

Discussion. The component composition of essential oils varies depending on different factors. This can be explained by the fact that the same plant species collected in different countries has a different component composition. *A. proceriformis* is no exception, the component composition of essential oils of this plant collected in different countries varies significantly. But, as the review showed, the main components of this essential oil were α-thujone, β-thujone, 1.8-cineol, 1.4-cineole, aromadendrene, isogermacrene D, davanone, trans-piperitol, 2-hydroxy-1,8-cineole, β-eudesmol and camphor, the content of these components exceeds 2 %. Essential oils are known for their antimicrobial properties. *A. proceriformis* essential oil also has antimicrobial properties, this is due to the presence of compounds such as camphor and 1,8-cineol, which are known for their antimicrobial properties. It has also been found that the essential oil shows anticancer and antioxidant properties.

Among the isolated secondary metabolites of wormwood, flavonoids and phenolic acids predominate in first place. In second place are coumarins and sesquiterpene lactones. Steroids and alkaloids were isolated only one compound of each. Among the isolated secondary metabolites of wormwood, flavonoids and phenolic acids predominate in the first place. In second place are coumarins and sesquiterpene lactones. Of the steroids and alkaloids, only one compound was isolated of each. It is known that flavonoids and polyphenolic compounds are natural antioxidants. Therefore, antioxidant properties are primarily possessed by secondary metabolites if *A. proceriformis*. The review also presents such properties of secondary metabolites as antimicrobial, antiviral, antitumor, anti-inflammatory. A compound of sesquiterpene lactone, artemisinin, which is used as an antimalarial agent, was isolated from this plant.

Conclusions. Many medicinal plants have been used for their therapeutic properties since ancient times. The presence of a certain medicinal properties are associated with the content of biologically active secondary metabolites of this plant. The genus *Artemisia* is known for its medicinal properties, and even some secondary metabolites are used as drugs against maleria and cancer. This review provides data on the component composition of essential oil and extracts of *A. proceriformis* that grow in different countries, as well as data on the biological activity of these substances. We have attempted to systematize this data to facilitate it's to use by researchers. There is no data on the study of the component composition of extracts of this plant species growing in Kazakhstan, except for the component composition of essential oil. Extracts of *A.*

proceriformis from Kazakhstan have not been studied. As it is known, the component composition of one plant can vary significantly depending on weather conditions, place of growth and etc. Thus, the study of the component composition of extracts of *A. proceriformis* growing in Kazakhstan remains relevant.

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Declaration of Competing Interest: The authors declare no conflict of interest.

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