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CHEMICAL CONSTITUENTS OF GEUM RIVALE L. AND THEIR BIOLOGICAL ACTIVITY

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The aim of the study is to review the literature data on the chemical constituents of arial and underground parts of *Geum rivale* L. (*Rosaceae*) and the pharmacological activity of its extracts and individual compounds.
Materials and methods. The study was carried out using Internet resources (Google Scholar, PubMed) and library databases (e-Library, Scopus, Web of Science). The main research methods were a review and analysis of the literature data on the topic for the period from 1958 up to the present.
Results. For the period from 1958 up to the present more than 80 components in the arial and underground parts of *G. rivale* have been identified. Among them there were components of the essential oil, phenolic acids and coumarins, aglycones of flavonoids, including luteolin, apigenin, quercetin and kaempferol, as well as a number of their glycosides and glucuronides, ellagitannins (hemin A, B, C, D, pedunculagin, stachiurin/casuarinin, tellimagrandin I). Some aspects of the pharmacological activity of total extracts and individual secondary metabolites of *G. rivale* have been studied, anti-inflammatory, antioxidant, antimicrobial, antiviral activities have been experimentally confirmed.
Conclusion. The analysis of the literature data showed that a further study of the composition of metabolites of *G. rivale* and their pharmacological activity is an urgent task, the solution of which will expand the range of use of this plant in medical practice and consider *G. rivale* as a promising source of pharmaceutical substances for the creation of new drugs and biologically active additives.
Keywords: river gravilat, *Geum rivale* L., phenolic compounds, essential oils, tannins, pharmacological activity

ХИМИЧЕСКИЕ КОМПОНЕНТЫ GEUM RIVALE L. И ИХ БИОЛОГИЧЕСКАЯ АКТИВНОСТЬ

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Целью исследования является обзор данных литературы о составе биологически активных веществ надземных и подземных органов гравилата речного (*Geum rivale* L.) и фармакологической активности его извлечений и индивидуальных соединений.

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Материалы и методы. Исследование проводили с использованием Интернет-ресурсов (Google Scholar, PubMed) и библиотечных баз данных (e-Library, Scopus, Web of Science). Основными методами исследования являлись обзор и анализ литературных данных по тематике исследования за период с 1958 года по настоящее время.
Результаты. В период с 1958 года по настоящее время в надземных и подземных частях гравилата речного идентифицировано более 80 компонентов в составе эфирного масла, ряд фенольных кислот и кумаринов, агликоны флавоноидов, в том числе лютеолин, апигенин, кверцетин и кемпферол, а также ряд их гликозидов и глюкуронидов, эллаготанины (гемин A, B, C, D, педункулагин, стахиурин/казуаринин, теллимаграндин I). Изучены некоторые аспекты фармакологической активности суммарных извлечений и индивидуальных вторичных метаболитов гравилата речного, экспериментально подтверждены противовоспалительная, антиоксидантная, противомикробная, противовирусная активности.
Заключение. Анализ литературных данных показал, что дальнейшее изучение состава метаболитов гравилата речного и их фармакологической активности является актуальной задачей, решение которой позволит расширить спектр использования данного растения в медицинской практике и рассматривать гравилат речной как перспективный источник фармацевтических субстанций для создания новых лекарственных препаратов и биологически активных добавок к пище.
Ключевые слова: гравилат речной, *Geum rivale* L., фенольные соединения, эфирные масла, танины, фармакологическая активность

INTRODUCTION

The genus *Geum* L. (*Rosaceae*) is represented by 58 species [1], about 20 of which grow on the territory of the Russian Federation [2-5]. *G. rivale*is is a perennial plant, the distribution area includes most of Europe up to the Ural Mountains, with the exception of the West of France, Spain and the Mediterranean region, as well as Western Siberia, Central Asia, some regions of North America [6, 7].

G. rivale is widely used in folk medicine for prevention and treatment of gastrointestinal diseases, including lack of appetite and diarrhea, malaria [8], for febrile diseases, muscle pain, hemorrhoids, for inflammatory diseases of the mucous membranes and skin integuments, as an antiseptic and astringent agent [9, 10]. In homeopathy, it is used for inflammatory diseases of the bladder and urinary tract, as well as for arthritis [9, 11, 12].

To date, a number of studies have been carried out to study the qualitative and quantitative composition of biologically active substances in the arial and underground parts of *G. rivale*, and some aspects of the pharmacological activity of extracts and individual groups of biologically active substances have been experimentally revealed.

The study of widespread plants as sources of pharmaceutical substances for the production of medicines and biologically active additives is an urgent task, since they show high efficiency along with low toxicity and allergenicity.

Based on this, the aim of the study was to review the literature data on the chemical composition of biologically active constituents of *G. rivale* and their pharmacological activity.

MATERIALS AND METHODS

The Internet resources (Google Scholar, PubMed) and library databases (e-Library, Scopus, Web of Science) as sources of information were used. The main research methods were the review and analysis of the literature data on the research topic for the period from 1958 up to the present.

RESULTS

Chemical components of Geum rivale L.

To date, a lot of data have been obtained on various groups of secondary metabolites contained in the arial and underground parts of the *G. rivale*. Thus, using the method of gas chromatography combined with a mass spectrometric detector (GC-MS), the component composition of the essential oil has been studied in sufficient detail [13, 14]. In the experiments, the essential oil was isolated from various parts of plant material by hydrodistillation. The components of a complex mixture of the essential oil were separated by gas chromatography with a flame ionization detector (GC-FID). The component identification was based on a comparison of mass spectra of the essential oil components with mass spectra of commercial libraries. The identification of isomers was based on a comparison of the retention index (RI) with the literature data. In the course of the experiment, more than 80 components were found in the samples of the essential oil of the arial and underground parts of *G. rivale* (compounds 51–143 in Table 1). The dominant components in *G. rivale* essential oil are 3-octen-1-ol (33.9%) and 3-hexenol (16.2%). In addition, the essential oil contains a large amount of sesquiterpenoids (32 compounds), a certain amount of monoterpenoids has been found [14]. Vollmann, C. et al. (1995) conducted a comparative analysis of the qualitative and quantitative composition of the essential oil of various species of the genus *Geum* L. As a result of the experiment, all species of the genus were divided into 2 large groups: the first group comprised the species containing a high percentage of eugenol (66–92%) and a low content pinene derivatives – *G. urbanum, G. fauriei* Levl. and *G. macrophyllum* Willd.; the second group comprised the species with

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a high content of pinene derivatives and a low content of eugenol (0.3–4.1%) – *G. rivale* L., *G. rhodopeum* Stoj. et Stefanov, *G. bulgaricum* Pancic, *G. borisii* Kellerer ex Siindermann, and *G. chiloense* Balb. [13].

Panizzi et al. (2000) analyzed the composition of triterpenoids in the arial part of *G. rivale* in the extracts obtained by extracting raw materials in a Soxhlet apparatus with n-hexane, chloroform, and an alcohol-chloroform mixture (1: 9). The isolation of compounds in pure form was carried out by sequential purification on Sephadex, silica gel, thin layer chromatography and reverse phase chromatography. The structure was confirmed using IR and UV spectroscopy, as well as ^{1}H and ^{13}C NMR methods. The compounds identified during the study are shown in Fig. 1 and numbered 1-10 in Table 1. [15, 16].

The most extensively represented group of secondary metabolites in the arial and underground parts of G. rivaleis are polyphenolic compounds. Obtaining extracts using solvents of different polarity makes it possible to study the qualitative and quantitative composition of various groups of polyphenolic compounds. The analysis of phenolic acids and coumarins is based on obtaining extracts with a methanol-chloroform mixture [15, 16, 18], petroleum ether [17] and n-butanol [22]. By means of IR spectroscopy methods and 1H- and 13C-NMR, HPLC-UV in comparison with standard samples, GC-MS, their component composition in the arial and underground parts of the river gravel was determined. The compounds identified in the work of several scientific groups, are shown in Fig. 2 and Table 1 under numbers 11-26 (Fig. 2). According to the estimates by Owczarek et al. (2013), the content of phenolic acids in the arial part is 5.9 mg/g, and in the underground part it is 18.9 mg/g [17]. In addition, Owczarek et al. (2014) determined the content of free ellagic acid (0.52 ± 0.01 mg/g) in the arial part of the river gravity (gallic acid was not detected in this case); in the underground part there was 0.43 ± 0.002 mg/g of ellagic acid, and gallic acid was not found there either [20].

Panizzi et al. (2000) also carried out extensive work on the study of the composition of flavonoids of the aerial part of G. rivale L. The extraction of this group of compounds was carried out from a mixture of the plant material pretreated with n-hexane, chloroform, and chloroform-methanol (9:1) by maceration with methanol at room temperature with subsequent purification on Sephadex and silica gel and separation on a C18 reverse phase column. In the study, 13 compounds were isolated, the structures of which were established by IR and UV spectroscopy, ^{1}H and ^{13}C NMR (Fig.3, Table 1) [16]. Owczarek et al. (2013) evaluated the quantitative content of flavonoids according to the method described in the Polish Pharmacopoeia of the VIII edition: in the underground part – 0.3 mg/g; in the aerial part – 3.0 mg/g [17].

Another group of polyphenolic compounds – tannins – is of great interest. The main methods of analysis of this group and the experimental data on the pharmacological activity were described in our previously published review [21]. In G. rivale, the composition of ellagitannins was also widely studied in the works by Moilanen et al. (2008, 2015). After the extraction of raw materials with 70% acetone with the addition of 0.1% ascorbic acid to prevent the oxidation of the compounds, the composition of ellagitannins (44–50) [22-23] was established by using HPLC-ESI-MS. The total acid content was determined by Owczarek et al. (2014) after hydrolysis of tannins with a 25% hydrochloric acid solution: ellagic acid – 40.31±1.08 mg/g in the arial part, 60.64±0.87 mg/g in the underground part; gallic acid – 7.45±0.08 mg/g in the arial part and 9.57±0.27 mg/g in the underground part (in terms of dry plant material). On the basis of the obtained results the authors made a conclusion about the greater prevalence of ellagitannins in comparison with gallotannins, both in the arial and underground parts of the studied species [20].

Rare sulfonated derivatives of ellagic acid obtained by precipitation from the aqueous extraction with boiling methanol, were studied by Owczarek et al. (2017). The following structures were established by UV spectroscopy, mass spectrometry, and ^{1}H- and ^{13}C-NMR: potassium salt of 3,3'-dimethoxy-4-sulfoxyellagic acid (29) and 3,3 ', 4'-trimethoxy-4-sulfoxyellagic acid potassium salt (30) (Fig. 4) [25].

Determination of the antioxidant activity of the extracts showed that the roots of *G. rivale* have a high antioxidant potential. According to the results, the authors of the work suggest that polyphenolic compounds bear the main responsibility for the antioxidant activity thanks to the transfer of a hydrogen atom during the reaction (HAT mechanism) [30].

Oszmianski et al. (2007) screened the antioxidant activity of tannins in the roots of *G. rivale*. During the research, the following experiments were carried out: thiolysis of proanthocyanidins according to the method described by Guyot et al. (2001) [37]; reverse phase HPLC after thiolysis; the content of proanthocyanidins (10.5 g/kg) and phenolic compounds (3.0 g/kg) in the feed were determined, as well as the degree of polymerization of proanthocyanidins – 3. For screening of the antioxidant activity, two methods were used by the authors: the DPPH test according to Yen et al.'s method (1995) [38] and the ABTS test by Re et al.'s the method (1999) [39]. This study demonstrated a significant antioxidant potential of the extract containing phenolic compounds [36].

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Pharmacological activity of extracts and components of G. rivale

Simultaneously with the study of the component composition of the secondary metabolites in the arial and underground parts of *G. rivale*, extensive studies of the pharmacological activity of the total extracts obtained using solvents of different polarities, as well as individual metabolites, were carried out. Thus, Tunon et al. (1995) conducted a study of the anti-inflammatory activity of the total water extract from the arial part of *G. rivale*, obtained by a two-stage extraction at room temperature, in tests of the effect on prostaglandin synthesis and PAF-induced exocytosis. The extract showed a high inhibitory activity in the PAF test, while an inhibitory effect on the biosynthesis of prostaglandins was not found [27]. In addition, the use of extracts from *G. rivale* as an anti-inflammatory agent in traditional medical practice is reported in the works by Birnesser et al. and Parimala et al. [28, 29].

Owczarek et al. (2015) investigated the total extracts of different polarity, obtained by the extraction of the methanol extract from the arial and underground parts of the *G. rivale*, in tests for antioxidant activity: DPPH test by method of Brand Williams, Cuvier and Berset [31] with the previously described modifications [32]; the FRAP test described by Pulido et al. [33] with some modifications [34]; the test for linoleic acid peroxidation according to Azuma et al.'s modified method [35, 32].

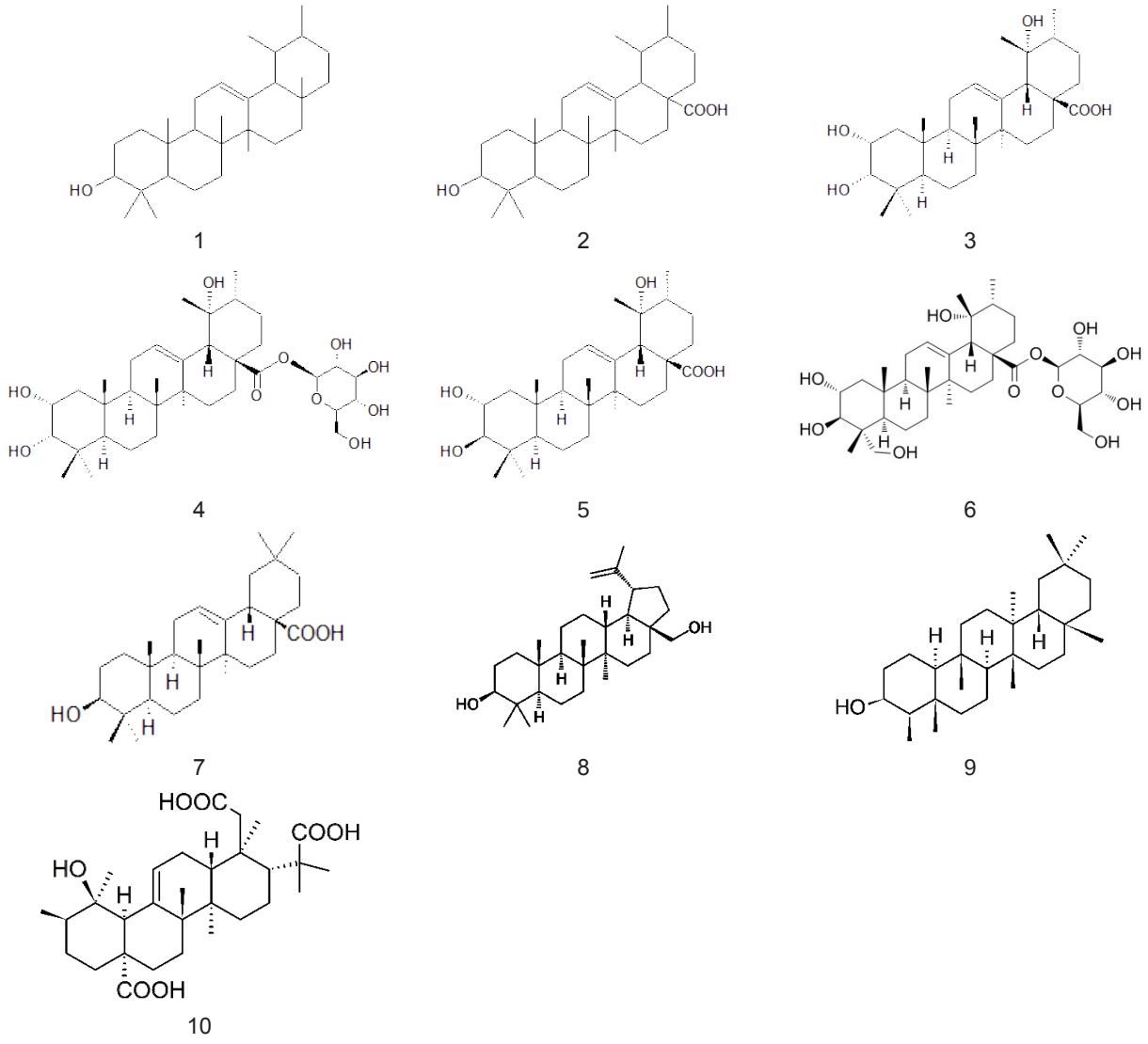

Figure 1 – Triterpenoids of the arial part of G. rivale (Panizzi, L. et al., 2000)

Note: 1 – α-amyrin; 2 – ursolic acid; 3 – euskafic acid; 4 – euskafic acid 28-glucoside; 5 – tormentic acid; 6 – nigaishigoside F1; 7 – oleic acid; 8 – betulin; 9 – epifriedelonol; 10 – cescropic acid

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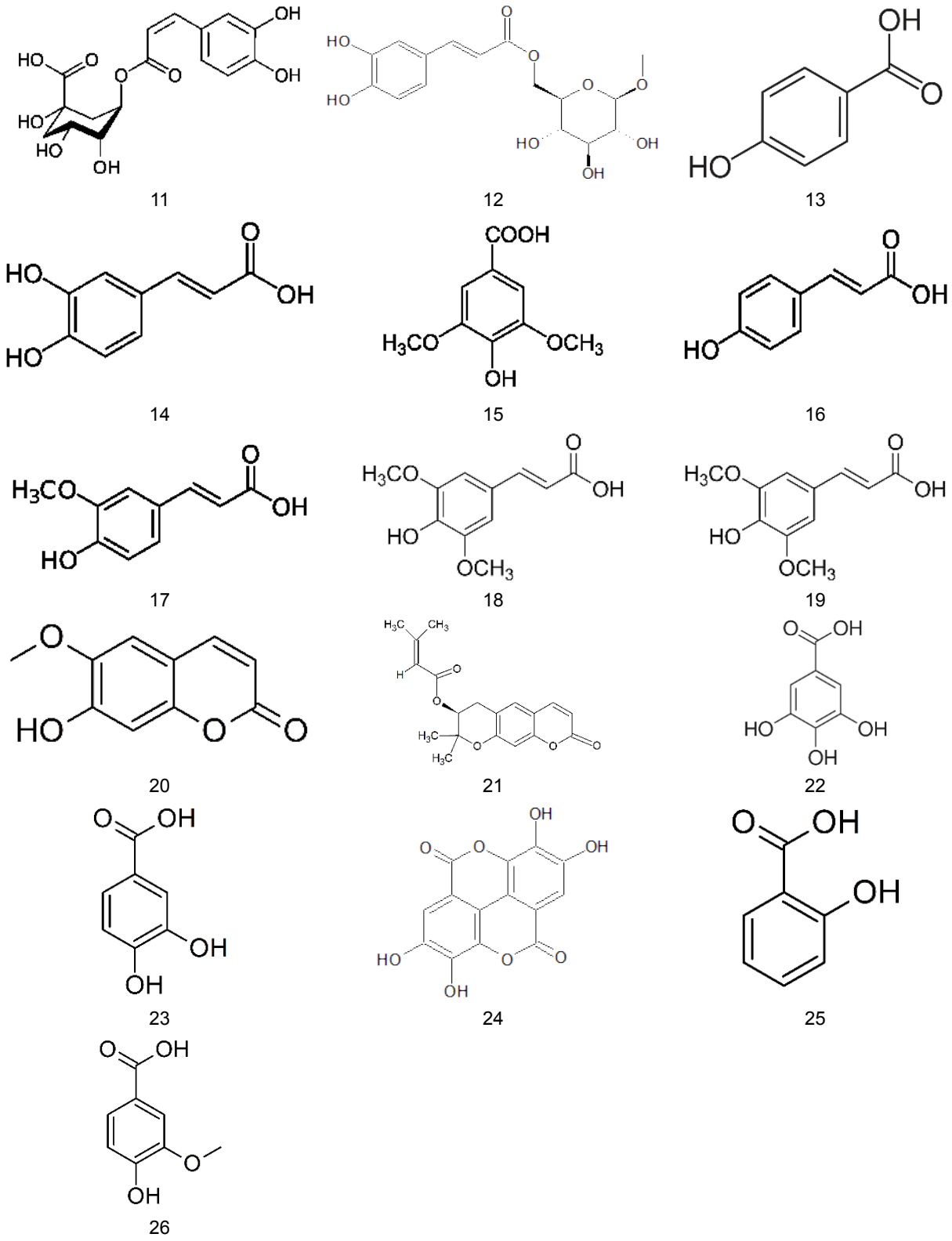

Figure 2 – Phenolic acids and coumarins of G. rivale (Panizzi et al.,2000; Owczarek et al., 2013)

Note: 11 – chlorogenic acid; 12 – 6-O-caffeyl-1-O-methyl-β-D-glucopyranose; 13 – p-hydroxybenzoic acid; 14 – caffeic acid; 15 – lilac acid; 16 – p-coumaric acid; 17 – ferulic acid; 18 – sinapic acid; 19 – scopoletin; 20 – esculetin; 21 – decursin; 22 – gallic acid; 23 – protocatechuic acid; 24 – ellagic acid; 25 – salicylic acid; 26 – vanillin

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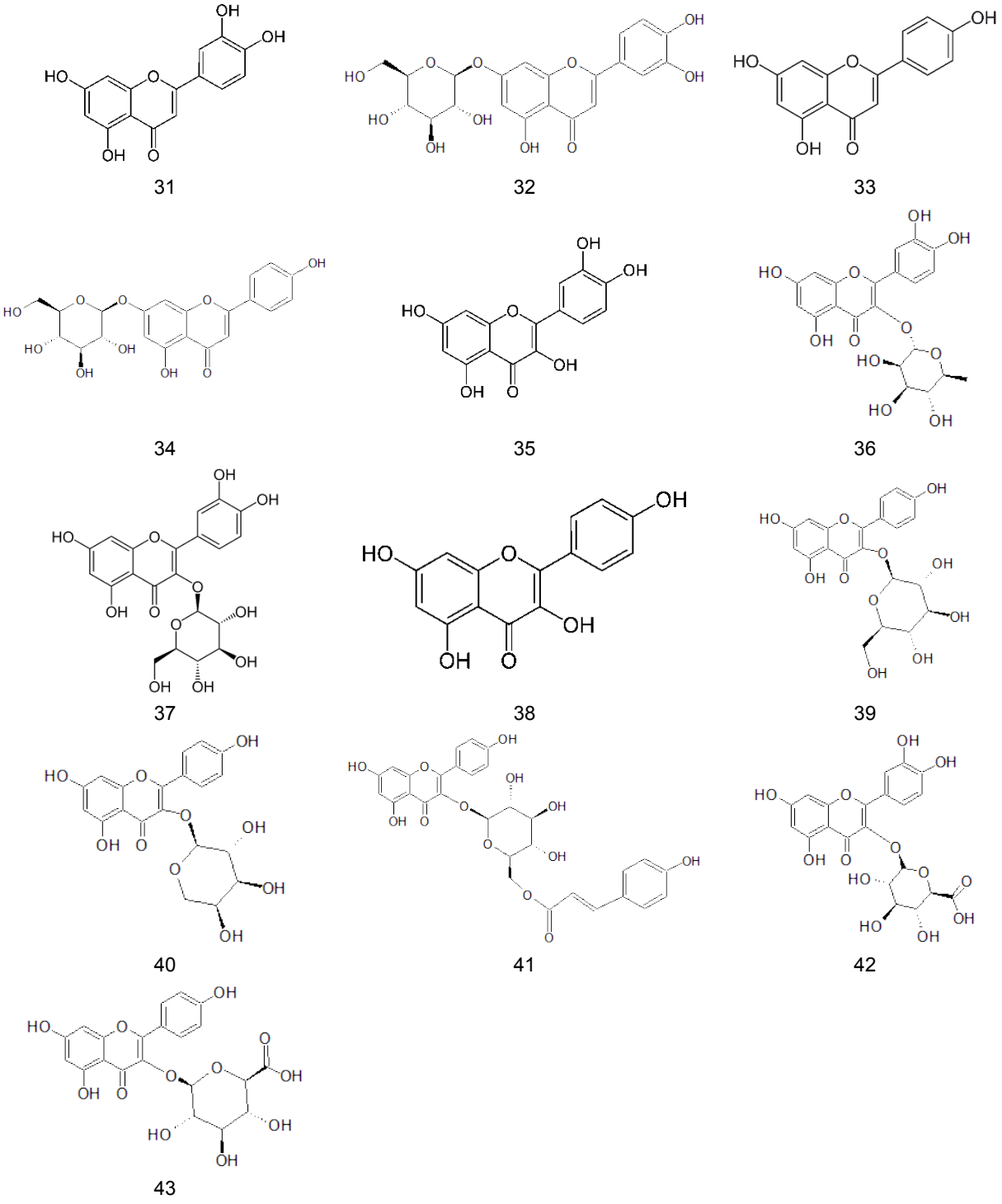

Figure 3 – Flavonoids of *G. rivale* (Panizzi et al., 2000)

Note: 31 – luteolin; 32 – luteolin-7-O-glucoside; 33 – apigenin; 34 – apigenin-7-O-glucoside; 35 – quercetin; 36 – quercetin-3-Oramnoside; 37 – quercetin-3-O-glucoside; 38 – kaempferol; 39 – kaempferol-3-O-glucoside; 40 – kaempferol-3-O-arabinoside; 41 – tilyroside; 42 – quercetin-3-O-glucuronide; 43 – kaempferol-3-O-glucuronide

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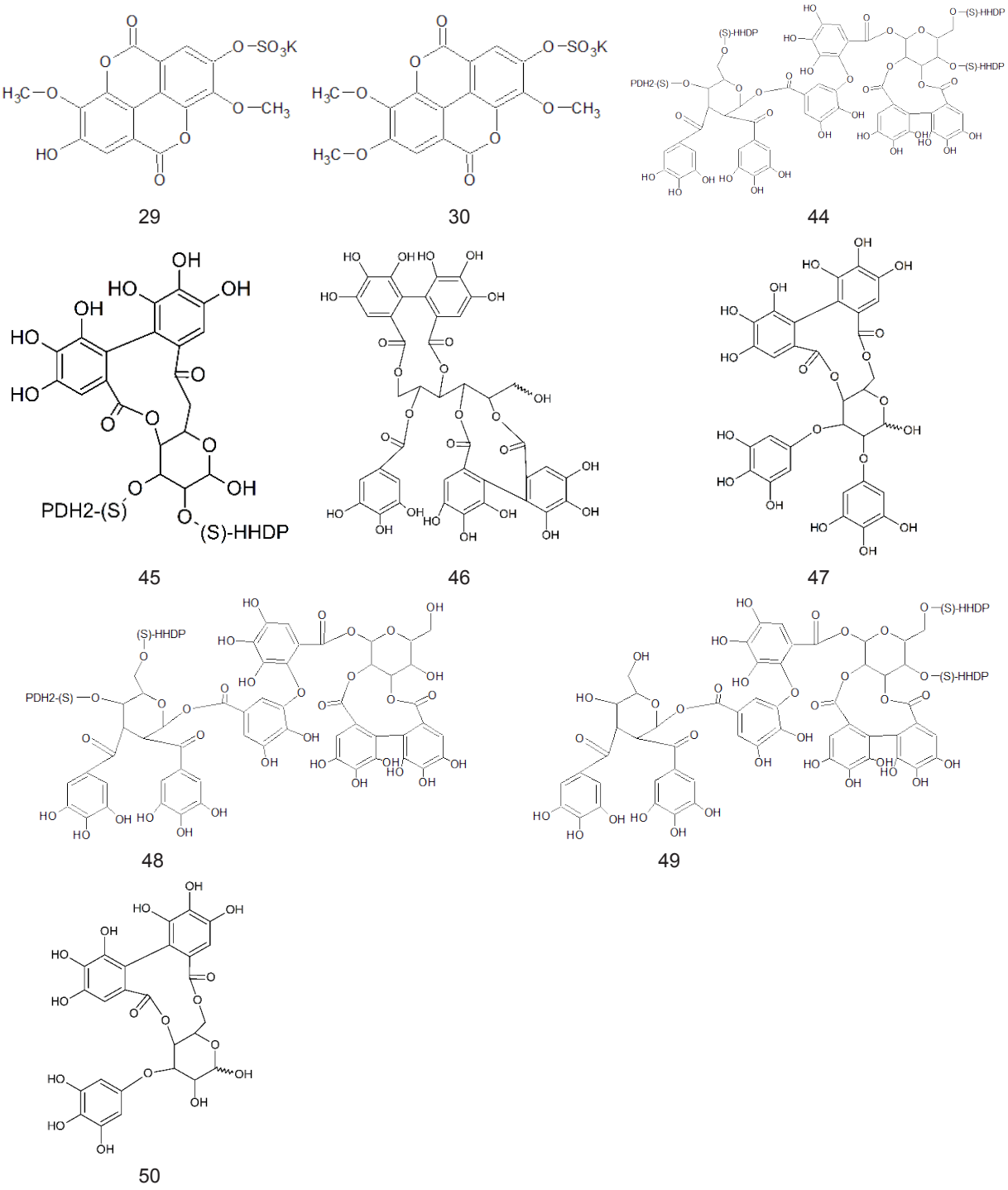

Figure 4 – Ellagitannins of *G. rivale* (Moilanen et al.,2008, 2015; Owczarek et al., 2017)

Table 1 – Biologically active compounds of G. rivale

№	Compounds	Morphological parts	References
Triterpenoids (Ursanes)			
1	α-amyrin	Arial part	14, 15
2	Ursolic acid		
3	Euskafic acid		
4	Euskafic acid 28-glucoside		15
5	Tormentic acid		14, 15
6	Nigaishigoside F1		14, 15, 22, 67
Other Triterpenoids			
7	Oleanolic acid	Arial part	14, 15
8	Betulin		
9	Epifriedelonol		
10	Cescropic acid		14, 15, 22, 67
Phenylpropanoids			
11	Chlorogenic acid	Arial and underground parts	14, 15, 17, 45
12	6-O-caffeyl-1-O-methyl-β-D-glucopyranose		14, 15, 22, 67
13	p-hydroxybenzoic acid		16
14	Caffeic acid	Arial parts	14, 15, 17, 45
15	Lilac acid	Arial and underground parts	16, 17
16	p-coumaric acid	Arial parts	16, 45
17	Ferulic acid	Arial and underground parts	16, 17
18	Sinapic acid		16, 17
19	Skopoletin		14, 15, 16
20	Esculetin		
21	Decursin		
Other constituents			
22	Gallic acid	Arial and underground parts	14, 15, 16, 19, 23, 45, 67
23	Protocatechuic acid		14, 15, 16
24	Ellagic acid		14, 15, 16, 19, 45
25	Salicylic acid		14, 15, 16
26	Vanillin	Arial parts	14, 16, 67
27	1-O-protocatechioyl glucose	Arial parts	22
28	Sucrose	Arial parts	
29	3,3'-dimethoxy-4-sulfoxyellagic acid potassium salt	Underground parts	23
30	3,3 ', 4'-trimethoxy-4-sulfoxyellagic acid potassium salt		
Flavonoids			
31	Luteolin	Arial part	14, 15
32	Luteolin 7-O-glucoside		
33	Apigenin		
34	Apigenin 7-O-glucoside		
35	Quercetin		
36	Quercetin 3-O-rhamnoside		
37	Quercetin 3-O-glucoside		
38	Kaempferol		
39	Kaempferol 3-O-glucoside		
40	Kaempferol 3-O-arabinoside		
41	Tiliroside		
42	Quercetin 3-O-glucuronide		
43	Kaempferol 3-O-glucuronide		
Ellagitannins			
44	Gemin A	Arial part	20, 21
45	Pedunculagin		21
46	Stachiurin / casuarinin		
47	Tellimagrandin 1		
48	Gemin B		
49	Gemin C		
50	Gemin D		
Essential oil constituents			

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№	Compounds	Morphological parts	References
51	(E) -2-hexenal	Arial part	13, 14
52	(Z), (E) -3-hexene-1-ol		
53	Hexanol		
54	Heptanol		
55	6-methyl-5-hepten-2-ol		
56	(Z) -3-hexenyl acetate		
57	α-pellandrene		
58	β-pellandrene		
59	(E) -β-ocimene		
60	(E) -2-octene-1-ol		
61	Octanol		
62	Terpinolen		
63	Nonanal		
64	Nonanol		
65	Terpinen-4-ol		
66	Deanal		
67	β-cyclocitral		
68	Dodecane		
69	(Z) -3-hexenyl-2-methylbutanoate		
70	(Z) -3-hexenyl isovalerate		
71	Tridecan		
72	(Z) -3-hexenyl crucible		
73	δ-element		
74	α-cubeben		
75	β-damascenone		
76	α-ylangen		
77	β-bourbonene		
78	β-cubeben		
79	β-caryophyllene		
80	β-copen		
81	α-humulene		
82	Alloaromadendren		
83	β-ionone		
84	γ-muurelen		
85	Germacren D		
86	(Z, E) – α-farnesene		
87	α-muurelen		
88	(E, E) – α-farnesene		
89	γ-cadinen		
90	α-calacoren		
91	Trans-nerolidol		
92	(Z) -3-hexenyl benzoate		
93	Caryophyllene oxide		
94	Viridiflorol		
95	Humulene epoxy II		
96	Farnesene epoxy		
97	Cubenol		
98	T-muurolol		
99	α-cadinol		
100	Pentadecanal		
101	Heptadecan		
102	Benzyl benzoate		
103	Octadecan		
104	Fitol		
105	Tricosan		
106	Tetracosan		
107	Hexacosan		
108	(Z) -hexenyl butyrate		

№	Compounds	Morphological parts	References
109	1-zopropylcyclohex-1-ene	Underground part	13, 14
110	Trans-linalool oxide		
111	Trans-myrtanal		
112	Palmitic acid		
113	Oct-1-en-ol		
114	α-guayenne		
115	Cumin aldehyde		
116	Nerol		
117	trans-anethole		
118	Geraniol		
119	2-methoxy-6-vinylphenol		
120	Isoeugenol		
121	Eugenol		
122	Perilla aldehyde		
123	Fellandral		
124	Perilla alcohol		
125	Mirtenal		
126	trans-pinocarveol		
127	Camphene	Arial and underground part	13, 14
128	1-octene-3-ol		
129	3-octanol		
130	Limonen		
131	Cis-linalool oxide		
132	Camphor		
133	Citronellol		
134	p-cymene		
135	δ-cadinen		
136	α-copen		
137	cis-myrtanol		
138	trans-myrtanol		
139	α-terpineol		
140	Mirtenol		
141	Linalool		
142	Nopinone		
143	cis-myrtanal		

Table 2 – Pharmacological effects of the main groups of constituents of *G. rivale*

Pharmacological effect	Extraction type or group of biologically active substances	References
Anti-inflammatory activity due to PAF-induced exocytosis	Total water extract	24, 25, 26
Antioxidant activity (DPPH-, FRAP-tests, linoleic acid peroxidation test)	Polyphenolic compounds	27
Antioxidant activity (DPPH and ABTS tests)	Phenolic acids and proanthocyanidins	33
Antimicrobial activity:		14, 15, 38, 68
a) antimicrobial activity against gram-positive and gram-negative microorganisms	Total polar extracts, triterpene fraction, flavonoid fraction, tannin fraction, ursolic acid, caffeic acid	
b) antifungal activity	Total polar extract, triterpene fraction, caffeic acid	
c) *Candida albicans*	Chloroform extract, total polar extracts, triterpene fraction, caffeic acid	
d) *Staphilococcus aureus, Pseudomonas aeruginosa*	Triterpene fraction, quercetin, kaempferol, caffeic acid, gallic acid	
Antiviral activity (influenza virus types A and B)	Ethanol extracts from the arial part	40

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Panizzi et al. (2000) investigated the antimicrobial activity of extracts of different polarity from the arial part of *G. rivale,* and some individual compounds. The dried raw material was extracted in a Soxhlet apparatus with n-hexane, chloroform, a mixture of chloroform-methanol 9:1, and then by maceration with methanol at room temperature. Then, the obtained total extracts were purified by column chromatography to individual compounds, their identification was carried out by IR and UV spectroscopy, ^{1}H and ^{13}C NMR. All the investigated fractions were dissolved in DMSO and screened for the antimicrobial activity by the agar diffusion method described by Clark, et al. (1981), using test microorganisms: *Staphylococcus aureus, Pseudomonas aeruginosa, Escherichia coli, Candida albicans* and *Aspergillus niger* [40]. The study showed that the total methanol extract has a high antimicrobial and antifungal activity, while the n-hexane extract showed a weak activity against bacteria and *Aspergillus niger*; chloroform extract had a pronounced activity against *Candida albicans*; and chloroform-methanol and water-methanol extracts were found active against all the tested organisms. When analyzing the purified extracts and individual compounds, the following results were obtained: triterpene fraction showed an efficiency comparable to methanol and chloroform-methanol extracts against all studied microorganisms; a mixture of flavonoids was found active against gram-positive and gram-negative bacteria in the absence of antifungal activity; the tannin fraction was active only against bacteria, but its effectiveness was lower than that of the flavonoid fraction; ursolic acid had zones of inhibition very similar to those obtained using a chloroform-methanol extract in the absence of antifungal effect; among the flavonoid aglycones, kaempferol and quercetin affected only *Staphylococcus aureus* and *Pseudomonas aeruginosa*, respectively, while apigenin had no antimicrobial and antifungal activity; caffeic acid showed a moderate activity against all test organisms, while gallic acid showed a pronounced effectiveness against *Staphylococcus aureus, Escherichia coli* and *Candida albicans* [16].

The identification of natural metabolites and synthetic agents that are effective in the prevention and treatment of diseases caused by influenza viruses of various types, is an urgent problem of the last decade. Researchers suggest that total native complexes of metabolites, as well as individual natural compounds of various natures, such as polyphenols, triterpenoids, alkaloids, organic acids, and some others, can be used as agents for inhibiting infections at various stages [42]. Therefore, in the work by Lobanov et al. (2016) the antiviral activity of 70 plant species belonging to 14 different families, including the aerial part of the *G. rivale, was* considered. The study was carried out using ethanol extracts obtained by the method described in the work by Kostina et al. (2013) [44]; avian influenza virus A / chicken / Kurgan / 05/2005 (H5N1) and a strain of human influenza virus A / Aichi / 2/68 (H3N2) adapted to laboratory mice, the titer of which was calculated by Spearman-Kerber's method using statistical processing according to Sachs, L. (1976) [45]. In the course of the study it was revealed that the ethanol extract from the arial part of *G. rivale* has a pronounced antiviral activity against both studied viral strains and can be recommended for a further research in this area in order to create phytopreparations for the prevention and treatment of influenza caused by these virus strains [43].

Ellagic acid is a metabolite of higher plants, it is in sufficiently large quantities in the arial and underground parts of *G. rivale*, both in free and bound forms as parts of ellagitannins. Due to its wide distribution, the possibilities of using this compound in medical practice are well studied. Thus, for the first time, a systematic review of the literature was conducted by García-Niño et al. (2015) and the following possible pharmacological effects of ellagic acid were described in detail [47]: antimutagenic [48], antigenotoxic [49–50], antiapoptotic [51], anticarcinogenic [52], antibacterial [53], antiviral [54], antimalarial [55], antiallergic [56], anti-inflammatory [57], antiatherogenic [58]; antidiabetic [59], antiepileptic [60], antidepressant [61], antinociceptive [62], neuroprotective [63], nephroprotective [64], cardioprotective [65] and hepatoprotective [66] activities. However, the work notes: the contribution of ellagic acid to the pharmacological effects of the extracts obtained from the arial parts of *G. rivale,* has not been revealed.

CONCLUSIONS

The analysis of the literature showed that *Geum rivale* L. has been subjected to phytochemical studies for a long period of time. This is due to both the rich raw material base of the plants and its widespread use in folk medicine.

For the period from 1958 to the present, more than 80 components have been identified in the arial and underground parts of the river gravity. The main groups of secondary metabolites have been characterized, including the essential oil, triterpenoids and phenolic compounds of the arial and underground parts of *Geum rivale* L. The most extensively represented group of secondary metabolites is polyphenolic compounds. Despite the sufficient knowledge of the chemical composition, the plant is not official in Russia.

The rich composition of polyphenolic compounds determines characteristic pharmacological effects of the plant, including anti-inflammatory, antioxidant, antimicrobial and antiviral activity. The pharmacological activity has been experimentally confirmed, both the extraction obtained by the extraction with solvents of polarity or fractionation, and some compounds. These types of activity may be useful against some socially significant pathologies, for example, antioxidant activity in the prevention and treatment of diseases of the cardiovascular, urinary and nervous systems, the antimicrobial and antiviral ac-

tivities in the treatment of the diseases caused by resistant strains of microorganisms and viruses.

However, the currently available data on the chemical composition and activity of *Geum rivale* L. do not give a general picture of the potential for using a plant as a source of new pharmaceutical substances of natural origin for the creation of medicines and biologically active additives.

Modern analytical methods in phytochemistry, dictate the development of the allocation of natural resources and compounds with the establishment of their exact structures using one of the methods of analytical magnetic resonance and infrared spectroscopy with a further study of their pharmacological potential. Therefore, it is advisable to continue the study of the composition of secondary metabolites of the arial and underground parts of this plant using modern methods of analysis to identify both – previously not discovered, as well as new for science natural compounds. The identification of specific compounds responsible for the development of types of biological activity valuable for medicine using *in silico* methods, the analysis of possible synergistic or additive effects of combinations of secondary metabolites, as well as the prediction of the mechanisms associated with the manifestation of a certain effect, may become a promising direction for further studies of *Geum rivale* L. The data obtained will make it possible to expand the range of use of *Geum rivale* L. in medicine.

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AUTHOR'S CONTRIBUTION

All authors equally contributed to the research work.

CONFLICT OF INTERESTS

The authors declare no conflict of interest.

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