ISSN 2518-1491 (Online),
ISSN 2224-5286 (Print)

«ҚАЗАҚСТАН РЕСПУБЛИКАСЫ
ҰЛТТЫҚ ҒЫЛЫМ
АКАДЕМИЯСЫ» РҚБ

«ҚАЗАҚСТАН РЕСПУБЛИКАСЫ
ҰЛТТЫҚ ҒЫЛЫМ АКАДЕМИЯСЫ» РҚБ

ХАБАРЛАРЫ

ИЗВЕСТИЯ

РОО «НАЦИОНАЛЬНОЙ
АКАДЕМИИ НАУК РЕСПУБЛИКИ
КАЗАХСТАН»

NEWS

OF THE ACADEMY OF SCIENCES
OF THE REPUBLIC OF
KAZAKHSTAN

SERIES
CHEMISTRY AND TECHNOLOGY

4 (461)

OCTOBER – DECEMBER 2024

PUBLISHED SINCE JANUARY 1947

PUBLISHED 4 TIMES A YEAR

ALMATY, NAS RK

«ҚР ҰҒА Хабарлары. Химия және технология сериясы»
ISSN 2518-1491 (Online),
ISSN 2224-5286 (Print)

Меншіктенуші: «Қазақстан Республикасының Ұлттық ғылым академиясы» РҚБ (Алматы қ.).Қазақстан Республикасының Ақпарат және қоғамдық даму министрлігінің Ақпарат комитетінде 29.07.2020 ж. берілген **№ KZ66VPY00025419** мерзімдік басылым тіркеуіне қойылу туралы куәлік.

Тақырыптық бағыты: *органикалық химия, бейорганикалық химия, катализ, электрохимия және коррозия, фармацевтикалық химия және технологиялар.*

Мерзімділігі: жылына 4 рет.

Тиражы: 300 дана.

Редакцияның мекен-жайы: 050010, Алматы қ., Шевченко көш., 28, 219 бөл., тел.: 272-13-19

http://chemistry-technology.kz/index.php/en/arhiv

Редакцияның мекенжайы: 050100, Алматы қ., Қонаев к-сі, 142, «Д.В. Сокольский атындағы отын, катализ және электрохимия институты» АҚ, каб. 310, тел. 291-62-80, факс 291-57-22, e-mail:orgcat@nursat.kz

«Известия НАН РК. Серия химии и технологий».
ISSN 2518-1491 (Online),
ISSN 2224-5286 (Print)

Собственник: Республиканское общественное объединение «Национальная академия наук Республики Казахстан» (г. Алматы).

Свидетельство о постановке на учет периодического печатного издания в Комитете информации Министерства информации и общественного развития Республики Казахстан **№ KZ66VPY00025419,** выданное 29.07.2020 г.

Тематическая направленность: *органическая химия, неорганическая химия, катализ, электрохимия и коррозия, фармацевтическая химия и технологии.*

Периодичность: 4 раз в год.

Тираж: 300 экземпляров.

Адрес редакции: 050010, г. Алматы, ул. Шевченко, 28, оф. 219, тел.: 272-13-19

http://chemistry-technology.kz/index.php/en/arhiv

Адрес редакции: 050100, г. Алматы, ул. Кунаева, 142, АО «Институт топлива, катализа и электрохимии им. Д.В. Сокольского», каб. 310, тел. 291-62-80, факс 291-57-22, e-mail:orgcat@nursat.kz

News of the National Academy of Sciences of the Republic of Kazakhstan. Series of chemistry and technology.
ISSN 2518-1491 (Online),
ISSN 2224-5286 (Print)
Owner: RPA «National Academy of Sciences of the Republic of Kazakhstan» (Almaty).
The certificate of registration of a periodical printed publication in the Committee of information of the Ministry of Information and Social Development of the Republic of Kazakhstan **No. KZ66VPY00025419,** issued 29.07.2020.
Thematic scope: *organic chemistry, inorganic chemistry, catalysis, electrochemistry and corrosion, pharmaceutical chemistry and technology.*
Periodicity: 4 times a year.
Circulation: 300 copies.
Editorial address: 28, Shevchenko str., of. 219, Almaty, 050010, tel. 272-13-19
http://chemistry-technology.kz/index.php/en/arhiv

Editorial address: JSC «D.V. Sokolsky institute of fuel, catalysis and electrochemistry», 142, Kunayev str., of. 310, Almaty, 050100, tel. 291-62-80, fax 291-57-22, e-mail: orgcat@nursat.kz

NEWS
OF THE NATIONAL ACADEMY OF SCIENCES OF THE REPUBLIC OF KAZAKHSTAN
SERIES CHEMISTRY AND TECHNOLOGY
ISSN 2224–5286
Volume 4. Number 461 (2024), 75–93
https://doi.org/10.32014/2024.2518-1491.252

UDC 615.32

D.T. Kassymova*, G.E. Zhusupova, 2024.
Al-Farabi Kazakh National University, Almaty, Kazakhstan.
*E-mail: Dariya.kassymova@kaznu.kz

DEVELOPMENT AND EVALUATION OF TOPICAL HERBAL GELS WITH PLANT EXTRACTS FROM *LIMONIUM GMELINII*

Kassymova Dariya – PhD candidate, Researcher, Al-Farabi Kazakh National University, Almaty, Kazakhstan, Dariya.kassymova@kaznu.kz, ORCID ID: https://orcid.org/0000-0002-3808-2051;
Zhusupova Galiya – Doctor of Chemical Science, Professor, Al-Farabi Kazakh National University, Almaty, Kazakhstan, ORCID ID: https://orcid.org/0000-0001-9133-2040.

Abstract. The article presents the results of the development of topical gel formulations based on plant extracts derived from the roots and the above-ground parts of *Limonium gmelinii*. The study evaluated the compatibility of plant extracts with excipients and optimized their content in the gel formulations. Various concentrations of carbomer and PG were tested to determine the most optimal gel compositions. The optimal formulations were selected based on organoleptic characteristics, colloidal and thermal stability, rheological properties, and the release kinetics of plant extracts. Gels containing 1.0% carbomer demonstrated optimal viscosity and thixotropic behavior, ensuring ease of application and product stability. The use of 10.0% PG resulted in a cumulative release of 87.36% for the above-ground parts extracts and 85.78% for the root extracts in *in vitro* tests. Long-term stability of the gels was confirmed over 12 months of storage.

Key words: *Limonium gmelinii*, topical gel formulations, soft dosage forms, carbomer, pharmaceutical development, plant-based extracts

Acknowledgements.

This research has been funded by the Science Committee of the Ministry of Science and Higher Education of the Republic of Kazakhstan (Grant No. AP19174425 for 2023-2025 years).

Д.Т. Касымова*, Г.Е. Жусупова, 2024.
«Әл-Фараби атындағы Қазақ Ұлттық Университеті», Алматы, Қазақстан.
*E-mail: Dariya.kassymova@kaznu.kz

LIMONIUM GMELINII ӨСІМДІГІНЕН АЛЫНҒАН ӨСІМДІК ЭКСТРАКТТАРЫ БАР ЖЕРГІЛІКТІ ҚОЛДАНУҒА АРНАЛҒАН ГЕЛЬДЕРДІ ӘЗІРЛЕУ ЖӘНЕ БАҒАЛАУ

Қасымова Дария – PhD докторанты, зерттеуші, әл-Фараби атындағы Қазақ ұлттық университеті, Алматы, Қазақстан, Dariya.kassymova@kaznu.kz, ORCID ID: https://orcid.org/0000-0002-3808-2051;
Жусупова Галия – химия ғылымдарының докторы, профессор, әл-Фараби атындағы Қазақ ұлттық университеті, Алматы, Қазақстан, ORCID ID: https://orcid.org/0000-0001-9133-2040.

Аннотация. Мақалада *Limonium gmelinii* өсімдігінің тамыры мен жер үсті бөліктерінен алынған өсімдік экстракттары негізінде жергілікті қолдануға арналған гельдік формулаларды әзірлеу нәтижелері ұсынылған. Зерттеу барысында өсімдік экстракттарының қосымша заттармен үйлесімділігі бағаланып, гель құрамындағы оңтайлы мөлшері анықталды. Гельдердің құрамын анықтау үшін карбомер мен пропиленгликольдің әртүрлі концентрациялары зерттелді. Оңтайлы құрамдар органолептикалық қасиеттері, коллоидтық және термиялық тұрақтылығы, реологиялық сипаттамалары және өсімдік экстракттарының босап шығу кинетикасы негізінде таңдалды. 1,0% карбомерді қамтитын гельдер оңтайлы тұтқырлық пен тиксотроптық қасиеттерді көрсетті, бұл олардың қолдану жеңілдігі мен өнімнің тұрақтылығын қамтамасыз етті. Пропиленгликольдің 10,0% концентрациясы *in vitro* сынақтарында жер үсті бөліктерінің экстракттары үшін 87,36% және тамыр экстракттары үшін 85,78% жинақталған босап шығуын қамтамасыз етті. Гельдердің ұзақ мерзімді тұрақтылығы 12 ай бойы сақтау кезінде расталды.

Түйін сөздер: *Limonium gmelinii*, жергілікті қолдануға арналған гельдер, жұмсақ дәрілік түрлер, карбомер, фармацевтикалық әзірлеу, өсімдік экстракттары.

Д.Т. Касымова*, Г.Е. Жусупова, 2024.
Казахский национальный университет имени аль-Фараби, Алматы, Казахстан.
*E-mail: Dariya.kassymova@kaznu.kz

РАЗРАБОТКА И ОЦЕНКА ГЕЛЕЙ ДЛЯ МЕСТНОГО ПРИМЕНЕНИЯ С РАСТИТЕЛЬНЫМИ ЭКСТРАКТАМИ ИЗ РАСТЕНИЙ ВИДА *LIMONIUM GMELINII*

Касымова Дария Талгатовна – PhD докторант, исследователь, Казахский национальный университет им. аль-Фараби, Алматы, Казахстан, Dariya.kassymova@kaznu.kz, ORCID ID: https://orcid.org/0000-0002-3808-2051;
Жусупова Галия Евентаевна – доктор химических наук, профессор, Казахский национальный университет им. аль-Фараби, Алматы, Казахстан, ORCID ID: https://orcid.org/0000-0001-9133-2040.

Аннотация: В статье представлены результаты разработки гелевых форм для местного применения на основе растительных экстрактов, полученных из корней и надземной части *Limonium gmelinii.* В ходе исследования была оценена совместимость растительных экстрактов с вспомогательными веществами и оптимизировано их содержание в составе гелей. Для определения оптимальных составов были изучены различные концентрации карбомера и пропиленгликоля. Оптимальные составы были выбраны на основе органолептических характеристик, коллоидной и термической стабильности, реологических свойств и кинетики высвобождения растительных экстрактов. Гели, содержащие 1,0% карбомера, продемонстрировали оптимальную вязкость и тиксотропное поведение, что обеспечило удобство нанесения и стабильность продукта. Использование 10,0% пропиленгликоля обеспечило кумулятивное высвобождение экстрактов надземной части растения на уровне 87,36% и экстрактов корней — 85,78% в *in vitro* тестах. Долгосрочная стабильность гелей была подтверждена в течение 12 месяцев хранения.

Ключевые слова: *Limonium gmelinii*, гели для местного применения, мягкие лекарственные формы, карбомер, фармацевтическая разработка, растительные экстракты.

Introduction. According to the WHO, plant materials are actively used in various countries both as traditional remedies and as ingredients in over-the-counter drugs and pharmaceutical raw materials, constituting a significant part of the global pharmaceutical market. WHO data from 2019 show that 109 countries have a registration system for herbal medicines, and 34 countries have included them in their national essential medicines list (NEML), indicating a growing interest in phytotherapy (WHO, 2019).

This trend is driven by an increasing number of studies on the chemical composition of plant extracts, improvements in the extraction techniques of biologically active compounds (BACs), and the proven efficacy of herbal medicines (Wegener, 2017). As of today, between 35,000 and 70,000 plant species have been screened for their therapeutic potential (Dapar, et al., 2020). Herbal preparations are widely used for respiratory, gastrointestinal, and urinary diseases, joint disorders, and as sedatives (Wegener, 2017).

Due to their wide range of therapeutic activities, plant extracts are highly valued in soft dosage forms such as gels as well. The pharmacological activity of herbal medicines is attributed to their complex chemical composition and the unique combinations of BACs, which often act synergistically, making them effective in treating various diseases (Wink, 2015). The use of plant-based preparations for topical treatment of skin conditions has several advantages, including ease of use, lack of systemic side effects, and the avoidance of first-pass liver metabolism (Javadzadeh and Azharshekoufeh Bahari, 2017).

Numerous studies in recent years have demonstrated the antibacterial, anti-inflammatory, antioxidant, and other beneficial properties of plant extracts for treating skin diseases. These extracts can also positively affect immune processes in the skin, improving inflammatory responses (Sitarek, et al., 2020).

There are positive results from testing plant-based gels for atopic dermatitis (Chu, et al., 2020), psoriasis (Herman and Herman, 2016), vitiligo (Choo, et al., 2020), arthritis (Aiyalu, et al., 2016) and osteoarthritis (Cameron and Chrubasik, 2013), herpes (Aslani, et al., 2018), diabetic foot ulcers (Marchianti, et al., 2021) and etc. The extracts used in these studies exhibited antimicrobial and wound-healing, antioxidant, anti-inflammatory, antidiabetic, hepatoprotective, and antipyretic properties.

Extracts from the roots and the above-ground parts of *Limonium gmelinii* (*L. gmelinii*) are rich in polyphenols, flavonols, tannins, and other bioactive compounds (Gadetskaya et al., 2015; Zhussupova et al., 2015), which explain their therapeutic potential . Extracts derived from the roots of this plant were used in the ointment "Limonidin," which is recommended for treating herpes, ulcerative processes, and inflammatory conditions in the oral cavity (Patent 14418 RK, 2008). However, hydrophilic gel bases may be more suitable for delivering active extracts from *L. gmelinii* due to their polarity and good solubility in aqueous solutions.

In this regard, the aim of this study was to develop and formulate topical gel preparations based on plant extracts from *Limonium gmelinii*, in accordance with ICH Q8 "Pharmaceutical Development" guidelines (European Medicines Agency, 2015). Additionally, the study aimed to evaluate the physicochemical properties and stability of the formulated gels to ensure their suitability for potential therapeutic use.

Methods and materials

The roots and above-ground parts of *L. gmelinii* were collected during the flowering period in Almaty region in 2020. The raw materials were authenticated using macro- and microscopy methods, thoroughly cleaned, dried, and then ground to a particle size of 2.0–3.0 mm. For the extraction of the above-ground parts and roots, the plant material was subjected to single ultrasonic extraction in an Elmasonic S 450 bath (Germany) at a raw material-to-extractant ratio of 1:5 (roots) and 1:7 (above-ground parts) for 45 minutes at 30°C. The filtered hydroalcoholic extracts were concentrated under vacuum at 40–45°C until dry to obtain a brown crystalline powder (Kassymova, et al., 2023).

The preparation of gel samples was carried out in several stages: 1) preparation of the aqueous dispersion of carbomer and its homogenization under constant stirring with the addition of a co-solvent to improve the wetting of the polymer; 2) neutralization of the base to pH 5.5–6.0; 3) preparation of solutions of plant extracts (active pharmaceutical ingredients, API) and the addition of excipients until all components were fully dissolved; 4) gradual mixing of the gel base with the solution of plant extracts and excipients; 5) adjustment of the gel pH to 5.5–6.0.

The compatibility of plant extracts with excipients was studied using IR spectra analysis on a PerkinElmer Spectrum BX Fourier-transform infrared spectrometer (USA). All gel samples based on plant extracts were tested for pH using a HANNA HI 2020-02 Edge electronic pH meter (USA), organoleptic properties, colloidal stability (centrifugation at 3000 rpm), thermostability (freezing/thawing), and homogeneity (Aiyalu, et al., 2016b; Aslani et al., 2018; Jamadar and Husen Shaikh, 2017).

The rheological behavior of the gels was evaluated using a Rheolab QC rotational

viscometer (Austria) in the shear rate range of 0.01–150 s^{-1}. The release kinetics of the API was studied using the *in vitro* method through a dialysis membrane with a Franz diffusion cell immersed in a thermostatic bath at 36–37°C as described in (Shahtalebi, et al., 2018). The stability during storage, organoleptic properties, pH, and the quantitative content of tannins and polyphenols were monitored for twelve months for all gel samples stored at room temperature (Aslani, et al., 2018).

The total polyphenol content was determined using the Folin-Ciocalteu reagent following the methodology described in (Kupina, et al., 2018), with certain modifications.

Results and Discussion

Justification for the selection of gel components and determination of their compatibility.

At the first stage, the compatibility of the extracts with excipients was studied, namely with the hydrophilic gelling agent carbomer, solvents—propylene glycol (PG), polyethylene glycol-400 (PEG-400), glycerin—which also serve as humectants and penetration enhancers, the neutralizer—triethanolamine (TEA), and the preservative—potassium sorbate. Menthol was used as a fragrance, but it also acted as a penetration enhancer (Leon Lachman, 2009). The compatibility of these gel components and extracts was studied using IR spectrum analysis of individual components and their mixtures with extracts from the above-ground parts and roots of *Limonium gmelinii.*

Each excipient was thoroughly mixed with extracts from the roots and the above-ground parts, dissolving them if necessary in 20% ethanol, at concentrations used in the gel formulation. Each mixture was placed in dark bottles and stored for one month while monitoring any changes.

After 30 days of storing the plant extracts mixed with various excipients at room temperature, no physical changes were observed, indicating their compatibility (Table 1).

Table 1 – Results of the study of plant extracts compatibility with gel excipients

Mixture with excipients	Extract from the roots	Extract from the above-ground parts
	Physical changes	
Carbomer	-	-
Carbomer + TEA	-	-
Glycerin	-	-
Propylene glycol	-	-
PEG-400	-	-
Menthol	-	-
Potassium sorbate	-	-

In the IR spectra of the extracts from the above-ground parts (Figure 1 (a)) and roots (Figure 1 (b)), broad absorption bands are observed at 3407 and 3399.1 cm^{-1}, respectively, characteristic of -OH groups involved in the formation of intermolecular hydrogen bonds in di- and/or polymers. The absorption bands at 1612.22 and 1613.4 cm^{-1} indicate C–C stretching vibrations of aromatic carbon atoms. Peaks between 700

and 1800 cm^{-1}, known as the "fingerprint region," may also be associated with aromatic ring stretching (C=C–C), characteristic of polyphenolic compounds (1450.8, 1348.43, 1035.49, 766.47 cm^{-1} for root extracts; 1447.25, 1037.08, 767.25 cm^{-1} for the avove-ground parts). Peaks at 1225.63 and 1233.09 cm^{-1} may also correspond to the vibrations of the phenolic C–O–H group.

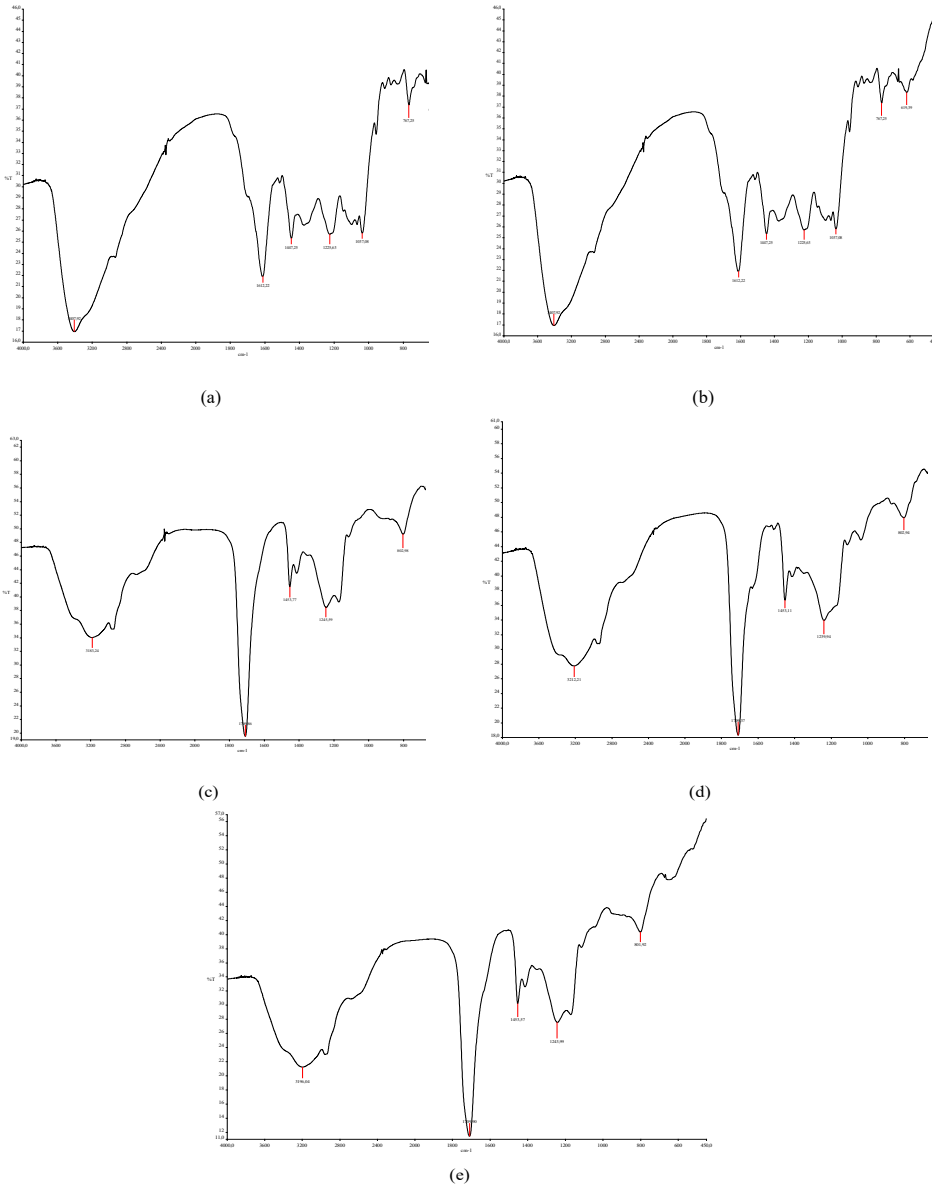

Figure 1. IR spectra of extract from the above-ground parts (a), extract from the roots (b), carbomer (c), mixture of extracts from the roots with carbomer (d), mixture of extracts from the above-ground parts with carbomer (e)

The IR spectrum of carbomer (Figure 1 (c)) is characterized by the largest absorption band at 1709.86 cm^{-1}, which is typical of C=O stretching vibrations involved in hydrogen bonding. In the physical mixture of carbomer and the extracts, characteristic peaks of the individual components are observed, indicating no chemical interaction between them (Figure 1 (d, e)).

Similarly, the absorption spectra of the mixtures of extracts with other excipients were analyzed, leading to the conclusion that the components are compatible.

Thus, based on experimental observations and IR analysis, it was concluded that there was no chemical or physical interaction between the gel components, and their compatibility was acceptable.

Determination of the optimal concentration of the gelling agent.

After establishing the compatibility of excipients and plant extracts derived from *L. gmelinii*, various gel formulations were tested. The aim of this stage was to select the optimal concentrations of excipients to achieve the desired characteristics in the final dosage form.

As mentioned earlier, the hydrophilic polymer carbomer was chosen as the gelling agent, due to its non-toxicity, ability to form transparent and bioadhesive gels, and the absence of skin irritation with repeated use. A technological advantage of carbomers also is their ability to form gels at room temperature.

To thicken the compositions with carbomer, the most commonly used mechanism is the neutralization of the polymer with an appropriate base. Triethanolamine (TEA) was selected as the neutralizing agent. The pH of the gels before neutralization with TEA was 3.5–4.0. According to the manufacturer's recommendations and literature data, the carbomer was neutralized to a pH of 5.5–6.0, which is considered favorable for topical skin application and does not provoke allergic reactions (Nurman, et al., 2019).

The concentration of carbomer varied from 0.5% to 1.5% (Table 2), while the concentrations of other components remained constant. The gels were evaluated organoleptically, as well as for homogeneity, flowability, viscosity, pH, and in tests for aggregate and thermal stability.

Table 2 – Composition of model gel samples with varying concentrations of carbomer

Gel components	F1	F2	F3	F4	F5	F6
Extract from the above-ground parts, %	5.0	5.0	5.0	-	-	-
Extract from the roots, %	-	-	-	5.0	5.0	5.0
Carbomer, %	0.5	1.0	1.5	0.5	1.0	1.5
Glycerin, %	5.0	5.0	5.0	5.0	5.0	5.0
Propylene glycol, %	5.0	5.0	5.0	5.0	5.0	5.0
Menthol, %	1.0	1.0	1.0	1.0	1.0	1.0
Ethanol (96.0%), %	20.0	20.0	20.0	20.0	20.0	20.0
Potassium sorbate, %	0.2	0.2	0.2	0.2	0.2	0.2
Triethanolamine, %	0.5	1.0	1.5	0.5	1.0	1.5
Purified water, %	q.s.	q.s.	q.s.	q.s.	q.s.	q.s.

The organoleptic properties of the gels were evaluated immediately after preparation by visual inspection in transparent bottles under transmitted or reflected daylight. All

the gel samples exhibited an acceptable pH, were transparent and homogeneous. All compositions remained stable in the phase separation test during centrifugation, where no sedimentation, phase separation, or coalescence was observed, further confirming the compatibility of the extracts and excipients. The pH of the gel samples before neutralization was in the range of 3.0–3.5 but was later adjusted to pH 5.0–6.0, which corresponds to the pH of topical skin applications (Nurman, et al., 2019). All results of the physicochemical analysis of the gels are summarized in Table 3.

Table 3 – Physicochemical properties of model gel samples

Quality indicators	F1	F2	F3	F4	F5	F6
pH	5.67±0.03	5.74±0.05	5.81±0.02	5.66±0.03	5.95±0.02	5.82±0.05
Viscosity, Pa*s	0.35±0.05	0.64±0.03	1.12±0.13	0.41±0.06	0.67±0.11	1.17±0.09
Appearance	Flowing, homogeneous, transparent dark-brown sample, easily spreadable	Thick, plastic, homogeneous, transparent dark-brown sample, easily spreadable	Jelly-like, homogeneous, transparent dark-brown sample, easily spreadable	Flowing, homogeneous, transparent dark-brown sample, easily spreadable	Gel-like, homogeneous, transparent dark-brown sample, easily spreadable	Jelly-like, homogeneous, transparent dark-brown sample, easily spreadable
Aggregate stability (centrifugation at 3000 rpm)	stable	stable	stable	stable	stable	stable
Thermal stability	stable	stable	stable	stable	stable	stable

The structural viscosity of the gels, as expected, increases with the concentration of carbomer (Figure 2) and falls within the range of 0.34–108 Pa*s (Pertsev, i dr., 2002), which is optimal for topical application. Measurements were taken at a shear rate of 100 s^{-1}, which corresponds to the approximate shear rates when squeezing the product out of the package and applying it (Khachatryan, et al., 2022).

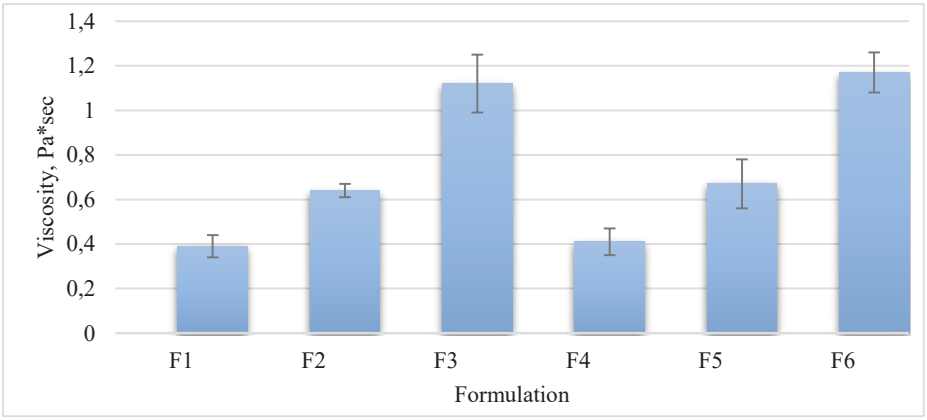

Figure 2. Structural viscosity of model gel samples

Gels with a carbomer concentration of 0.5% in samples F1 and F4 were visually insufficiently viscous, while samples F3 and F6 were thick, non-flowing, and jelly-like, which seems less convenient for patient use and may cause difficulties during subsequent technological operations (Gupta and Garg, 2002). Additionally, thick gels can limit the release of active pharmaceutical ingredients and reduce bioadhesive properties (Safitri, et al., 2021).

Based on the collected data, gels with a carbomer concentration of 1.0% were selected as the most optimal for further research. These results are consistent with those reported in previous studies. For instance, the research conducted by Suzilla W. et. al. (Suzilla, et al., 2020) found that gels formulated with 1.0% carbopol 940 had the best overall physicochemical properties, including optimal viscosity, stability, and spreadability. The study on *Boswellia* vaginal gel found that 1% carbomer formed the most stable and homogenous gel, while lower concentrations (e.g., 0.5%) resulted in insufficient viscosity and poor stability, leading to phase separation (Dehdari et al., 2021). These consistent outcomes suggest that a 1.0% carbomer concentration is a robust choice for ensuring the desired balance between the gel's texture and application ease. Moreover, higher concentrations, as noted in the research (Suzilla, et al., 2020), often lead to overly thick gels that compromise spreadability and user experience. This further supports the selection of 1.0% carbomer for the optimized formulation of topical gels.

Determination of the optimal concentration of excipients.

As co-solvents, humectants, and penetration enhancers, glycerin, propylene glycol (PG), and polyethylene glycol-400 (PEG-400) were tested. These solvents are widely used in various gel compositions and can affect both the swelling process of polymers and the solubility of active pharmaceutical ingredients (API). Propylene glycol is considered one of the best non-toxic penetration enhancers and plasticizers, increasing the transdermal absorption of many APIs (Aiyalu et al., 2016b; Budi et al., 2022). Additionally, it is reported that PG not only enhances penetration but also increases the retention of flavonoids such as chrysin and quercetin in the skin (Dyja and Jankowski, 2017). In several studies, PEG-400 or glycerin is frequently added to water when forming carbomer gels, positively affecting their rheological and mucoadhesive properties (Slavkova et al., 2023). These solvents also help dissolve menthol more effectively. The compositions of the model gel samples are presented in Table 4. The gels were formulated with constant concentrations of carbomer (1.0%) and plant extracts (5.0%).

Table 4 – Composition of model gel samples with varying concentrations of co-solvents

Gel components, %	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16
Extract from the above-ground parts	5.0	-	5.0	-	5.0	-	5.0	5.0	-	-
Extract from the roots	-	5.0	-	5.0	-	5.0	-	-	5.0	5.0
Carbomer	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Glycerin	5.0	-	-	5.0	-	-	-	-	-	-
Propylene glycol	-	5.0	-	-	5.0	-	10.0	15.0	10.0	15.0

PEG-400	-	-	5.0	-	-	5.0	-	-	-	-
Ethanol (96.0%)	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
Menthol	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Potassium sorbate	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Triethanolamine	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Purified water	q.s.	q.s.	q.s.	q.s.	q.s.	q.s.	q.s.	q.s.	q.s.	q.s.

The physicochemical properties of gels F7–F16 were studied using the previously described methods and showed satisfactory results (Table 5).

Table 5 – Physicochemical properties of model gel samples

Quality indicators	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16
pH	5.78± 0.05	5.88± 0.02	5.91± 0.05	5.82± 0.01	5.84± 0.06	5.88± 0.05	5.92± 0.03	5.78± 0.04	5.75± 0.04	5.95± 0.02
Appearance	Thick, plastic, homogeneous, transparent dark-brown sample, easily spreadable									
Aggregate stability (centrifugation at 3000 rpm)	Stable	Stable	Stable	Stable	Stable	Stable	Stable	Stable	Stable	Stable

During the preparation of the laboratory gel series, it was noted that the time required to mix formulas with PG and PEG-400 into a homogeneous state was shorter than for compositions with glycerin, where lumps of swollen polymer remained for a longer time. Homogeneous gels with PG and PEG-400 were obtained within 3 hours, while it took up to 4.5 hours to prepare gels with glycerin.

However, it was more important to establish and compare the release rates of extracts from different bases using the in vitro method. The release kinetics directly influence the therapeutic effect of the medicinal form (Leon Lachman, 2009). Optimal compositions were also selected based on data from studies on the viscoelastic properties of the gels.

The release kinetics from the gel base were studied using the diffusion method of plant extracts through a cellulose membrane into phosphate buffer solution (pH=6.0–6.5).

The release evaluation was performed using UV spectrophotometry. The absorption maxima for both extracts corresponded to a wavelength of 268 nm, at which the optical density was measured to build calibration graphs.

According to the curves presented in Figure 3, samples F7–F9 exhibited high release rates of extracts from the gel bases. Within 10 minutes, the released amount of extracts from formulations F7, F8, and F9 was 53.4%, 60.4%, and 42.8%, respectively. The maximum release after 360 minutes was 81.8% for F8, which contained PG. The gel composition F7 with glycerin had a slightly lower release rate than F8, with a cumulative release of 78.2%. Formulation F9 had the lowest release rate, as evidenced by the first hour's result of 63.5%.

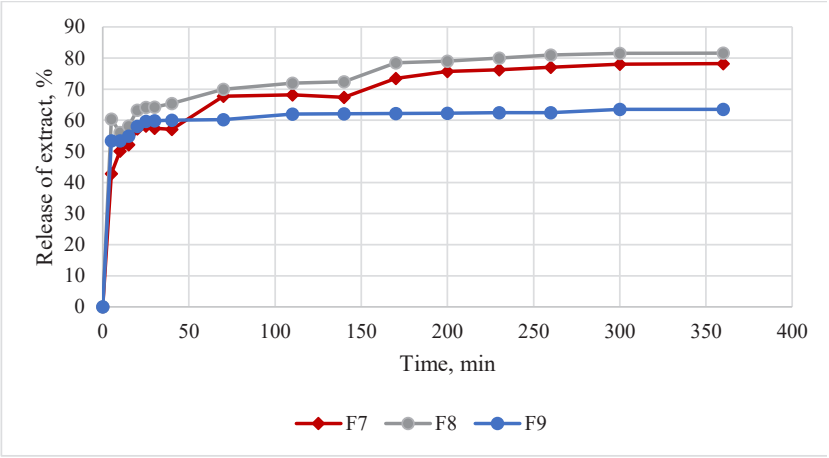

Figure 3. Release curves of the extracts from roots from formulations F7–F9

A similar release kinetics was observed for formulations F10–F12 (Figure 4). The extract from the above-ground parts diffused from the gel bases F10, F11, and F12 within 10 minutes in the amounts of 51.8%, 59.6%, and 43.1%, respectively. The highest release of extract from the above-ground parts occurred within 360 minutes from formulations F10 and F11, at 80.5% and 82.3%, respectively.

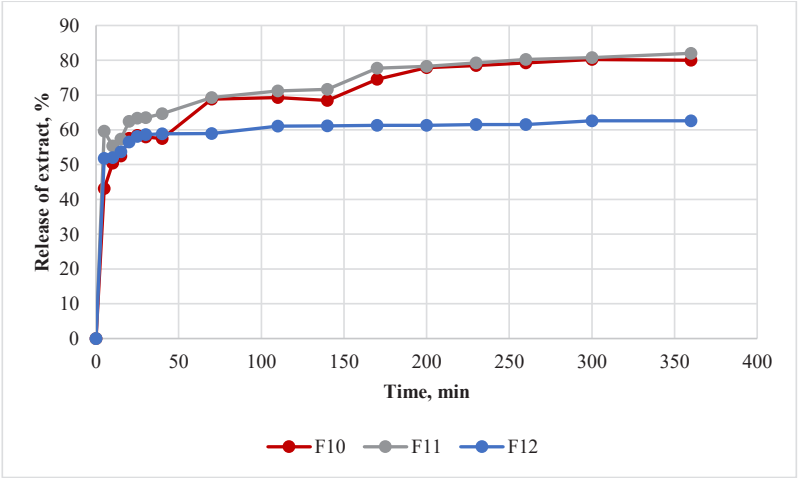

Figure 4. Release curves of the extracts from the above-ground parts from formulations F10–F12

Formulations with PG demonstrated a high release rate of up to 70% for both root and above-ground part extracts within the first hour, indicating their good solubility in the gel base. The preliminary dissolution of the extracts in a water-ethanol mixture, as the most suitable solvent, significantly influenced their subsequent solubility in the gel

base. However, it should also be noted that the extracts from roots and above-ground parts of *L. gmelinii* are soluble in propylene glycol, moderately soluble in water, and insoluble in glycerin and PEG-400. Thus, formulations F8 and F11 contain a solvent mixture that is most optimal for the release of extracts from the medicinal form.

The next step was to determine the optimal amount of PG to be added to the gel composition. Additional gels were prepared with PG concentrations increased to 10.0% and 15.0%, and their release kinetics were studied (Figure 5), along with their flow rheograms.

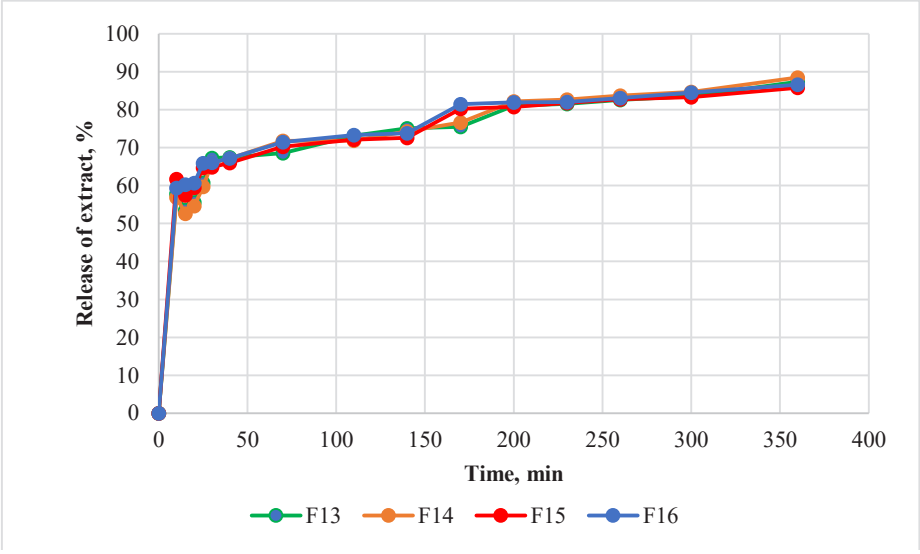

Figure 5. Release curves of the extracts from roots and above-ground parts from formulations F13–F16

The addition of 10% propylene glycol (PG) increased the release percentage to 87.36%, and further increasing the concentration to 15% had a negligible effect on this parameter. This led to the conclusion that both 10.0% and 15.0% PG concentrations are equally optimal for use in the gel formulations.

Determining the rheological characteristics of medicinal gel forms is not mandatory according to pharmacopoeial requirements, but they are important parameters for assessing the quality of dosage forms during development, stability studies, and selecting production conditions. To study the viscoelastic properties of the gels, flow curves were constructed to show the relationship between shear stress and shear rate, ranging from 0 to 150 s^{-1} at 20°C (Figure 6).

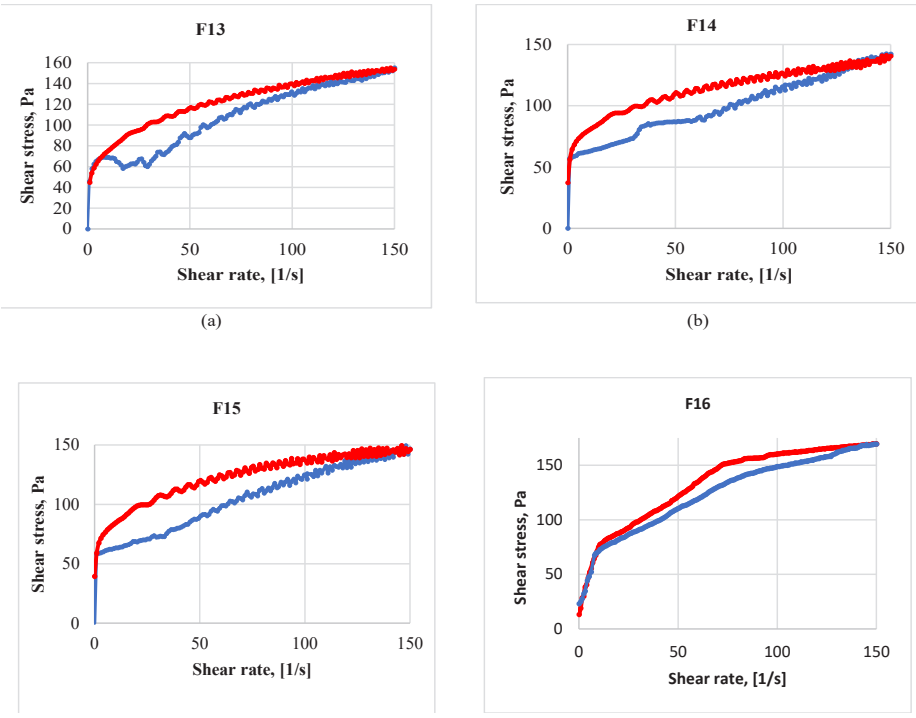

Figure 6. Flow rheograms of gel samples F13 (a), F14 (b), F15 (c), F16 (d)

As seen in Figure 6, the flow curves exhibit ascending and descending lines, forming a pronounced hysteresis loop, which indicates the presence of thixotropic properties in the gel samples. Thixotropy is typical for structured systems with plastic flow behavior, which deform under the influence of mechanical force. This characteristic reflects the good pharmaceutical and consumer properties of the product, particularly its ease of extrusion from tubes and spreadability, which in turn influences user convenience. The hysteresis loop area of sample F16 is somewhat smaller than that of samples F13–F15, and the differences in the rheology of samples F13 and F14 are statistically insignificant.

Thus, based on the release kinetics and rheological characteristics, propylene glycol (PG) at a concentration of 10.0% was chosen as the co-solvent, plasticizer, and penetration enhancer for the gel carrier base of extracts derived from *L. gmelinii*. PG enhances the solubility of plant extracts and promotes higher release rates of active ingredients, which is consistent with findings from other studies where PG significantly improved drug release from topical gels (Dehdari et al., 2021). Similarly, research shows that PG facilitates drug permeation through biological membranes and enhances skin retention of active compounds, leading to improved drug flux and delivery efficiency in skin-mimicking systems (Ruiz et al., 2022). These studies reinforce the conclusion that PG is an optimal choice for topical gel formulations, allowing for better drug absorption and retention, ultimately enhancing the therapeutic potential of the gel while minimizing systemic exposure.

Determination of optimal concentration of plant extracts and study of gel stability

The development of herbal gel formulations was further conducted with two concentrations of the active ingredient – 5.0% and 7.0%. Previously developed ointments based on root extracts of *L. gmelinii* demonstrated therapeutic activity at a 5.0% concentration (Patent 14418 RK., 2008). To enhance therapeutic efficacy, it was feasible to develop gel formulations with a higher concentration.

At this stage of research, an additional method of preparing gels from concentrated extracts was also studied to simplify the technology and reduce the time required to prepare the gels. The concentrated extracts were obtained during the concentration stage after the ultrasonic extraction process. The percentage of dried extract in the concentrated herbal extracts was measured after ultrasonic extraction, concentration, and complete removal of the solvent. The percentage of introduced extract, calculated based on dry matter, was 5.0±1.05%. This method allows for significantly reducing the time required to obtain dry extracts during ultrasonic extraction and introduces the extracts into the gel base in a pre-dissolved form. The gel formulations are shown in Table 6.

Table 6 – Composition of model gel samples with different co-solvent concentrations

Formulation	F17	F18	F19	F20	F21	F22
Extract from the above-ground parts	5.0	7.0	-	-	-	-
Extract from the root	-	-	5.0	7.0	-	-
Concentrated extract (above-ground parts) 17.0%	-	-	-	-	30.0	-
Concentrated extract (roots) 17.0%	-	-	-	-	-	30.0
Ethanol	20.0	20.0	20.0	20.0	20.0	20.0
Propylene glycol	10.0	10.0	10.0	10.0	10.0	10.0
Carbomer	1.0	1.0	1.0	1.0	1.0	1.0
Menthol	1.0	1.0	1.0	1.0	1.0	1.0
Triethanolamine (TEA)	1.0	1.0	1.0	1.0	1.0	1.0
Potassium sorbate	0.2	0.2	0.2	0.2	0.2	0.2
Purified water	q.s.	q.s.	q.s.	q.s.	q.s.	q.s.

The appearance of the gels containing extracts from the roots ans the above-ground parts did not differ and is shown in Figure 7 – transparent brown-colored gels with a specific plant odor.

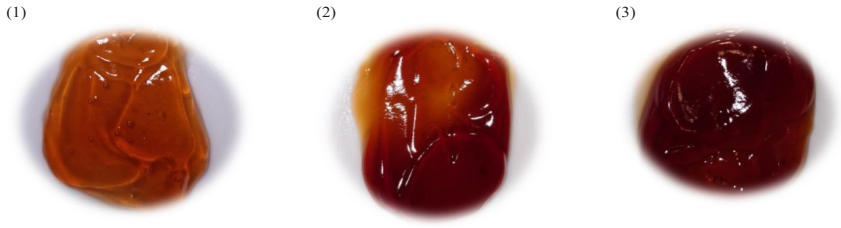

Figure 7. Gel appearance (1) – 5% gel obtained from dry extracts; (2) – 5% gel obtained from concentrated extract; (3) 7% gel obtained from dry extract

Upon changing the percentage of introduced extracts in the gels, it was found that the concentration of the extracts did not significantly affect the rheological properties of the gels or their cumulative release from the base. Formulations F17-F22 exhibited similar pseudoplastic behavior and the presence of a hysteresis loop, confirming their thixotropic properties (Figure 8).

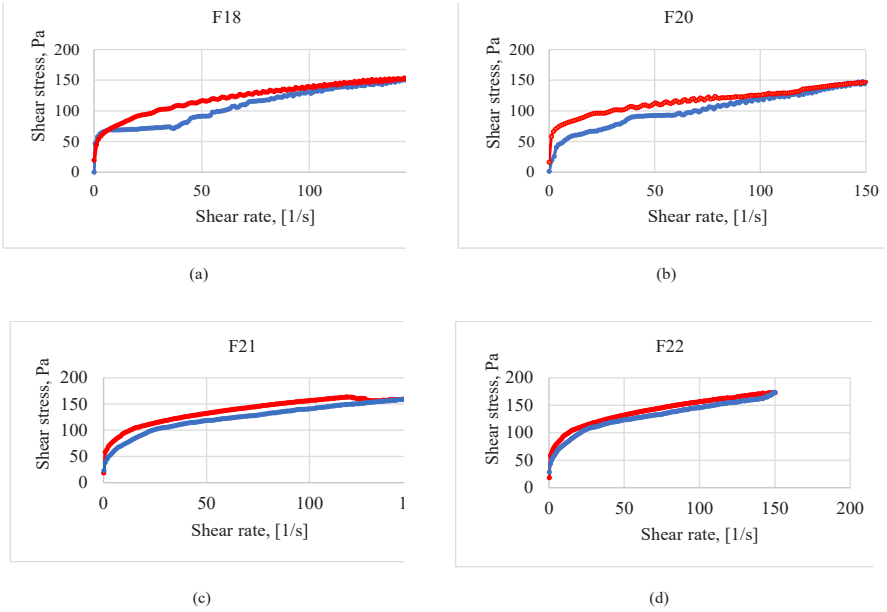

Figure 8. Flow rheograms of gel samples F18 (a), F20 (b), F21 (c), F22 (d)

The data obtained once again demonstrated that the prepared gels are capable of deforming under mechanical force and flowing, positively affecting the pharmaceutical-technical characteristics and allowing the base to spread easily over the skin (Jurca et al., 2020). The release from formulations F17-F22 also showed satisfactory results, ranging from 84.25% for F22 to 88.49% for F18 (Figure 9).

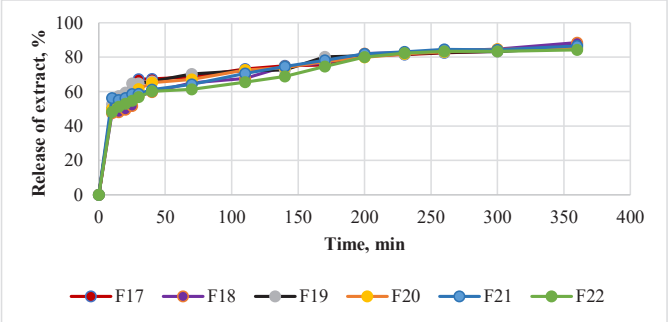

Figure 9. Release kinetics of extracts from model gel samples F17-F22

Subsequent evaluation of the gels with varying concentrations of the active extract was conducted using a set of physicochemical methods according to the quality requirements of the State Pharmacopoeia of Kazakhstan (Gosudarstvennaya farmakopeya Respubliki Kazakhstan, 2008). The gel samples were tested for stability during 12 months of storage. During this period, the quantitative content of the active extract in the gel samples was monitored.

The active ingredients of the extracts are various polyphenolic compounds, which, as noted earlier, are strong anti-inflammatory agents. The Folin-Ciocalteu test for total polyphenols showed high levels in the dry extracts from *L. gmelinii* plants – 32.5±1.2% in the above-ground parts and 44.7±2.5% in the roots. This method was also used for the quantitative measurement of total polyphenols in the gels, and a direct correlation was confirmed between the amount of introduced extract and the quantity of the analytical marker found (Table 7).

Table 7 – Physicochemical properties of model gel samples

Quality indicators	F17	F18	F19	F20	F21	F22
Description	Homogeneous transparent thick gel of soft consistency, brown color, easily rubs in					
pH	5.98±0.02	6.35±0.04	6.40±0.02	5.99±0.01	6.21±0.01	6.35±0.02
Identification - Tannins	+	+	+	+	+	+
Homogeneity	Homo-geneous	Homo-geneous	Homo-geneous	Homo-geneous	Homo-geneous	Homo-geneous
Quantitative determination - Tannins (≥1.0%)	1.15±0.05	1.59±0.03	1.60±0.02	2.20±0.05	1.52±0.04	2.15±0.04
Total polyphenols (≥1.50%)	2.01±0.05	2.88±0.04	1.25±0.02	2.19±0.01	1.62±0.04	2.85±0.04
Aggregate stability	Stable	Stable	Stable	Stable	Stable	Stable

The evaluation of gels with varying concentrations of active extract from *Limonium gmelinii* demonstrated their stability over a 12-month storage period, maintaining physicochemical consistency such as pH, homogeneity, and active ingredient content. The total polyphenol content showed a direct correlation between the amount of extract introduced and the concentration of polyphenols detected, confirming the efficient incorporation of bioactive compounds into the gels. The stable levels of tannins and polyphenols, along with consistent gel characteristics, suggest that the formulations are both chemically stable and effective over time. This indicates their suitability for further pharmaceutical development and potential therapeutic applications, particularly for their anti-inflammatory properties.

Conclusion

The study successfully developed stable topical gel formulations based on plant extracts from *Limonium gmelinii*. The optimal concentration of carbomer (1.0%) and propylene glycol (10.0%) was identified, ensuring suitable viscosity, ease of application, and effective release of active compounds. Rheological analysis demonstrated

thixotropic behavior, contributing to the gel's practicality for topical use. Stability testing confirmed that the gels maintained their physical and chemical properties over 12 months, ensuring consistency in the therapeutic ingredients. The findings suggest that these gel formulations are well-suited for industrial-scale production and could be further developed as plant-based topical treatments for various inflammatory skin conditions.

References

Aiyalu R.; Govindarjan A.; Ramasamy A. (2016) Formulation and Evaluation of Topical Herbal Gel for the Treatment of Arthritis in Animal Model, Brazilian Journal of Pharmaceutical Sciences, doi:10.1590/s1984-82502016000300015 (in Eng.).Aiyalu, R., Govindarjan, A., Ramasamy, A., 2016b. Formulation and evaluation of topical herbal gel for the treatment of arthritis in animal model. Brazilian Journal of Pharmaceutical Sciences 52, 493–507. https://doi.org/10.1590/s1984-82502016000300015

Aslani A., Zolfaghari B., Fereidani Y. (2018) Design, Formulation, and Evaluation of a Herbal Gel Contains Melissa, Sumac, Licorice, Rosemary, and Geranium for Treatment of Recurrent Labial Herpes Infections, Dent Res J (Isfahan), doi:10.4103/1735-3327.231865 (in Eng.).Bao, Y., Li, H., Li, Q.Y., Li, Y., Li, F., Zhang, C.F., Wang, C.Z., Yuan, C.S., 2018. Therapeutic effects of Smilax glabra and Bolbostemma paniculatum on rheumatoid arthritis using a rat paw edema model. Biomedicine and Pharmacotherapy 108. https://doi.org/10.1016/j.biopha.2018.09.004

Budi H.S., Anitasari S., Ulfa N.M., Juliastuti W.S., Aljunaid M., Ramadan D.E., Muzari K., Shen Y.-K. (2022) Topical Medicine Potency of Musa Paradisiaca Var. Sapientum (L.) Kuntze as Oral Gel for Wound Healing: An In Vitro, In Vivo Study, Eur J Dent., doi:10.1055/s-0041-1740226 (in Eng.).Cameron, M., Chrubasik, S., 2013. Topical herbal therapies for treating osteoarthritis. Cochrane Database of Systematic Reviews 5. https://doi.org/10.1002/14651858.CD010538

Choo W.T., Teoh M.L., Phang S.M., Convey P., Yap W.H., Goh B.H., Beardall J. (2020) Microalgae as Potential Anti-Inflammatory Natural Product Against Human Inflammatory Skin Diseases, Front Pharmacol, DOI: 10.3389/fphar.2020.01086.

Chu M., Tsang M.S., Lam C.W.-K., Quan Z.B., Wong C.K. (2020) The Active Compounds and Therapeutic Mechanisms of Pentaherbs Formula for Oral and Topical Treatment of Atopic Dermatitis Based on Network Pharmacology, Plants, 1166, doi:10.3390/plants9091166 (in Eng.).

Dapar, M.L.G., Alejandro, G.J.D., Meve, U., Liede-Schumann, S., 2020. Quantitative ethnopharmacological documentation and molecular confirmation of medicinal plants used by the Manobo tribe of Agusan del Sur, Philippines. J Ethnobiol Ethnomed 16, 14. https://doi.org/10.1186/s13002-020-00363-7

Dehdari S.; Hajimehdipoor H.; Ara L., Tansaz M. (2021) Formulation and Quality Assessment of Boswellia Vaginal Gel, Research Journal of Pharmacognosy, doi:10.22127/rjp.2021.233569.1600 (in Eng.).

Dyja R., Jankowski A. (2017) The Effect of Additives on Release and in Vitro Skin Retention of Flavonoids from Emulsion and Gel Semisolid Formulations, Int J Cosmet Sci., doi:10.1111/ics.12395 (in Eng.).

European Medicines Agency ICH Guideline Q8 (R2) on Pharmaceutical Development (2017) https://www.ema.europa.eu. 01.06.2009 (in Eng.).

Gadetskaya A.V., Zhussupova A.I.; Shalakhmetova T.M.; Murzakhmetova M.K.; Zhussupova G.E. (2015) Natural Antioxidants of Plant Origin, International Journal of Biology and Chemistry, doi:10.26577/2218-7979-2015-8-1-67-72.

Gianfaldoni S., Wollina U., Tirant M., Tchernev G., Lotti J., Satolli F., Rovesti M.,França K., Lotti T. (2018) Herbal Compounds for the Treatment of Vitiligo: A Review, Maced J Med Sci, doi: 10.3889/oamjms.2018.048 (in Eng.).

Gosudarstvennaya farmakopeya Respubliki Kazakhstan (2008). Almaty, Izdatel'skij dom «Zhibek zholy», ISBN 978-601-7152-43-7.

Gupta P., Garg S. (2002) Recent Advances in Semisolid Dosage Forms for Dermatological Application, Pharmaceutical Technology, https://www.pharmtech.com/view/recent-advances-semisolid-dosage-forms-dermatological-application (in Eng.).

Herman A.; Herman A. (2016) Topically Used Herbal Products for the Treatment of Psoriasis – Mechanism of Action, Drug Delivery, Clinical Studies, Planta Med., doi:10.1055/s-0042-115177 (in Eng.).

Jamadar M.J.; Husen Shaikh R. (2017) Preparation and evaluation of herbal gel formulation, Journal of Pharmaceutical Research, https://api.semanticscholar.org/CorpusID:211630783 (in Eng.).

Javadzadeh Y., Azharshekoufeh Bahari L. (2017) Therapeutic Nanostructures for Dermal and Transdermal Drug Delivery, Nano- and Microscale Drug Delivery Systems. Elsevier, Amsterdam. ISBN 978-0-323-52727-9.

Jurca T., Józsa L., Suciu R., Pallag A., Marian E., Bácskay I., Mureșan M., Stan R.L., Cevei M., Cioară F. et al. (2020) Formulation of Topical Dosage Forms Containing Synthetic and Natural Anti-Inflammatory Agents for the Treatment of Rheumatoid Arthritis, Molecules, doi:10.3390/molecules26010024 (in Eng.).

Kassymova D., Zhusupova G., Ogay V., Zhussupova A., Katragunta K., Avula B., Khan I.A. (2023) Phytochemical Profiles and In Vitro Immunomodulatory Activities of Extracts Obtained from Limonium Gmelinii Using Different Extraction Methods, Plants, 4019, doi:10.3390/plants12234019 (in Eng.).

Khachatryan G., Khachatryan L., Krystyjan M., Lenart-Boroń A., Krzan M., Kulik K., Białecka A., Grabacka M., Nowak N., Khachatryan K. (2022) Preparation of Nano/Microcapsules of Ozonated Olive Oil in Hyaluronan Matrix and Analysis of Physicochemical and Microbiological (Biological) Properties of the Obtained Biocomposite, Int J Mol Sci., 14005, doi:10.3390/ijms232214005 (in Eng.).

Kupina S., Fields C., Roman M.C., Brunelle S.L. (2018) Determination of Total Phenolic Content Using the Folin-C Assay: Single-Laboratory Validation, First Action 2017.13, J AOAC Int., doi:10.5740/jaoacint.18-0031 (in Eng.).

Leon Lachman (2009) The Theory and Practice of Industrial Pharmacy. CBS Publishers & Distributors, New Delhi. ISBN 0812109775, 9780812109771.

Marchianti A.C.N., Sakinah E.N., Elfiah U., Putri N.K.S., Wahyuliswari D.I., Maulana M., Ulfa E.U. (2021) Gel Formulations of Merremia Mammosa (Lour.) Accelerated Wound Healing of the Wound in Diabetic Rats, J Tradit Complement Med, doi:10.1016/j.jtcme.2019.12.002 (in Eng.).

Nurman S., Yulia R., Irmayanti, Noor E., Candra Sunarti T. (2019) The Optimization of Gel Preparations Using the Active Compounds of Arabica Coffee Ground Nanoparticles, Sci Pharm, doi:10.3390/scipharm87040032 (in Eng.).

Patent 14418 RK. Method for obtaining a total polyphenolic complex from the roots of Limonium gmelinii / K.D. Rakhimov, G.E. Zhusupova, Abilov; published on 15.10.2007, Bulletin No. 6. – 5 pages. Pat. 14418 RK. Sposob polucheniya summar'nogo polifenol'nogo kompleksa iz korney kermeka Gmelina / K.D. Rakhimov, G.E. Zhusupova, Abilov; opubl. 15.10.2007, Byul. № 6. – 5 s.

Pertsev I.M. i dr. (2002) Kontrol' kachestva i proizvodstvo myagkikh lekarstvennykh sredstv v svete trebovaniy gosudarstvennoy farmakopei Ukrainy [Tekhnologiya lekarstv] 8: 29–31 (in Russ.).

Ruiz V.H., Encinas-Basurto D., Sun B., Eedara B.B., Dickinson S.E., Wondrak G.T., Chow H.-H.S., Curiel-Lewandrowski C., Mansour H.M. (2022) Design, Physicochemical Characterization, and In Vitro Permeation of Innovative Resatorvid Topical Formulations for Targeted Skin Drug Delivery, Pharmaceutics, doi:10.3390/pharmaceutics14040700 (in Eng.).

Safitri F.I., Nawangsari D., Febrina D. (2021) Overview: Application of Carbopol 940 in Gel. International Conference on Health and Medical Sciences (AHMS 2020), Paris, Atlantis Press. P. 5.

Shahtalebi M., Asghari G., Rahmani F., Shafiee F., Jahanian-Najafabadi A. (2018) Formulation of Herbal Gel of Antirrhinum Majus Extract and Evaluation of Its Anti- Propionibacterium Acne Effects, Adv Biomed Res., doi: 10.4103/abr.abr_99_17 (in Eng.).

Sitarek P., Merecz-Sadowska A., Kowalczyk T., Wieczfinska J., Zajdel R., Śliwiński T. (2020) Potential Synergistic Action of Bioactive Compounds from Plant Extracts against Skin Infecting Microorganisms, Int J Mol Sci, doi:10.3390/ijms21145105 (in Eng.).

Slavkova M., Tzankov B., Popova T., Voycheva C. Gel Formulations for Topical Treatment of Skin Cancer: A Review, Gels, doi:10.3390/gels9050352 (in Eng.).

Suzilla W.Y., Izzati A., Isha I., Zalina A., Rajaletchumy V.K. (2020) Formulation and Evaluation of Antimicrobial Herbosomal Gel from Quercus Infectoria Extract, IOP Conf Ser Mater Sci Eng, 022030, doi:10.1088/1757-899X/736/2/022030 (in Eng.).

Thandar Y., Gray A., Botha J., Mosam A. (2017) Topical Herbal Medicines for Atopic Eczema: A

Systematic Review of Randomized Controlled Trials, British Journal of Dermatology, doi:10.1111/bjd.14840 (in Eng.).

Wegener T. (2017) Patterns and Trends in the Use of Herbal Products, Herbal Medicine and Herbal Medicinal Products, Int J Complement Altern Med, doi:10.1186/s13002-020-00363-7 (in Eng.).

WHO Global Report on Traditional and Complementary Medicine. – Luxembourg: World Health Organization, 2019. – 228 pp.

Wink M. (2015) Modes of Action of Herbal Medicines and Plant Secondary Metabolites, Medicines, doi:10.3390/medicines2030251 (in Eng.).

Zhussupova A., Zhussupova G., Gadetskaya A. (2015) Creation of Medicinal Products on the Basis of Limonium Gmelinii, Planta Med., doi:10.1055/s-0035-1565422 (in Eng.).

МАЗМҰНЫ

ХИМИЯ

СОДЕРЖАНИЕ

ХИМИЯ

CONTENTS

CHEMISTRY

Publication Ethics and Publication Malpractice
in the journals of the National Academy of Sciences of the Republic of Kazakhstan

For information on Ethics in publishing and Ethical guidelines for journal publication see http://www.elsevier.com/publishingethics and http://www.elsevier.com/journal-authors/ethics.

Submission of an article to the National Academy of Sciences of the Republic of Kazakhstan implies that the described work has not been published previously (except in the form of an abstract or as part of a published lecture or academic thesis or as an electronic preprint, see http://www.elsevier.com/postingpolicy), that it is not under consideration for publication elsewhere, that its publication is approved by all authors and tacitly or explicitly by the responsible authorities where the work was carried out, and that, if accepted, it will not be published elsewhere in the same form, in English or in any other language, including electronically without the written consent of the copyright-holder. In particular, translations into English of papers already published in another language are not accepted.

No other forms of scientific misconduct are allowed, such as plagiarism, falsification, fraudulent data, incorrect interpretation of other works, incorrect citations, etc. The National Academy of Sciences of the Republic of Kazakhstan follows the Code of Conduct of the Committee on Publication Ethics (COPE), and follows the COPE Flowcharts for Resolving Cases of Suspected Misconduct (http://publicationethics.org/files/u2/New_Code.pdf). To verify originality, your article may be checked by the Cross Check originality detection service http://www.elsevier.com/editors/plagdetect.

The authors are obliged to participate in peer review process and be ready to provide corrections, clarifications, retractions and apologies when needed. All authors of a paper should have significantly contributed to the research.

The reviewers should provide objective judgments and should point out relevant published works which are not yet cited. Reviewed articles should be treated confidentially. The reviewers will be chosen in such a way that there is no conflict of interests with respect to the research, the authors and/or the research funders.

The editors have complete responsibility and authority to reject or accept a paper, and they will only accept a paper when reasonably certain. They will preserve anonymity of reviewers and promote publication of corrections, clarifications, retractions and apologies when needed. The acceptance of a paper automatically implies the copyright transfer to the National Academy of Sciences of the Republic of Kazakhstan.

The Editorial Board of the National Academy of Sciences of the Republic of Kazakhstan will monitor and safeguard publishing ethics.

Правила оформления статьи для публикации в журнале смотреть на сайтах:
www:nauka-nanrk.kz
http://chemistry-technology.kz/index.php/en/arhiv
ISSN 2518-1491 (Online), ISSN 2224-5286 (Print)

Директор отдела издания научных журналов НАН РК *А. Ботанқызы*
Редакторы: *Д.С. Аленов, Ж.Ш. Әден*
Верстка на компьютере *Г.Д. Жадырановой*

Подписано в печать 17.12.2024.
Формат 60x88$^{1}/_{8}$. Бумага офсетная. Печать – ризограф.
13,5 п.л. Тираж 300. Заказ 4.

Национальная академия наук РК
050010, Алматы, ул. Шевченко, 28, т. 272-13-19