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Research of technological properties of medicinal plant raw material of Siberian Statice (*Limonium gmelinii*)

Kopel Violeta, Barna Oksana, Plaskonis Yuliya
I. Horbachevsky Ternopil National Medical University, Ternopil, Ukraine

Address for correspondence:
Barna Oksana
E-mail: barna@tdmu.edu.ua

Abstract: *the article presents the results of studying the technological properties of medicinal plant raw materials Siberian Statice (Limonium gmelinii), namely specific, volumetric, bulk density, determination of absorption coefficient and swelling rate, as well as porosity, free volume layer and fractional composition. Grinded raw materials from the aboveground part of Siberian Statice, which included stems, inflorescences, flowers was the object of the study. Siberian Staticea (Limonium gmelinii) is a perennial herbaceous bare plant of the Kermek genus, which contains tannins, flavonoids, hydroxycinnamic acids, anthocyanins, coumarins, carbohydrates, polysaccharides, organic acids, amino acids and others. The raw material in the Genichesk district of the Kherson region was harvested in 2021. The study of basic technological properties was carried out according to generally accepted methods, which are listed in the State Pharmacopoeia of Ukraine. The data obtained during the study indicate that the composition of the grinded raw material is polydisperse and it is not possible to determine one predominant fraction. Particles with a size of 2,8-1,0 mm are about 80% of the composition. This diversity of composition can be explained by the fact that the studied aboveground part of plant raw materials includes a thick-branched stem, inflorescences with small regular flowers. The humidity of the studied raw materials is 0,23%. The specific density of raw materials is 1,3446 ± 0,0073 g/cm³, and the volumetric density of plant raw materials is 0,4679 ± 0,0450 g/cm³. Bulk mass after shrinkage decreased from 80 to 69, which is 13,75%. Volumetric shrinkage increased from 0,1251 g/cm³ to 0,1436 g/cm³. Indicators of porosity, porosity and free volume layer (0,6933 g/cm³, 0,7326 g/cm³, 0,9073 g/cm³, respectively) are quite high, which indicates a good absorption capacity of raw materials. The average value of the absorption coefficient was 6,33 ± 0,34, which indicates a high cost of extractant, and the swelling rate shows that the investigated raw material doesn't swell, this indicates the presence of pores inside the stem, where the extractant is retained, but does not increase linear dimensions and volume plant raw materials. The technological properties of Siberian Statice (Limonium gmelinii) raw materials have been experimentally determined, which allow choosing the optimal extraction methods for the studied raw materials, namely the extraction method, the ratio of raw materials: extractant, the nature of the extractant.*

Key words: Siberian Statice (Limonium gmelinii), plants medicinal, flower essences.

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Introduction

The modern world is increasingly turning to herbal medicines for the treatment of various pathological conditions, as well as their prevention. They have a wide range of biological action, low toxicity and are in demand among the population. Therefore, the study of new sources for the creation of drugs based on medicinal plant raw materials is quite relevant.

Siberian Statice herb was selected for the study, as this medicinal plant raw material is official only in the Kazakhstan Republic. In Ukraine, this raw material is used only in folk medicine. Only the root of Siberian Statice is used, from which the substance "Limonidine" was obtained, on the basis of which a tincture and ointment were obtained. Therefore, the aboveground part of the studied raw material is a promising source of biologically active substances and requires further research. This raw material has a wide range of biological action, namely it has high antioxidant, anti-inflammatory, capillary-strengthening, hepatoprotective, antimicrobial, antimutagenic and antiviral properties. Used at the gastrointestinal tract diseases, improves blood supply to internal organs, also has a wound-healing effect, and is effective for rinsing the mouth with any inflammatory diseases (Жусупова Г., і ін., 2012; Гродзінський, А. М., 1992).

To obtain a medicinal substance from the grass of Siberian Statice, it is necessary to choose the optimal method of production, which will ensure the maximum yield of active substances. The extraction of BAS from medicinal plant raw materials is an important process in the creation of herbal medicines. Extraction is a physical-technological process based on diffusion phenomena and its efficiency depends on many parameters: selectivity of the extractant, extraction method, degree of grinding of raw materials, etc., as well as technological properties of raw materials (Grytsyk, A, Dubel, N & Grytsyk, L 2021; України, Д. Ф., 2014). Therefore, for choosing of extraction methods, the nature of the extractant and the ratio of raw materials: extractant, need to study the technological characteristics of raw materials, because these indicators will affect the efficiency of the extraction process (Протункевич, О. О., Присяжнюк, К. О. & Пономарьова Л. А., 2019). They make it possible to define cost norms of plant raw materials and extractant for the efficiency of the extraction process.

Aim

Investigation of technological parameters of medicinal plant raw materials Siberian Statice (Limonium gmelinii) to select the optimal extraction regime. The study was aimed to determine the properties of raw materials such as: specific, volumetric, bulk density, determination of the absorption coefficient and swelling rate, as well as porosity, porosity, free volume layer and fractional composition.

Materials and methods

Grinded raw materials from the aboveground part of Siberian Statice (Limonium gmelinii) which included stems, inflorescences, and flowers was the object of the study. The raw material was harvested of wild plants in the fields between the Henichesk town and the Henicheska Hirka village, near the Henichesk Strait in the Henichesk district of the Kherson region in August 2021. Siberian Staticea (Limonium gmelinii) is a perennial herbaceous bare plant of the Kermek genus, which contains tannins, flavonoids, hydroxycinnamic acids, anthocyanins, coumarins, carbohydrates, polysaccharides, organic acids, amino acids and others (Кожамкулова, Ж. А., 2011). The research of basic technological properties was carried out according to generally accepted methods. (Басага Є. І., 2013; Протункевич, О. О., Присяжнюк, К. О. & Пономарьова Л. А., 2019; Шалата, В. Я. & Сур, С. В. 2012; України, Д. Ф., 2014)

Results

First of all, the fractional composition of medicinal plant raw materials was studied. After all, the first stage of raw material processing is grinding, which is one of the main factors influencing the diffusion rate and completeness of extraction of biologically active substances during extraction, which affects the density, swelling and absorption coefficients of plant raw materials. Assessment of the quality of raw materials was performed by sieve analysis, which is a quantitative characteristic of the fractional composition of grinded medicinal plant raw materials. The weighted average particle size is the main parameter.

Table 1. The results of the fractional composition determination (n = 3)

Sieves No	The size of the sieve cells, mm	Sieve analysis of raw materials		
		Average value, %.	Total balance, %.	Passing through a sieve, %.
3	4,0	11,394	11,394	88,606
4	2,8	16,601	27,995	72,005
5	2,0	20,792	48,787	51,213
6	1,4	25,045	73,832	26,168
7	1,0	17,067	90,899	9,101
8	0,7	6,714	97,613	2,387
9	0,5	1,635	99,248	0,752
Pallet		0.752	100	0

The sieve analysis results of medicinal plant raw materials are in table 1.

Analyzing the data obtained during the study, we can conclude that the composition of the grinded raw material is polydisperse and it is not possible to determine one predominant fraction. Particles with a size of 2,8-1,0 mm are about 80% of the composition. This diversity of composition can be explained by the fact that the studied aboveground part of plant raw materials includes a thick branched stem, inflorescences with small regular flowers.

Determination of loss-on–drying of medicinal plant raw materials was performed according to the SPU method (України, Д. Ф., 2014). Humidity of the investigated raw materials is 0,23%, have been established as a result of research.

Further research at determining the volumetric and specific density of raw materials was aimed, which have no less effect on the completeness of extraction.

Specific density (d_s) is the ratio of absolutely dry grinded medicinal plant raw materials to the volume of plant raw materials. The study of this indicator will further predict the raw materials loading volume extractor (Шалата, В. Я. & Сур, С. В., 2012; України, Д. Ф., 2014). The results of the study are shown in table 2.

The specific density of raw materials is 1.3446 ± 0.0073 g/cm^3.

Volumetric density (d_v) was defined as the ratio of the mass of grinded raw material at natural or specified humidity to its total volume, containing pores, cracks and capillaries filled with air (України, Д. Ф., 2014). The results of determining the volumetric density are shown in table 3.

Bulk density (d_b) was defined as the ratio of grinded raw material at natural or specified humidity to the total volume occupied by the raw material together with the pores of the particles and the free volume between them (Alkhalaf, M.V., Ruban, O. A., Gerbina, N.A. & Masliy, J. S., 2018; Бисага Є. І., 2013; Grytsyk A. et al, 2021; України, Д. Ф., 2014).

Bulk volume and volumetric shrinkage were determined according to the SPU methods. The results of the experiment are shown in table 4.

The results of the experiment show that the bulk volume after shrinkage decreased from 80 to 69, which is 13,75%. Volumetric shrinkage increased from 0,1251 g/cm^3 to 0,1436 g/cm^3.

Table 2. The results of the specific density raw materials determination (n = 3)

Mass of absolutely dry grinded raw materials, g	Mass of pycnometer with purified water, g	Mass of pycnometer with water and raw materials, g	Specific density of raw materials, g/cm^3	The average value of the specific density of raw materials, g/cm^3
5,011	173,558	174,856	1,3495	1,3446±0,0073
5,008	173,342	174,642	1,3506	
5,017	174,072	175,327	1,3336	

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Table 3. The results of the volumetric density of plant raw materials determination (n = 3)

Ser. No.	Mass of plant raw materials, g	Volume occupied by raw materials, g/cm³	Volumetric density of raw materials, g/cm³	The average value of the volumetric density of raw materials, g/cm³
1	10,028	20	0,5014	0,4679±0,0450
2	10,038	20	0,5019	
3	10,011	25	0,4004	

The volumetric density of plant raw materials is 0,4679 ± 0,0450 g/cm³.

The obtained results of specific, volumetric and bulk density of plant raw materials used to calculate its porosity and free volume layer, which make it possible to identify the required ratio of raw materials: extractant. These indicators are calculated according to the SPU formulas (України, Д. Ф., 2014).

Porosity of raw materials (P_r) was characterized as the size of the cavities inside the raw material particles and was defined as the ratio of the difference between the specific density and volumetric density to the specific density.

Porosity of the raw material layer (P_l) was characterized as the size of the cavities between the particles of plant material and was defined as the ratio of the difference between volumetric and bulk density to volumetric density.

The free volume of the raw material layer (V) is characterized as the relative volume of free space per unit of raw material layer (cavities inside and between particles), and is calculated as the ratio of the difference between specific and bulk densities to specific density. The results of determining the porosity, porosity of the raw material layer and free volume of the raw material layer are shown in table 5.

Determination of absorption and swelling coefficients are important indicators of the extraction conditions choice, which show the ability of raw materials to absorb the extractant, which

Table 4. The results of the bulk volume and volumetric shrinkage of plant raw materials determination (n = 3)

Volumetric shrinkage	Raw materials mass	Bulk volume after shrinkage, ml	Bulk density (before shrinkage), m/V_0, g/ml	Bulk density (after shrinkage), m/V_{1250}, or m/V_{2500}, g/ml	Shrinkage capacity (V_0-V_{1250}) ml
V_0	10,003	80	0,1250	0,1429	10
V_{10}		78			
V_{500}		72			
V_{1250}		70			
V_0	10,007	78	0,1283	0,1450	9
V_{10}		76			
V_{500}		70			
V_{1250}		69			
V_0	10,004	82	0,1220	0,1429	12
V_{10}		78			
V_{500}		72			
V_{1250}		70			
Average value			0,1251 ± 0,0021	0,1436 ± 0,0009	10,3 ± 1,3

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Table 5. The results of the porosity, porosity of the raw material layer and free volume of the raw material layer determination

Porosity g/cm^3	0,6933
Porosity of the raw material layer g/cm^3	0,7326
Free volume layer g/cm^3	0,9073

The porosity, porosity of the raw material layer and free volume layer are quite high, which indicates good absorption capacity of raw materials.

affects the cost factor in the process, because using tabular values is not always rational.

To determine the absorption coefficient in a graduated glass cylinder with a capacity of 25 ml (height - 125 ± 5 mm, the price of the mark - 5 ml), equipped with a ground stopper was placed 1 g of the raw material. 25 ml of 96,6% ethanol solution was added to the test sample and closed the cylinder by stopper. Leave to infuse for 4, 6 and 8 hours. 4, 6 and 8 hours after, the extractant was drained and the volume of the fused extract was measured. The absorption coefficient was determined by the ratio of the obtained extract volume to the filled extractant volume (Шалата, В. Я. & Сур, С. В., 2012; України, Д. Ф., 2014). The results are shown in table 6.

The average value of the absorption coefficient was 6,33 ± 0,34, which indicates the high cost of the extractant.

At the swelling coefficients determination, 1.0 g of the grinded tested sample was placed in a graduated glass cylinder of 25 ml capacity, height (125 ± 5) mm, division value of 0,5 ml, equipped with a ground stopper. The test sample was wet by 1,0 ml 96% ethanol, 25 ml of water was added and the cylinder was closed. The cylinder was shacked vigorously every 10 min during 1 h, then left for 3 h. By rotating the cylinder around the vertical axis, the main volume of fluid is released after 90 min test start. Measure the volume occupied by the test sample, taking into account the sticky mucus (України, Д. Ф., 2014). The results of the experiment are shown in table 7.

The study results of the absorption and swelling coefficients indicate that raw material has the ability to absorb the extractant, but does not swell, which indicates the presence of pores inside the stem, where the extractant is retained, but does not increase the linear dimensions and volumes of raw materials.

The main technological parameters are summarized, based on the data obtained during the experiment, are shown in table 8.

Conclusions

The technological properties of Siberian Statice (Limonium gmelinii) raw materials have been experimentally determined, namely loss-on–drying, fractional composition, specific, volumetric and bulk density, porosity, porosity of the raw material layer, absorption and swelling coefficient. The obtained data indicate that the composition of the grinded raw material is polydisperse, since the studied aboveground part of plant raw

Table 6. The absorption coefficient determination (n = 3)

Raw materials mass, g.	95% ethanol volume, ml.	Infusion duration, h	Obtained extract volume, ml.	Absorption coefficient
1,000	25	4	22	3.0
		6	20	5.0
		8	19	6.0
1,003	25	4	21	4.0
		6	19	6.0
		8	18	7.0
1,005	25	4	22	3.0
		6	20	5.0
		8	19	6.0
Average value				6,33 ± 0,34

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Table 7. The results of the plant raw materials swelling coefficient determination

Ser.No./ mass, g	Ethanol/ water volume for wetting raw materials	The frequency of the cylinder shaking during 1 hour	Total duration of raw materials swelling, h	The test sample occupied volume, with the sticky mucus, ml
1 / 1,000	1/25	Every 10 minutes	4	7,5
			6	7,5
			8	7,5
2 / 1,002	1/25	Every 10 minutes	4	7,5
			6	7,5
			9	7,5
3 / 1,005	1/25	Every 10 minutes	4	8,0
			6	8,0
			9	8,0

materials includes a thick-branched stem, inflorescences with small regular flowers. The humidity of the studied raw materials is 0.23%. Value of specific, volumetric and bulk density, porosity, porosity of the raw material layer and free volume layer indicates a good absorption capacity of raw material. But researched raw material does not swell, which indicates the presence of pores inside the stem, where the extractant is retained, but does not increase the linear dimensions and volumes of raw materials. The determined technological properties allow choosing the optimal extraction methods for the studied raw materials.

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This study hadn't obtained external funding.

Conflicts of interest

Authors have no conflict of interest to daclare.

Consent to publication

All authors have read and approved the final version of the manuscript. All authors have agreed to publish this manuscript.

ORCID ID and AUTHORS CONTRIBUTION

(B,C,D) Kopel Violeta

0000-0002-5047-1359 (A,D,E,F) Barna Oksana

0000-0001-5299-1879 (D,E) Plaskonis Yuliya

A – Research concept and design, B – Collection and/or assembly of data, C – Data analysis and interpretation, D – Writing the article, E – Critical revision of the article, F – Final approval of article

Table 8. The main technological parameters of plant raw materials

Technological parameters	Unit of measurement	The results of determination n = 3
Loss-on–drying	%	0,23
Specific density	g/cm^3	1,3446 ± 0,0073
Volumetric density	g/cm^3	0,4679 ± 0,0450
Bulk density to shrinkage	g/cm^3	0,1251 ± 0,0021
Bulk density after shrinkage	g/cm^3	0,1436 ± 0,0009
Porosity	-	0,6933
Porosity of the raw material layer	-	0,7326
Free volume layer	-	0,9073
Absorption coefficient	-	0,75 ± 0,017
Swelling coefficient	-	0

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Вивчення технологічних властивостей лікарської рослинної сировини Кермеку Гмеліна

(*Limonium Gmelinii)*

Копель Віолета, Барна Оксана, Пласконіс Юлія

Тернопільський національний медичний університет імені І.Я. Горбачевського,
м. Тернопіль, Україна

Address for correspondence:

Barna Oksana
E-mail: barna@tdmu.edu.ua

Анотація: в статті представлено результати вивчення технологічних властивостей лікарської рослинної сировини Кермека Гмеліна (*Limonium gmelinii),* а саме питомої, об'ємної та насипної густини, визначення коефіцієнта поглинання та показника набухання, а також пористість, порозність, вільний об'єм шару та фракційний склад. Об'єктом дослідження була подрібнена сировина з надземної частини Кермеку Гмеліна яка включала стебла, суцвіття, квіти. Кермек Гмеліна (*Limonium gmelinii*) – багаторічна трав›яниста гола рослина з роду кермекових, що містить дубильні речовини, флаваноїди, гідроксикоричні кислоти, антоціани, кумарини, вуглеводи, полісахариди, органічні кислоти, амінокислоти та ін. Сировина була заготовлена у Генічеському районі Херсонської області у 2021 році. Вивчення основних технологічних властивостей проводилося за загальноприйнятими методиками, які наведені у Державній фармакопеї України. Отриманні під час дослідження дані свідчать, що склад подрібненої сировини є полідисперсним і не можливо визначити одну переважаючу фракцію. Порядку 80 % складу складають частки з розміром 2,8-1,0 мм. Таку різноманітність складу можна пояснити тим, що досліджувана надземна частина рослинної сировини включає в себе товсте розгалужене стебло, суцвіття з дрібними правильними квітами. Вологість досліджуваної сировини становить 0,23 %. Питома густина сировина становить 1,3446±0,0073 г/см3, а об'ємна густина рослинної сировини становить 0,4679±0,0450 г/см^3. Насипний об'єм після усадки зменшився з 80 до 69, що у відсотках становить 13,75 %. Насипна густина після усадки зросла з 0,1251 г/см3 до 0,1436 г/см3. Показники пористості, порозності та вільного об'єму шару (0,6933 г/см^3, 0,7326 г/см^3, 0,9073 г/см^3 відповідно) є досить високі, що вказує на добру поглинаючу здатність сировини. Середнє значення коефіцієнта поглинання становило 6,33±0,34, що свідчить про великі затрати екстрагенту, а показник набухання показує, що досліджувана сировина не набухає, це свідчить про наявність пор всередині стебла, де затримується екстрагент, але не збільшується лінійні розміри і об›єми сировини. Експериментально визначено технологічні властивості сировини Кермеку Глеміна (*Limonium gmelini*i), які дають змогу обрати оптимальні методи екстрагування для досліджуваної сировини, а саме метод екстрагування, співвідношення сировина : екстрагент, природу екстрагента.

Ключові слова: Кермек Гмеліна (*Limonium gmelinii)*, лікарська рослинна сировина, технологічні властивості.