STUDY OF THE PHARMACOTECHNOLOGICAL PARAMETERS OF GINGER RHIZOMES FOR DEVELOPING THE CONDITIONS EXTRACTING OF EXTRACTIVE SUBSTANCES

Ilona Konovalenko, Anna Kriukova

National University of Pharmacy, Kharkiv, Ukraine

Introduction. Interest in natural biologically active compounds derived from medicinal plant raw materials is steadily increasing, driven by their undeniable advantages: gentle therapeutic action, low toxicity, absence of severe side effects, and complications [1].

Such compounds include biologically active substances (BAS) found in ginger rhizomes, which has long been used in traditional medicine across various countries and described in monographs of foreign pharmacopoeias and State Pharmacopoeia of Ukraine [2]. The main components of the chemical composition of medicinal ginger rhizomes, which contribute to its pharmacological activity, are phenolic compounds– gingerols and shogaols [3]. Ginger is employed as an anti-inflammatory agent for muscle pain, osteoarthritis, rheumatoid arthritis, and inflammatory joint conditions, which are common chronic ailments requiring long-term therapy [4, 5]. The anti-inflammatory effect of BAS in ginger rhizomes is mediated by selective inhibition of cyclooxygenase-2 (COX-2) enzymes and 5-lipoxygenase, which are responsible for the production of prostaglandins, prostacyclins, thromboxane, and leukotrienes [6, 7]. Unlike many non-steroidal anti-inflammatory drugs, ginger rhizomes compounds do not inhibit COX-1 [8].

Additionally, ginger rhizomes suppresses the synthesis of interleukin-1β and tumor necrosis factor-α, which are key modulators of the cartilage degradation process. Therefore, the development of a solid dosage form of dried extract from medicinal ginger is a relevant task.

The search for accessible, economically viable, and officially recognized medicinal plant raw materials that demonstrate the necessary pharmacological effects led to the identification of ginger rhizomes.

Everyday medical practice requires the implementation of methods that combine high effectiveness, safety, and accessibility. Phytotherapy is a form of medicinal auxiliary therapy that meets all these requirements. The goal of phytotherapy is to influence the self-regulation processes of the human body. Typically, treatment with herbal preparations has side effects, but in a smaller number and strength compared to drugs of synthetic origin, and their high therapeutic activity has been substantiated by the results of fundamental research conducted by Ukrainian and international pharmacologists. The results of research on the pharmaceutical market of drugs indicate that medicinal ginger is a universal plant and is represented on the pharmaceutical market of Ukraine as part of herbal preparations for the treatment of diseases of the digestive and respiratory organs, for the correction of excess weight, reduction of the urge to vomit and nausea, etc. But it is necessary to note the absence of medicines and dietary supplements of Ukrainian production based on ginger, which indicates the expediency and relevance of their development.

Purpose of the study

Research on the pharmacotechnological properties of ginger rhizomes, including physicochemical investigations and extraction methods aiming to efficiently extract biologically active substances, has been conducted.

Materials and Methods

The objects of the study are ginger rhizomes (manufacturer "Medagroprom", Dnipro). Research methods: information–search, information–analytical, physico–chemical, pharmacotechnological (specific weight, bulk density, apparent density, porosity, heterogeneity of the material, free volume of the layer, angle of repose, water absorption coefficient) [9, 10].

Results and Discussion

First stage of the research involved studying the particle size reduction of the medicinal plant raw material to determine the parameters for the technological processes. The intensification of the extraction process of biologically active substances directly depends on the particle size reduction of the raw material.

Table 1. Technological parameters of ginger rhizomes (n=5, P=95 %)

Parameter, dimension	Ginger rhizomes
Specific mass ($d_{п}$), g/cm^3	0.936 ± 0.125
Volumetric mass (d_{o}), g/cm^3	0.195 ± 0.075
Bulk mass ($d_{н}$), g/cm^3	0.435 ± 0.042
Humidity, %	9.2 ± 0.2
Porosity of raw materials (Pr)	0.123 ± 0.085
Porosity of layer (Pl)	0.457 ± 0.055
The free volume of the layer (V)	0.955 ± 0.113
Fluidity, sec/100.0 g	49.37 ± 3.15
Angle of natural slope, degree	33.7 ± 0.35
Coefficient of water absorption (Cw)	1.55 ± 0.03

An important step in the development of a herbal medicinal product is the comminution of the raw material, which involves damaging its structure and increasing the surface area to enhance extraction [11, 12]. As a result of

DOI: 10.5281/zenodo.10256701

comminution, cell components are exposed, and during extraction, their contents are leached out by the extractant. The use of a rotor knife mill, such as the PM-250, ensured particle uniformity.

The next stage of the investigation of the plant raw material involved studying the technological parameters, including specific weight, bulk density, apparent density, porosity, heterogeneity, free volume of the layer, flowability, angle of repose, and water absorption coefficient.

The results of determining the technological parameters of the investigated raw material are presented in table 1.

The conducted technological studies confirmed that the studied raw material is characterized by a high value of bulk mass and high diversity. In the pharmaceutical and industrial conditions of the production of herbal preparations, raw materials with a high bulk mass and high variance must be compacted into the extractor during loading.

The studied raw material had low porosity. This indicator indicates that less internal juice will be formed during the swelling during the extraction process and there is a need to intensify the extraction of biologically active substances.

An important parameter that is taken into account to ensure uniform mixing of medicinal plant raw materials and the extractant is the volumetric weight. This indicator in the studied raw material had a value within 0.195 g/cm^3. This is due to the fact that ginger rhizomes occupy a large volume due to their structure.

The free volume of the layer for ginger rhizomes had high values, which shows the need to use larger volumes of the extractant to wet the medical plant material (MPM) and compact it when loading it into the extraction device.

The difference between the specific and volumetric weight shows that the raw material occupies a large volume, as a result of which it is necessary to take into account when calculating the ratio of MPM and the finished product, choosing the size of the extractor, the features of loading the raw materials, etc.

The water absorption coefficient was 1.55. This indicator is an important characteristic when calculating the amount of extractant in the subsequent production of liquid extract.

The determined indicators are qualitative parameters of the technology and allow to control and evaluate the technological parameters of the preparation of the dry extract.

One of the important stages in the complex of research in the creation of new drugs is the substantiation of rational extraction modes [13]. The first stage in the development of a dry extract is the production of a liquid extraction from MPM. Since the dry extract being developed is a solid medicinal form that is used in medical practice in the form of infusions, decoctions or herbal teas, the substantiation of the optimal conditions for the production of both the dry extract itself and water extracts from it should be based on a complex of pharmacotechnological studies.

The process of obtaining an extract from medicinal plant raw materials is focused on the maximum yield of biologically active substances. Since the extraction of BAS from MPM cells occurs due to extraction, it was expedient to study the influence of various pharmaceutical factors on the yield of extractive substances [14].

The completeness and speed of extraction of medicinal plant raw materials by the extractant are affected by such factors as the type of extractant, time (duration) of extraction, temperature and dispersion of particles (degree of grinding) of the raw material, which characterizes the extraction surface [15]. The key factor that characterizes the extraction efficiency is the extraction mode.

At the first stage of research, it was necessary to determine the type of extractant and the temperature regime of extraction. Purified water and 40 % ethyl alcohol were used as an extractant. The completeness of extraction was determined by the quantitative content of extractive substances and qualitative reactions to groups of biologically active substances.

In order to study the influence of pharmaceutical factors on the release of extractive substances from medicinal plant raw materials, a fraction with a grinding degree of 1–3 mm was studied, which was ground on a grater, after which the raw materials were dried and sieved through sieves No. 1–5.

Extraction was carried out at a standard ratio of raw material: extractant 1:10. The extraction time at this stage was set at 15 minutes. The extraction temperature varied from 50 °C to 90 °C in steps of 10 °C (table 2).

Table 2. Dependence of the yield of extractive substances on the type of extractant and temperature regimes of extraction of ginger rhizomes (n=5, P=95 %)

Ratio of raw materials: extract agent	Extraction temperature, °C	Extraction time, min	Extractives, %	
			purified water	ethanol 40 %
1:10	50	15	10.2 ± 0.1	8.7 ± 0.2
	60		10.9 ± 0.2	9.3 ± 0.2
	70		11.8 ± 0.1	10.5 ± 0.1
	80		12.1 ± 0.1	11.8 ± 0.1
	90		14.3 ± 0.1	13.8 ± 0.2

Based on the results of the study, it was determined that the optimal temperature for extracting ginger rhizomes is 90 °C. Extraction with purified water and 40 % ethanol showed satisfactory results.

The next stage was the intensification of the extraction process depending on the extractant:raw

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material ratio and the time of extraction in a water bath followed by cooling to room temperature. Purified water at an extraction temperature of 90 °C was used as an extractant.

According to the generally accepted technology of water extraction, raw materials were placed in a heated infuser, poured with purified water at room temperature in the ratio of 1:5, 1:10, 1:15 and 1:20, taking into account the water absorption coefficient determined by us (Cw=1.55), infused in a boiling water bath, left for further cooling at room temperature. Then the resulting infusion was filtered, bringing the total volume of the water extract with MPM and purified water to the required volume. Infusion in a water bath was carried out for 15, 30, 45, 60 and 180 minutes, infusion until cooling - 30 minutes.

Table 3. The dependence of the extractives level and dry residue on the extraction time and the ratio of raw materials: ginger rhizome extract (n=5, P=95 %)

Ratio of raw materials: extract agent	Extraction time in a water bath, min				
	15	30	45	60	180
Dry residue content, %					
1:5	3.05 ± 0.01	3.48 ± 0.01	3.85 ± 0.01	4.02 ± 0.01	4.56 ± 0.01
1:10	4.01 ± 0.02	4.36 ± 0.01	4.85 ± 0.02	**5.08 ± 0.02**	**5.21± 0.02**
1:15	3.74 ± 0.01	4.03 ± 0.02	4.25 ± 0.01	4.69 ± 0.01	5.01 ± 0.01
1:20	3.27 ± 0.02	3.65 ± 0.02	4.12 ± 0.02	4.58 ± 0.02	4.98 ± 0.02
Content of extractive substances, %					
1:5	13.8 ± 0.1	14.2 ± 0.1	14.9 ± 0.1	15.8 ± 0.1	16.2 ± 0.2
1:10	15.5 ± 0.2	16.1 ± 0.1	16.8 ± 0.2	**17.5 ± 0.2**	**18.3 ± 0.2**
1:15	13.9 ± 0.1	14.9 ± 0.2	15.7 ± 0.1	16.7 ± 0.1	17.5 ± 0.2
1:20	13.3 ± 0.2	14.7 ± 0.1	15.3 ± 0.2	15.5 ± 0.1	16.4 ± 0.1

The results of the study of the dependence of the content of the dry residue and the level of extractives from ginger rhizomes on the time of extraction, the ratio of raw materials: extractant and extractant purified water at an extraction temperature of 90 °C are shown in table 3 and figure 1.

It was experimentally established that increasing the time of infusion in a water bath from 60 to 180 min leads to an increase in the content of both extractive substances and dry residue in the liquid extract, which leads to the intensification of the extraction process. The ratio of raw materials and extractant (purified water) is advisable to take 1:10, since increasing the ratio does not lead to extraction efficiency.

In this way, the maximum level of extractives is ensured when obtaining a liquid extract with a raw material particle size of 1–3 mm, a ratio of raw materials and extractant – 1:10, extraction for 60–180 min at a temperature of 90 ± 5 °C, infusion until cooling – 30 min .

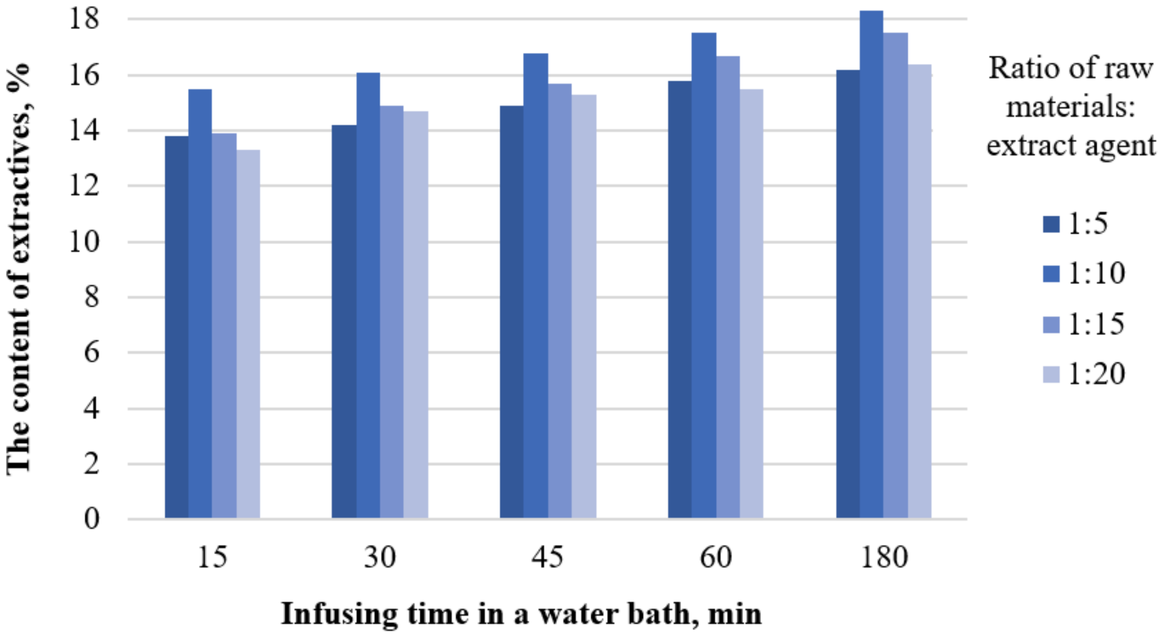

Fig. 1: Dependence of the level of extractives on the mode of ginger rhizomes extraction (n=5, P=95 %)

Parallel studies on the selection of an effective extractant obtained liquid extracts from ginger rhizomes using ethanol as an extractant in concentrations of 40 % and 70 % by two methods of extraction: maceration and percolation.

DOI: 10.5281/zenodo.10256701

Extraction was carried out under the same conditions, namely, by the standard method of maceration in 40 and 70 % ethanol, using crushed and unsifted ginger rhizomes with a particle size of 1–3 [16]. The volume of ethanol was determined taking into account the absorption coefficient of the extractant. Crushed raw materials were infused for 7 days at a temperature not exceeding 25 °C and a ratio of raw materials: finished product of 1:10, settling was carried out at a temperature of 8–10 °C for 48 hours. in order to sediment ballast substances, the settled product was decanted, filtered and adjusted to the required volume with ethanol. When substantiating the extraction parameters by the percolation method, which was carried out in a laboratory filtration extractor, each sample was taken fractionally with a step of DER 1:1 (drug extract ratio – the ratio of the starting material and the obtained extract). 50.0 g of crushed raw materials were loaded into the extractor, he extractant was fed to the "mirror" and infused for 24 hours. After infusion, percolation was performed at a rate of 3–4 ml/min. Extract samples were collected separately with a step of DER 1 : 1. The extraction was carried out until the total extract of DER 1 : 10 was obtained. In each of the hoods, the amount of dry residue was examined using a Sartorius MA-150 moisture analyzer (Germany), and the yield of extractives was calculated based on the obtained data substances during the entire extraction process for each type of raw material. In order to determine the optimal conditions for the extraction of raw materials for each of the experiments, the dependence of the main criteria of the efficiency of the extraction process on the change in the "raw material: extract" ratio was calculated.

The extraction process was controlled by determining the quantitative content of extractive substances in the obtained samples. The results are shown in table 4.

Thus, extraction with 40 % ethanol provides better extraction efficiency of BAS from plant raw materials when using the percolation method.

Table 4. Dependence of the extractives level on the ethanol concentration, the ratio of raw materials: extractant and the type of extraction of ginger rhizomes (n=5, P=95 %)

Ratio of raw materials: extract agent	Extract agent	
	40 % ethanol	70 % ethanol
maceration		
1:5	13.8 ± 0.1	11.7 ± 0.1
1:10	**14.8 ± 0.2**	12.8 ± 0.1
1:15	14.5 ± 0.2	12.3 ± 0.1
1:20	14.1 ± 0.1	11.9 ± 0.1
percolation		
1:5	15.6 ± 0.2	14.2 ± 0.1
1:10	**16.2 ± 0.1**	14.5 ± 0.2
1:15	15.7 ± 0.1	14.1 ± 0.2
1:20	15.5 ± 0.2	13.9 ± 0.1

It should be noted that maceration is not an efficient, cost-effective method, and at the same time it is time-consuming, and the percolation method requires industrial capacities. At the same time, ethanol, as an extractant, is not an economically beneficial solvent compared to purified water. Therefore, according to the results of the study, purified water was selected as an extractant for the preparation of liquid ginger rhizome extract.

Conclusions

1. The main technological parameters of the medicinal plant raw material were determined, which confirmed that the ginger rhizomes are characterized by high values of porosity, free volume of the layer, bulk mass and low porosity of the raw material.
2. On the basis of pharmacotechnological studies, the influence of extraction parameters was studied. It was determined that the optimal mode of extraction of the aqueous extract is infusion in a water bath (water temperature - 90 °C) for 60 minutes, infusion at room temperature until cooling - 30 minutes at a ratio of raw materials: extractant 1:10.

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conducted technological studies confirmed that the studied raw material is characterized by a high value of bulk mass and high diversity. Volumetric weight in the studied raw material had a value within 0.195 g/cm^3. Free volume of the layer for ginger rhizomes had high values, which shows the need to use larger volumes of the extractant to wet the MPM and compact it when loading it into the extraction device. The difference between the specific and volumetric weight shows that the raw material occupies a large volume, as a result of which it is necessary to take into account when calculating the ratio of MPM and the finished product, choosing the size of the extractor, the features of loading the raw materials, etc. The water absorption coefficient was 1.55. This indicator is an important characteristic when calculating the amount of extractant in the subsequent production of liquid extract. The maximum level of extractives is ensured when obtaining a liquid extract with a raw material particle size of 1–3 mm, a ratio of raw materials and extractant – 1:10, extraction for 60–180 min at a temperature of 90 ± 5 °C, infusion until cooling – 30 min. Maceration is not an efficient, cost-effective method, and at the same time it is time-consuming, and the percolation method requires industrial capacities. At the same time, ethanol, as an extractant, is not an economically beneficial solvent compared to purified water. **Conclusions.** The main technological parameters of the medicinal plant raw material were determined, which confirmed that the ginger rhizomes are characterized by high values of porosity, free volume of the layer, bulk mass and low porosity of the raw material. On the basis of pharmacotechnological studies, the influence of extraction parameters was studied. It was determined that the optimal mode of extraction of the aqueous extract is infusion in a water bath (water temperature – 90 °C) for 60 minutes, infusion at room temperature until cooling - 30 minutes at a ratio of raw materials: extractant 1:10.
Keywords: ginger rhizomes, pharmacotechnological properties, extraction.

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DOI: 10.5281/zenodo.10256701