DETERMINATION OF SOME NUMERICAL INDICATORS OF DIFFERENT TYPES OF PLANT RAW MATERIALS OF *ONOPORDUM ACANTHIUM* L.

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Introduction. Today, the popularity of phytochemical research continues to rise [1, 2]. Plants of the Asteraceae family have attracted considerable attention [3, 4].

The genus Onopordum of the Asteraceae family includes over 50 species [5], which are widespread in Eurasia, northern Africa and are invasive in North America. The chemical composition and biological properties of the plant raw material of *Onopordum acanthium* have been most extensively studied [5].

Plant raw material of *Onopordum acanthium* contains soluble sugars, inulin, proteins, fatty oil, saponins, sesquiterpene lactones, triterpenes, sterols, phenolic compounds (phenolcarboxylic acids, coumarins, flavonoids, tannins) and alkaloids. Extracts from plant raw material have traditionally been used as a bactericidal, cardiotonic, hemostatic, and diuretic agent, for the treatment of nervousness, as an antitumor agent, and for the treatment of inflammation of the bladder, respiratory, and urinary systems. Pharmacological studies have shown that *Onopordum acanthium* has antibacterial, antioxidant, anticancer, anti-inflammatory, analgesic, antipyretic, hypotensive, antiepileptic, wound healing, xanthine oxidase and ACE inhibitory effects (Fig. 1) [6-10].

Iranian researchers studied the morphological, phytochemical, and biological properties of the roots, stems, leaves, flowers, and fruits of *Onopordum acanthium*. At the same time, the composition of phenolic compounds, antioxidant, enzyme-inhibiting, hypoglycemic, antisclerotic, antimicrobial and genotoxic effects were established. This made it possible to position *Onopordum acanthium* as a promising natural source of phenolic compounds, which is promising for the creation of phytomedicines in the therapy of oxidative stress, diabetes and neurodegenerative disorders [11].

Thus, in the seeds of *Onopordum acanthium*, the quantitative content of total phenols was determined by the reagent of Folin–Ciocalteu in terms of gallic acid, and antibacterial activity of hexane and methanol extracts from this type of plant raw material was established in vitro, which makes it possible to predict the same activity in vivo [12, 13].

Other species in the genus also attract researchers' attention. Thus, the effect of various drying methods (room, microwave, convective, air, and freeze-drying) on the chemical composition and microbiological activity of aqueous extracts of *Onopordum nervosum* flowers has been studied. Their effects on milk coagulation and antioxidant activity have been established in both wild and cultivated plants [14].

Italian scientists studied the role of the enzyme onopordin from the flowers of *Onopordum platylepis* in the production of sheep's milk cheeses. Overall, the results obtained indicated the prospects for using this plant raw material as a new source of coagulant [15].

It is believed that the nutritional properties of *Onopordum acanthium* (unripe anthodium as artichoke substitutes and seeds as a source of fatty oil (up to 35%)) are not of significant value. At present, the plant has significant biomass and excellent drought resistance, and is promising for green energy applications. Solid fuel in the form of pellets is obtained from the shoots of *Onopordum acanthium*, and the so-called biodiesel is obtained from the seeds of this plant using a patented method. That is, the plant raw material of *Onopordum acanthium* as a source of several types of biofuels has significant potential [16].

We conducted marketing research on domestic producers of *Onopordum acanthium* plant raw materials (grass, flowers and fruits are available) and dietary supplements with extracts from this plant [17, 18].

The aim is to determine the quantitative content of total polyphenols, total hydroxycinnamic acids and total flavonoids in Onopordum acanthium plant raw materials of different phenological phases, what is harvested in Ukraine.

Materials and methods

Plant raw materials were harvested in the corresponding phases of vegetation from wild specimens of *Onopordum acanthium* in the summer of 2025 in the village of Velyka Babka, Chuhuyiv district, Kharkiv region (49.98167; 36.74639) (series 1), the village of Trybusivka, Tulchyn district, Vinnytsia region (48.18500; 28.66306) (series 2) and on the outskirts of Nizhyn, Chernihiv region (51.04278; 31.87361) (series 3). Leaves and stem before the beginning of flowering in the vegetative phase (May), stem leaves and stem in the mass flowering phase (June), fruits in the mass fruiting phase (July) with subsequent air-shade drying.

The quantitative content of total polyphenols in terms of pyrogallol and absolutely dry plant raw materials was determined according to the method of the State Pharmacopoeia of Ukraine (SPhU) 2.0 monograph "Millefolii herba^{N}"[19].

Initial solution. 1000.0 mg of powdered raw material (355) (2.9.12) is placed in a 250 ml round-bottom flask, 150 ml of water R is added, heated for 30 min in a water bath, cooled under running water and quantitatively transferred to a 250 ml volumetric flask. The round-bottom flask is rinsed with water R, the washings are transferred to a volumetric flask and the volume of the solution is adjusted to 250.0 ml with water R. The precipitate is allowed to settle and the liquid is filtered through filter paper with a diameter of 125 mm, discarding the first 50 ml of the filtrate.

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5.0 ml of the resulting filtrate is adjusted to a volume of 25.0 ml with water R. To 2.0 ml of the resulting solution add 1.0 ml of phosphorus molybdenum-tungsten reagent R (P0648, DP UKRNDNC) , 10.0 ml of water R, stirring after each addition, and make up to 25.0 ml with sodium carbonate solution R (AR CAS 497-19-8, AllChim). After 30 min, measure the optical density (2.2.25) of the solution at a wavelength of 760 nm, using water R as a compensation liquid.

Test solution. Immediately before the test, dissolve 50.0 mg pyrogallol (TU 6-095319-86) in water R and make up to 100.0 ml with the same solvent. Make up to 100.0 ml with water R.

Compensation solution. To 2.0 ml of the resulting solution, add 1.0 ml of phosphorus-molybdenum-tungsten reagent R and 10.0 ml of water R, stirring after each addition, and make up to 25 ml with sodium carbonate solution R. After 30 min, measure the optical density (2.2.25) of the solution at a wavelength of 760 nm, using water R as a compensation liquid.

The content of the sum of polyphenols, expressed as pyrogallol, in percent, is calculated by the formula:

$$\frac{62.5 \times A_1 \times m_2 \times P}{A_0 \times m_1 \times 100},$$

where:

A_i - the optical density of the test solution,

A_0 - the optical density of the reference solution,

m_1 - the mass of the test raw material, in mg,

m_2 - the mass of the test raw material, in mg,

P - the pyrogallol content in the pyrogallol raw material, in %.

The quantitative content of total hydroxycinnamic acids in terms of chlorogenic acid – according to the method of the monograph SPhU 2.0 "Urticae folium"[19].

Initial solution. 1.5 g (accurate weight) of the powdered plant raw material (350) (2.9.12) places in a 200 ml flask, add 90 ml of ethanol (50 %, v/v) R (ALFA Lux 96, Ukraine, 95 %), heat under reflux on a water bath for 30 min, cool to room temperature and filter into a 100 ml volumetric flask through a cotton swab. Wash the swab with 10 ml of 50% (v/v) ethanol (R) and filter the washings into the same volumetric flask. Make up the volume with ethanol (50 %, v/v) R to mark and mix. Filter the resulting solution through a blue ribbon filter paper, discarding the first 15 ml of the filtrate.

Test solution. 1.0 ml of the stock solution place in a 10 ml volumetric flask, add successively, stirring after each addition, 2 ml of a 0.5 M hydrochloric acid solution (ACS, Heneywell Resarch Chemicals, REALAB, 37 %), 2 ml of a freshly prepared solution of 10 g of sodium nitrite R (BASF MyChem, 99,5 %) and 10 g of sodium molybdate R (hlr, 99,12%) in 100 ml of water R, 2 ml of dilute sodium hydroxide solution R (AllChim, 98,0 %), make up to the mark with water R and mix.

Compensation solution. 1.0 ml of the stock solution is placed in a 10 ml volumetric flask, and successively add 2 ml of a 0.5 M hydrochloric acid solution and 2 ml of dilute sodium hydroxide solution R, stirring after each addition, then make up to the mark with water R and mix.

Immediately measure the optical density (2.2.25) of the test solution at 525 nm in a 10-mm-thick cuvette, using the compensation solution as the reference.

The content of total hydroxycinnamic acids, expressed as chlorogenic acid, in percent, is calculated by the formula:

$$\frac{A \times 1000}{188 \times m},$$

where:

A – is the optical density of the test solution at a wavelength of 525 nm;

m – is the mass of the test sample, in grams.

The specific absorption index of chlorogenic acid, which is 188, is used.

Total flavonoids in terms of hyperoside according to the method of the monograph SPhU 2.0 "Betulae folium" [19].

Initial solution. 0.200 g of the powdered plant raw material (355) (2.9.12) place in a 100-ml round-bottomed flask, add 1 ml of a 5 g/l solution of hexamethylenetetramine R (art X0163028, Thermo Fisher Scientifia), 20 ml of acetone R and 2 ml of hydrochloric acid R1(ACS, Heneywell Resarch Chemicals, REALAB, 37 %), boil under reflux for 30 min and filter through a cotton swab into a 100-ml flask. Add the cotton swab to the residue in the round-bottomed flask and extract in 2 portions, 20 ml each, of acetone R (art 100070697, ChimReactive), each time boiling under reflux for 10 min, cool to room temperature, filter each extract through a cotton swab into the flask. The resulting cooled combined acetone extracts are filtered through a paper filter into a volumetric flask, the volume of the solution is adjusted to 100 ml with acetone R, rinsing the flask and the paper filter. 20.0 ml of the resulting solution place in a separating funnel, add 20 ml of water R and extract the mixture with 15 ml, and then with 3 portions, each of 10 ml, of ethyl acetate R (art.0028, >99,5 %, AllChim). The resulting ethyl acetate extracts are combined in a separating funnel, washed with 2 portions, each of 50 ml, of water R, filtered over 10 g of anhydrous sodium sulfate R (>98 %, AllChim) into a 50 ml volumetric flask and the volume of the solution is adjusted to 50.0 ml with ethyl acetate R.

Test solution. To 10.0 ml of the stock solution add 1 ml of aluminium chloride reagent R and make up to 25.0 ml with a 5 % (v/v) solution of glacial acetic acid R (>99,9 %, Agua Oxide) in methanol R (>99,5 %, EMPLURA, Merck).

Compensation solution. Make up to 25.0 ml with a 5 % (v/v) solution of glacial acetic acid R in methanol R.

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Measure the optical density (2.2.25) of the test solution after 30 min in comparison with the compensation solution at a wavelength of 425 nm.
The content of total flavonoids, in terms of hyperoside, in percent, is calculated by the formula:

$$\frac{A \times 1.25}{m},$$

where:
A – is the optical density of the test solution at a wavelength of 425 nm,
m – is the mass of the test raw material, in grams.
The specific absorption index of hyperoside, equal to 500, is used.

Results and discussion.

The results of the study are given in the table.

The results obtained for determining the quantitative content of each BAS group are comparable across the plant raw material series.

For all types of plant raw materials and all series, the following pattern is observed: the content of total polyphenols>the content of total flavonoids>the content of total hydroxycinnamic acids.

The highest content of BAS is observed in the leaves in the mass flowering phase: the content of total polyphenols in terms of pyrogallol is the highest of the determined groups of compounds and ranges from 7.14 ± 0.02 % (series 3) to 7.85 ± 0.02 % (series 2); the content of total hydroxycinnamic acids in terms of chlorogenic acid is 1.05 ± 0.01 % (series 3) – 1.54 ± 0.01 % (series 2). The content of total flavonoids in terms of hyperoside ranges from 4.14 ± 0.01 % (series 1) to 5.02 ± 0.021% (series 2).

Table. Quantitative content of different groups of phenolic compounds in plant raw materials of different phases of vegetation and places of collection (%, P>0,95, n=5)

The object studied	Quantitative content		
	total polyphenols in terms of pyrogallol	total hydroxycinnamic acids in terms of chlorogenic acid	total flavonoids in terms of hyperoside
Series 1			
Leafy stem in the vegetative phase before flowering	2.17 ± 0.01	0.10 ± 0.01	1.03 ± 0.01
Stem leaves in the mass flowering phase	7.25 ± 0.02	1.15 ± 0.01	4.14 ± 0.01
Stem in the mass flowering phase	3.78 ± 0.02	0.12 ± 0.01	2.12 ± 0.01
Fruits in the mass fruiting phase	4.45 ± 0.01	3.05 ± 0.02	0.80 ± 0.01
Series 2			
Leafy stem in the vegetative phase before flowering	3.05 ± 0.02	0.15 ± 0.01	1.76 ± 0.01
Stem leaves in the mass flowering phase	7.85 ± 0.02	1.54 ± 0.01	5.02 ± 0.01
Stem in the mass flowering phase	4.15 ± 0.02	0.98 ± 0.01	2.45 ± 0.02
Fruits in the mass fruiting phase	4.78 ± 0.01	2.78 ± 0.01	0.96 ± 0.01
Series 3			
Leafy stem in the vegetative phase before flowering	2.84 ± 0.01	0.75 ± 0.01	1.14 ± 0.01
Stem leaves in the mass flowering phase	7.14 ± 0.01	1.05 ± 0.01	4.86 ± 0.01
Stem in the mass flowering phase	3.97 ± 0.02	1.65 ± 0.01	2.01 ± 0.02
Fruits in the mass fruiting phase	4.05 ± 0.02	2.56 ± 0.01	0.78 ± 0.01

Conclusions

For the first time in domestic series of a number of types of plant raw materials of *Onopordum acanthium* from different places of collection, the quantitative content of total polyphenols, total hydroxycinnamic acids and total flavonoids was determined. The dynamics of the accumulation of each group of BAS was traced depending on the

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vegetation phase and place of growth. The lower limits of the quantitative content of each group of BAS in each type of plant raw material were also established. The most attractive in this regard are leaves in the mass flowering phase, for which the content of total polyphenols was not lower than 7.1 %, total hydroxycinnamic acids was not lower than 0.54 %, total flavonoids – not lower than 4.15 %.

Prospects for further research

Given the promising nature of the study of plant raw materials containing phenolic carboxylic acids, in particular hydroxycinnamic acids, due to aspects of their biological activity [20, 21], it is advisable to conduct a systematic in-depth study of plant raw materials (root, leaves, stem, baskets, fruits) of *Onopordum acanthium* as sources of these biologically active compounds with a relevant pharmacological action.

Conflict of interest: none.

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Determination of some numerical indicators of different types of plant raw materials of *Onopordum acanthium* L

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Introduction. Today, the popularity of phytochemical research continues to rise. Plants in the family Asteraceae have attracted considerable attention. The genus Onopordum of the Asteraceae family includes over 50 species, which are widespread in Eurasia, northern Africa and are invasive in North America. The chemical composition and biological properties of the plant raw material of *Onopordum acanthium* have been most extensively studied. Plant raw material of *Onopordum acanthium* contains soluble sugars, inulin, proteins, fatty oil, saponins, sesquiterpene lactones, triterpenes, sterols, phenolic compounds (phenolcarboxylic acids, coumarins, flavonoids, tannins) and alkaloids. Extracts from plant raw material have traditionally been used as a bactericidal, cardiotonic, hemostatic and diuretic agent, for the treatment of nervousness, as an antitumor agent, and for the treatment of inflammation of the bladder, respiratory and urinary systems. We conducted marketing research on domestic producers of *Onopordum acanthium* plant raw materials (grass, flowers and fruits are available) and dietary supplements with extracts from this plant. **The aim** is to determine the quantitative content of total polyphenols, total hydroxycinnamic acids and total flavonoids in *Onopordum acanthium* plant raw materials of different phenological phases of harvesting. **Materials and methods.** Plant raw materials were harvested in the corresponding phases of vegetation from wild specimens of *Onopordum acanthium* in the summer of 2025 in the village of Velyka Babka, Chuhuyiv district, Kharkiv region (series 1), the village of Trybusivka, Tulchyn district, Vinnytsia region (series 2) and on the outskirts of Nizhyn, Chernihiv region (series 3). Leaves and stem before the beginning of flowering in the vegetative phase (May), stem leaves and stem in the mass flowering phase (June), fruits in the mass fruiting phase (July) with subsequent air-shade drying. The quantitative content of total polyphenols in terms of pyrogallol, of total hydroxycinnamic acids in terms of chlorogenic acid, and of total flavonoids in terms of hyperoside was determined according to the method of the State Pharmacopeia of Ukraine (SPhU) 2.0. **Results and discussion.** The results obtained for determining the quantitative content of each BAS group are comparable across the plant raw material series. For all types of plant raw materials and all series, the following pattern is observed: the content of total polyphenols>the content of total flavonoids>the content of total hydroxycinnamic acids. The highest content of BAS is observed in the leaves in the mass flowering phase: the content of total polyphenols in terms of pyrogallol is the highest of the determined groups of compounds and ranges from 7.14 ± 0.02 % (series 3) to 7.85 ± 0.02 % (series 2); the content of total hydroxycinnamic acids in terms of chlorogenic acid is 1.04 ± 0.01 % (series 3) – 1.54 ± 0.01 % (series 2). The content of total flavonoids in terms of hyperoside ranges from 4.13 ± 0.02 % (series 1) to 5.02 ± 0.02 % (series 2). **Conclusions.** For the first time in a domestic series of a number of types of plant raw materials of *Onopordum acanthium* from different places of collection, the quantitative content of total polyphenols, total hydroxycinnamic acids, and total flavonoids was determined. The dynamics of the accumulation of each BAS group were traced according to the vegetation phase and growth location. The lower limits of the quantitative content of each group of BAS in each type of plant raw material were also established. The most attractive in this regard are leaves in the mass flowering phase, for which the content of total polyphenols was not lower than 7.1 %, total hydroxycinnamic acids was not lower than 0.54 %, and total flavonoids were not lower than 4.15 %.

***Keywords**: Onopordum acanthium*, leaves, steam, fruits, polyphenols, hydroxycinnamic acids, and flavonoids

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