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HIGH-QUALITY ANALYSIS OF DRY EXTRACT OF PRICKLY ARTICHOKE RAW MATERIAL (CYNARA SCOLYMUS L.) CULTIVATED IN UZBEKISTAN

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The aim. *Artichoke plants are increasingly cultivated in Uzbekistan, where there is growing interest in their raw materials for potential applications within the pharmaceutical industry. This exploration aims to evaluate the feasibility and advantages of integrating components derived from artichokes into pharmaceutical formulations, focusing on their recognized medicinal properties and the possible economic benefits that could arise from such innovations.*

Materials and methods. *For the creation of highly effective preparations on the basis of artichoke raw material (Cynara scolymus L.) cultivated in Uzbekistan, qualitative and quantitative analysis of some biologically active substances contained in the raw material was carried out, as well as a comparative assessment of their accumulation in the plant growing in different climatic conditions. During qualitative analysis of artichoke prickly raw material cultivated in Uzbekistan, identified important biologically active substances such as phenolic compounds, oxycinnamic acids and flavonoids, tannins, amino acids, and ascorbic acid.*

Results. *The quantitative analysis conducted on artichoke raw material revealed a notably high concentration of several biologically active compounds. Specifically, the study identified significant levels of chlorogenic acid, which is known for its antioxidant properties; cynaroside, recognized for its potential health benefits; riboflavin, an essential vitamin; caffeine, a stimulant; and caffeic acid, another potent antioxidant. These findings underscore the nutritional value and potential therapeutic applications of artichoke.*

Conclusions. *The artichoke prickly (Cynara cardunculus) is notable for its significant accumulation of essential bioelements, including sodium, potassium, calcium, and magnesium. These minerals are present in high concentrations within the plant's raw material, suggesting that it possesses valuable medicinal properties. The therapeutic potential of these elements enhances the appeal of an artichoke prickly as a promising source for medicinal applications*

Keywords: *artichoke, cynaroside, bioelements, hepatoprotective agents, extract of artichoke, caffeine, flavonoid*

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1. Introduction

Plant remedies have been integral to medicine since the inception of disease treatment, with historical records indicating their use for thousands of years [1, 2]. The therapeutic applications of plant-derived preparations are well-documented, showcasing mankind's reliance on nature for healing [3, 4]. In contemporary times, the exploration of the pharmacological properties of various medicinal plants, their extracts, and individual bioactive compounds has gained significant traction within the scientific community [5, 6]. This research is crucial as it not only validates traditional practices but also uncovers new therapeutic potentials that may surpass those offered by synthetic pharmaceuticals [7, 8].

The cultivation of medicinal plants in diverse geographical regions presents an opportunity to ensure a steady supply of raw materials tailored to local healthcare needs. In Uzbekistan, for instance, there is a pressing need to establish a robust base for hepatoprotective agents derived from local flora [9, 10]. Among these efforts, the introduction and cultivation of artichoke prickly (Cynara cardunculus) have emerged as particularly relevant due to its documented health benefits and potential efficacy in liver protection [11, 12].

However, the development of medicines from these plant sources is fraught with challenges, primarily concerning quality control and standardization. Ensuring that herbal products meet specific safety and efficacy standards is essential for their acceptance in modern medicine [13, 14]. This complexity underscores the necessity for rigorous scientific evaluation and regulatory frameworks to support the integration of plant-based therapies into conventional healthcare systems.

Aim of the research. Artichoke plants are cultivated in Uzbekistan, and there is interest in exploring the potential use of their raw materials in the pharmaceutical industry. This topic aims to assess the viability and benefits of incorporating artichoke plant components into pharmaceutical products, considering their medicinal properties and potential economic impact.

2. Planning (methodology) of research

1. Selection of an extractant to obtain a dry extract from artichoke raw material.

2. TLC analysis for the identification of biologically active substances in a dry extract based on prickly artichoke raw materials (Cynara scolymus L.).

3. Quantitative determination of biologically active substances using spectrophotometry and HPLC methods.

4. Analysis of minerals in the dry extract by ICP-MS.

3. Materials and methods

This study was conducted from 2022 to 2023, focusing on high-quality analysis of dry extract from prickly artichoke raw material cultivated in Morocco, Russia and Uzbekistan.

The following equipment and materials were used in this study: Agilent Technologist 1100 series instrument (Agilent Technologies Inc., USA) with degassers G1322A and G1379A, and variable wavelength spectrophotometric detector VWD G1314, solvent pump 1311A, autosampler G1313A, column thermostat G1316A, diode matrix detector DAD G 1315B; Zorbax Agilent Eclipse XDB-C8 columns (4.6×250 mm and 2.1×12.5 mm); Filtrak-FN 18 paper, Agilent 6890 N instrument with flame ionization detector, 30 mm capillary column, ICP-MS (inductively coupled plasma mass spectrometer) AT 7500a instrument, Perkin-Elmer IR spectrometer, model 2000, PC-6 refrigerated centrifuge, T 339 amino acid analyzer (Microtechna- Prague) with software control, 3.7×45 cm column (Ostion LG ANB), SF-46 spectrophotometer; Supelco Discovery HS C18 columns (4.6×75 mm and 4.0×20 mm), silufol and silica gel plates, Filtrak-FN 18 paper.

TLC was performed on Filtrak-FN 18 paper in the solvent system butanol-1-pyridine-water (6:4:3) (system1). Acidic aniline phthalate (developer 1) and 5 % urea solution (developer 2) were used for stain identification. Chromatograms were developed at 105–110 °C.

The elemental composition of mineral substances was analyzed on the device ICP-MS (inductively coupled plasma mass spectrometer) AT 7500a. Instrument parameters: plasma power 1200 W, integration time 0.1 sec, peristaltic pump rotation speed – 0.1 r/sec. A multi-element (27 component) standard solution with the content of target components 1.0 mg/l was used as a standard.

For qualitative identification of the main active BAS, the dry extract was dissolved in purified water in a mass-volume ratio of 1:10 and slightly heated in a water bath until complete dissolution of the powder.

Qualitative detection of oxycinnamic acids was carried out by BC method, 2 % acetic acid solution was used as mobile phase. The chromatogamma was air dried and viewed under UV light. Under UV light, blue fluorescence was evident indicating the presence of oxycinnamic acids.

Detection of flavonoids was carried out with caustic soda. To 1 ml of aqueous solution of dry extract prepared as described above, a few drops of caustic soda solution were added. The appearance of yellow coloration was observed.

When adding a few drops of iron-ammonium alum to 1 ml of the solution under study, dark green coloring appeared, indicating the presence of tannins.

Quantitative determination of the sum of oxycinnamic acids in terms of chlorogenic acid was carried out by SF-method. The exact weight of the dry sample (0.08825 g) was dissolved in 50 ml of 50 % ethyl alcohol (solution A). From solution A 0.5 ml was taken into a 25 ml volumetric flask and the volume of the flask was brought to the mark with 50 % ethyl alcohol. The optical density of the solution was measured on a spectrophotometer SF-46 at a wavelength of 329±2 nm. The reference solution was 50 % ethyl alcohol.

In parallel, the optical density of the solution of the working standard sample (WSS) of chlorogenic acid was measured under similar conditions. For this purpose, a precise sample (0.00700 g) of chlorogenic acid was transferred into a 50 mL flask and dissolved with 50 % ethyl alcohol. From the solution, 0.5 ml was taken into a 25 ml flask, and the volume of the flask was brought to the mark with 50 % ethyl alcohol. The optical density of the solution was measured on a spectrophotometer SF-46 at a wavelength of 329±2 nm. The comparison solution was 50 % ethyl alcohol.

Quantitative study of some BAS in the dry sample was carried out by reversed-phase HPLC To determine the elemental composition, a sample from the object was decomposed in a mixture of nitric and perchloric acids (8 ml:2 ml) in a microwave oven “Milestone” with power programming from 250 to 500 W and temperature from 180 to 220 °C.

The obtained solution was quantitatively transferred into a 100 ml measuring flask and further used for direct injection into the spray chamber of the ICP-MS (inductively coupled plasma mass spectrometer) AT 7500a instrument.

Instrument parameters: plasma power 1200 W, integration time 0.1 s, peristaltic pump rotation speed – 0.1 r/s. Other parameters of the device are set in the process of adjustment and are unchanged during the period between maintenance periods.

A multi-element (27 component) standard solution with the content of target components 1.0 mg/l was used as a standard.

The study employed descriptive statistics to summarize data, followed by inferential statistical tests such as ANOVA and regression analysis to evaluate differences and relationships among variables. These methods ensured robust analysis of the dry extract’s quality from Cynara scolymus L. cultivated in Uzbekistan.

4. Result

To standardize the medicinal raw materials of artichoke, it is necessary to introduce “signal” indicators that can be used to judge the quality of raw materials, such as moisture, ash content, extractive substances, etc., as well as to conduct a comparative analysis of these indicators in plants growing in different climatic conditions.

An important characteristic of raw material is its marketable humidity, at which leaves are stored in dry rooms without spoilage. For a complete picture of the quality of raw materials, determine the ash content, as this value shows the total content of mineral substances contained both in the raw material itself and in impurities. Ashes are insoluble in hydrochloric acid, which characterizes the silica impurity. The data on the cultivated plants in different countries are presented in Table 1.

Table 1

Elemental analysis of moisture and ash content determination of Cynara scolymus leaves

No.	Numerical parameters of artichoke leaves (in terms of absolutely dry raw material)	Marocco	Russia (Caucasian Mineral Waters)	Mongolia	Uzbekistan
1	Moisture, %	11.8±0.3	11.3 ±0.4	5.5±0.05	8.75±0.4
2	Ash, %	7.4±0.3	6.9±0.3	7.9±0.7	11.2±0.4
3	Ash insoluble in HCl, %	2.1±0.1	1.8±0.04	–	2.0±0.07
4	Organic impurities, %	0.7±0.04	0.6±0.03	–	0.7±0.04
5	Mineral impurities, %	0.6±0.03	0.6±0.03	–	0.6±0.03

Comparative analysis of artichoke raw material growing in different climatic conditions, the humidity values in countries with sharply continental climate are lower than in countries with high humidity in the air. The lowest values can be observed in a country with an arid climate (Mongolia). Ash values also varied according to the geography of cultivation. The highest ash content was found in the leaves of artichoke cultivated in Uzbekistan. For other parameters (organic and mineral impurities), the results were comparable [3–5, 7].

Since the moisture content of artichoke leaves is one of the valuable indicators affecting the value of raw materials, it is recommended to use air-drip irrigation when cultivating this plant in countries with arid climate.

For qualitative identification of biologically active substances contained in prickly artichoke, we prepared 70 % alcohol extract from artichoke raw material (mass-volume ratio 1:10, temperature 60ºC, for 30 min, three-fold extraction); 40 % liquid aqueous-alcoholic extract diluted with water (ratio 1:10); and aqueous solution of dry extract (mass-volume ratio 1:10).

Comparative analysis of extractive substances by different solvents in artichoke raw material is presented in Table 2.

Table 2

Content of extractive substances in the raw material of artichoke prickly spiny (in %)

Countries extractants	Morocco	Russia (Caucasian Mineral Waters)	Uzbekistan
Purified water	23.2±0.6, ε=±2.7	25.4±0.2, ε=±1.1 %	27.98±0.2, ε=±1.3 %
Ethyl alcohol 40 %	21.4±0.6, ε=±2.82 %	22.1±0.4, ε=±1.6 %	24.7±0.5, ε=±1.5 %
Ethyl alcohol 70 %	16.8±0.5, ε=±3.1 %	18.3±0.6, ε=±3.2 %	23.9±0.4, ε=±1.5 %

Table 2 shows that the compared samples of artichoke cultivated in Morocco, Russia and Uzbekistan are comparable in terms of extractive content. In all samples, the aqueous extract was the most effective for the extraction of biologically active substances from Cynara scolymus [4, 5].

The norm of organic and mineral impurities is considered appropriate when their content in the samples is not more than 1 %, the leaves of Cynara scolymus cultivated in the conditions of the Republic of Uzbekistan correspond to the standard indicators.

Phytochemical study of the leaves of artichoke pricklypear cultivated in Uzbekistan has been carried out in order to create an effective medicinal preparation or standardized extracts with pharmacological effects, including hepatoprotective [8–11].

Qualitative evaluation of flavonoids was carried out using TCA and chemical analytical reactions. TLC was performed on Megske chromatographic plates with silica gel 60 F 254 on aluminum substrate (10×15 cm) in the solvent system n-butanol - acetic acid – water (4:2:1), comparing with standard samples of rutin, luteolin, quercetin, scutelarin, cynaroside. The adsorption zones were detected in UV light at a wavelength of 254 nm. The chromatographic plate, after chromatography, was dried in a desiccator at 100–105 °C (Table 3).

Reactions with caustic soda were also performed to detect flavonoids qualitatively. Qualitative detection of oxycinnamic acids was carried out by paper chromatography in chromatography chamber 6.2 % acetic acid was used as the mobile phase. Tannins were detected with ferric alum. Qualitative detection of amino acids was carried out using ninhydrin reaction. Qualitative detection of alkaloids in the objects was carried out using silicon tungstic acid. The obtained data are shown in Table 4.

The presence of flavonoids, oxycinnamic acids, tannins, amino acids was found in the raw material of artichoke prickly. Alkaloids were not detected.

Table 5 shows the qualitative composition of some biologically active substances of artichoke raw material growing in different countries.

As can be seen from Table 5, no alkaloids were detected in the raw material of artichoke cultivated in Uzbekistan in the reaction with silicotungstic acid.

Table 3

Flavonoids detected in leaves and extracts of artichoke prickly pear by TLC method

Flavonoids found	Artichoke raw material
Rutin	*Rf*=0.76
Quercetin	*Rf*=0.88
Luteolin	*Rf*=0.91
Cynaroside	*Rf*=0.83
Scutelarin	*Rf*=0.90
Hyperoside	*Rf*=0.78

Table 4

Qualitative composition of some biologically active substances of artichoke prickly pear raw material cultivated in Uzbekistan

Identified substances	Methods and conditions of analysis	Analytical effect of the reaction	Artichoke raw material
1	2	3	5
Flavonoids	Reaction: with caustic soda	Yellow staining	+
Oxycinnamic acids	BC method mobile phase 2 % acetic acid solution	Blue fluorescence of stains in UV light	+
Tannins	Reaction with iron-ammonium alum	Dark green staining	+
Amino acids	Reaction with 0.1 % ninhydrin	Red-violet stains	+
Alkaloids	Reaction with silicon-tungstic acid	White precipitate	–

Table 5

Comparative analysis of qualitative composition of biologically active substances of artichoke prickly pear raw material

Country / Substances	Morocco	Russia (Caucasian Mineral Waters)	Mongolia	Uzbekistan
Oxycinnamic acids	+	+	+	+
Flavonoids	+	+	+	+
Tannins	+	+	–	+
Amino acids	+	+	Not determined	+
Alkaloids	+	+	–	–
Ascorbic acid	+	+	+	+

As can be seen from the table in the raw artichoke cultivated in Uzbekistan, identified important biologically active substances such as phenolic compounds oxycinnamic acids and flavonoids, tannins, amino acids, ascorbic acid, which is a good antioxidant.

Qualitative study of ascorbic acid was carried out by HPLC method. peak detection was carried out at UV 243 nm. The retention time in minutes was 2.380 and the peak area was 32.14 mAU*s.

For quantitative analysis, alcoholic (96 % ethyl alcohol diluted with 0.1 % orthophosphoric acid to 70 %, raw material to extractant ratio 1:100, for 2 hours) extraction of artichoke prickly pear raw material in 0.1 % orthophosphoric acid (1:100 ratio, ultrasonic bath) was used and determined by HPLC method. The obtained data are presented in Fig. 1, Table 6.

As can be seen from Table 6, obtained results of quantitative determination of some biologically active substances in artichoke raw material, high content of chlorogenic acid, cynaroside, riboflavin, caffeine and caffeic acid is shown.

For the quantitative determination of the sum of oxycinnamic acids in artichoke raw material, a precise weight of the raw material, ground to the size of particles passing through a sieve with holes with a diameter of 1 mm, was placed in a 200 ml flask and 60 ml of 50 % ethyl alcohol was added. The flask was connected to a reflux condenser and heated in a boiling water bath for 1 hour. After cooling, the contents of the flask were filtered through absorbent cotton into a 100 mL flask. The extraction was carried out two more times. The obtained extracts were quantitatively transferred into a 200 mL flask, and the flask's volume was brought to the mark with 50 % ethyl alcohol (solution A). 0.5 ml of solution A was placed in a 25 ml flask, and the volume of the flask was brought to the mark with 50 % ethyl alcohol.

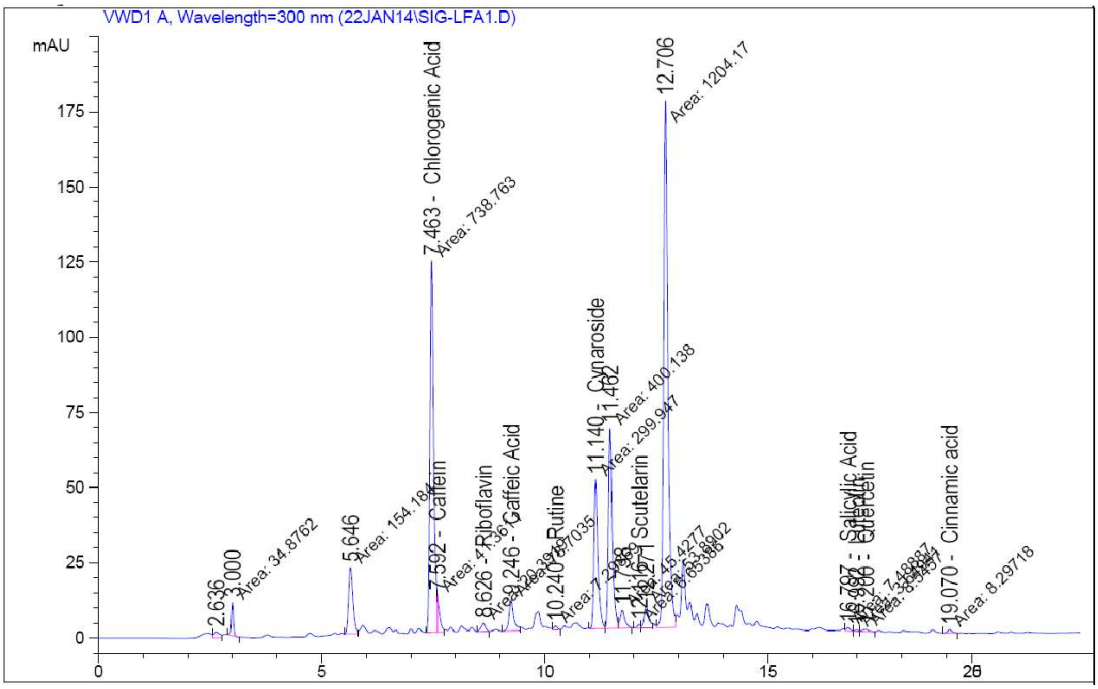

Fig. 1. Chromatogram of 70 % alcoholic extract from the raw material in artichoke prickly pear

Table 6

Quantitative composition of some biologically active substances of artichoke raw material determined by HPLC method

No.	Identified substances	Retention time, min	Peak area, rms or mAU*s	Substance content, μg/mL
1	Chlorogenic acid	7.463	738.76	57.1457
2	Caffeine	7.592	41.36	42.3348
3	Riboflavin	8.626	20.39	5.2883
4	Caffeic acid	9.246	78.70	1.7315
5	Rutin	10.240	7.29	1.0600
6	Cynaroside	11.140	299.94	34.4802
7	Scutelarin	12.116	6.65	4.4626^{-1}
8	Salicylic acid	16.797	7.48	8.7589^{-1}
9	Luteolin	16.992	3.64	1.8431^{-1}
10	Quercetin	17.200	8.54	7.0792^{-1}
11	Cinnamic acid	19.070	8.29	2.4211^{-1}

The optical density of the solution was measured on a spectrophotometer SF-46 at a wavelength of 329±2 nm. The reference solution was 50 % ethyl alcohol. In parallel, under similar conditions, the optical density of the solution of chlorogenic acid RSO prepared similarly to the test solution from a sample weighing about 0.00700 g (exact sample) was measured.

The content of the sum of oxycinnamic acids in per cent in terms of chlorogenic acid was calculated by the formula:

$$X = \frac{D_1 \cdot m_0 \cdot C \cdot 100}{D_0 \cdot m_1 \cdot (100 - W)},$$

where D_1 – optical density of alcoholic extract of artichoke leaves; D_0 – optical density of RDF of chlorogenic acid; m_1 – weight of the standard sample, g; m_0 – weight of raw material, g; C – purity of the standard sample, %; W – loss in mass during drying of the analyzed sample of artichoke leaves, %.

The data are presented in Table 7.

The sum of oxycinnamic acids in artichoke raw material in terms of chlorogenic acid averaged 1.86 %, which indicates a sufficient accumulation of oxycinnamic acids in this plant grown in Uzbekistan.

Table 7

Content of oxycinnamic compounds in terms of chlorogenic acid in artichoke prickly pear

No.	Optical density, D	Found oxycinnamic acids, %	Metrological characteristics
1	0.233	1.89	$\overline{X} = 1.86$; $S = 0.0212$; $S_{\overline{X}} = 0.0095$; $\Delta X = 0.0544$; $\Delta\overline{X} = 0.0242$; $\varepsilon = 2.90$; $\overline{\varepsilon} = 1.30$
2	0.228	1.85	
3	0.230	1.86	
4	0.232	1.88	
5	0.227	1.84	

Artichoke raw material is rich in minerals and trace elements: first of all, calcium, potassium, magnesium and iron. The relative content of cations varies along the row K>Mg>Na>Fe>Zn>Cu.

The elemental composition of artichoke raw material was determined by the mass spectrometric method.

The results of the mass spectrometric analysis of artichoke leaves are presented in Table 8.

The obtained data of elemental analysis testify to active accumulation of such important bioelements as sodium, potassium, calcium, magnesium, phosphorus, iron, boron, manganese, zinc, copper in the leaves of artichoke prickly pear, accumulation of such bioelements as sodium, potassium, calcium, magnesium in high concentrations makes it promising to use the plant as a source of these elements.

Table 8

Elemental composition of leaves of prickly artichoke cultivated in Uzbekistan

No.	Elemental composition	Elemental content, mg/kg	Elemental composition	Elemental content, mg/kg
1	Li	5.200	As	2.00
2	Be	1.000	Se	6.800
3	Na	6,500	Br	6.00
4	Mg	4,100	Rb	10.00
5	Al	370.0	Sr	29.0
6	P	2,200	Mo	9.500
7	S	1,200	Pd	1.900
8	K	44,000	Ag	1.00
9	Ca	11,000	I	4.00
10	V	36.00	Ba	27.00
11	Cr	110.0	Zn	27.00
12	Mn	41.00	Pt	<0.05500
13	Fe	930.0	Au	3.000
14	Co	2.300	Hg	0.6300
15	Ni	14.00	Pb	6.000
16	Cu	8.700	Bi	1.100

5. Discussion

The research on the dry extract of prickly artichoke (Cynara scolymus L.) cultivated in Uzbekistan presents several advantages. Firstly, it highlights the potential health benefits associated with this plant, such as its antioxidant properties and its role in liver health, which are supported by various phytochemical analyses. The study also provides a comprehensive profile of the bioactive compounds present in the extract, contributing to the existing body of knowledge regarding Cynara scolymus and its applications in traditional medicine.

However, there are disadvantages to consider. The results may be limited by the specific environmental conditions under which the prickly artichoke was cultivated in Uzbekistan, which might not be representative of other regions. Additionally, while the study identifies beneficial compounds, it may not fully explore their bioavailability or efficacy in human subjects, limiting practical applications.

When comparing these findings with other studies, it is essential to reference works that have investigated

similar aspects of Cynara scolymus. For instance, a study conducted by [2] highlights the pharmacological properties of artichoke leaf extract, emphasizing its potential health benefits. The study reviews various bioactive compounds found in artichokes, such as cynarin and chlorogenic acid, which are associated with antioxidant, anti-inflammatory, and hepatoprotective effects [15].

Moreover, another research article by [3] investigates how different cooking methods affect the antioxidant profile and physical characteristics of artichokes. The findings suggest that certain cooking techniques can enhance or diminish the antioxidant capacity of artichokes. For instance, boiling may lead to a loss of some beneficial compounds, while steaming preserves more antioxidants compared to other methods. This research underscores the importance of cooking practices in maximizing the health benefits derived from consuming artichokes [16–20].

Practical relevance. The practical relevance of this research lies in its implications for both dietary supplementation and medicinal use. Given the identified health benefits associated with prickly artichoke extracts, there is potential for developing functional foods or herbal supplements aimed at improving liver function and providing antioxidant support. Furthermore, this research could pave the way for further exploration into commercial cultivation practices that optimize yield and bioactive compound concentration.

Study limitations. Despite its contributions, this study has limitations that should be acknowledged. One significant limitation is the lack of clinical trials assessing human responses to the extract; thus, while laboratory results are promising, they do not guarantee similar outcomes in humans. Additionally, variations in growing conditions (such as soil type and climate) could affect compound concentrations and overall efficacy but were not extensively controlled or reported within this study.

Prospects for further research. Future research prospects include conducting clinical trials to evaluate the safety and efficacy of prickly artichoke extracts in human populations. Additionally, studies focusing on different extraction methods could provide insights into optimizing yields of specific bioactive compounds. Investigating genetic variations among different cultivars grown under diverse environmental conditions may also reveal how these factors influence phytochemical profiles.

6. Conclusion

Creation of original preparations on the basis of artichoke raw materials with good tolerability and almost complete absence of side effects, cultivated in Uzbekistan is very relevant, as the creation of drugs hepatoprotective action depends on quality medicinal raw materials. Biological activity of artichoke raw material is determined by the presence of oxycinnamic acids, flavonoids, vitamins, tannins, macro- and microelements, and amino acids.

In a comparative analysis of artichoke raw material growing in different climatic conditions, the humidity values in countries with sharply continental climates are lower than in countries with high humidity in the air. The lowest values can be observed in a country with an arid climate (Mongolia). Ash values also varied according to the geography of cultivation. The highest ash content was found in the leaves of artichoke cultivated in Uzbekistan. For other parameters (organic and mineral impurities), the results were comparable. The moisture content of artichoke leaves is one of the valuable indicators affecting the value of raw material, which means that it is recommended to use air-drip irrigation when cultivating this plant in countries with arid climates.

Qualitative analysis of artichoke prickly raw material cultivated in Uzbekistan identified important biologically active substances such as phenolic compounds, oxycinnamic acids and flavonoids, tannins, amino acids, and ascorbic acid, which is a good antioxidant.

Quantitative determination of some biologically active substances in artichoke raw material showed high content of chlorogenic acid, cynaroside, riboflavin, caffeine and caffeic acid.

The sum of oxycinnamic acids in the leaves of artichoke prickly pear in terms of chlorogenic acid indicates a sufficient accumulation of oxycinnamic acids in the plant grown under the conditions of Uzbekistan.

Accumulation of such bioelements as sodium, potassium, calcium, magnesium in high concentrations in the raw material of artichoke prickly makes it promising to use this plant as a source of these elements.

Conflict of interest

The authors declare that they have no conflict of interest in relation to this research, whether financial, personal, authorship or otherwise, that could affect the research and its results presented in this paper.

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Data availability

The manuscript has no associated data.

Use of artificial intelligence

The authors confirm that they did not use artificial intelligence technologies when creating the current work.

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