

# Development Of Technology of Dry Extract of Purple Echinacea for Obtaining the Active Pharmacological Ingredient "Immunaship"

Zulfiya Zuparova<sup>1\*</sup>, Aziza Khudayshukurova<sup>2</sup>, Guzaloy Ismoilova<sup>3</sup>, Gayrat Djanaev<sup>1</sup>, Ravshan Imomiyon<sup>4</sup>, Mansur Ergashov<sup>2</sup>

<sup>1</sup>Department of Pharmacology, Tashkent State Medical University, Tashkent, Republic of Uzbekistan

<sup>2</sup>Department of Pharmacology, Termez Branch of Tashkent State Medical University, Termez, Republic of Uzbekistan

<sup>3</sup>Department of Pharmaceutical Chemistry, Tashkent Pharmaceutical Institute, Tashkent, Republic of Uzbekistan

<sup>4</sup>Pharmacognosy, Technology of Medicines and Biotechnology department, State Institution "Scientific Research Pharmaceutical Center", Dushanbe, Tajikistan.

**Abstract.** Modern drug development benefits considerably from biologically active constituents found in medicinal plants. This study formulates a powdered extract named *Immunaship*, produced through extraction of *Echinacea purpurea* combined with rosehip fruits, both known for supporting immune function. Existing extraction techniques for plant-based immunostimulants often fail to achieve high concentrations of biologically active compounds while maintaining stable physical and chemical properties.

Researchers applied bismaceration for polyextraction, followed by HPLC analysis and spectrophotometric evaluation of the extract's composition. The assessment included fractional composition, bulk density, flowability, angle of repose, and moisture content. The resulting dry extract contains six key compounds—chlorogenic acid, rutin, caffeic acid, cynaroside, luteolin, and quercetin—along with a phenylpropanoid level of 1.35%, expressed as chicoric acid. Elemental analysis confirmed the presence of essential minerals such as potassium, calcium, magnesium, and iron, which enhance the sample's biological value. Excipients must be incorporated to improve formulation stability and improve the powder's flow characteristics.

**Keywords.** Dry extract, *Echinacea purpurea*, Polyextraction, Bioactive substances, Physicochemical parameters, HPLC profiling, Elemental analysis, Phenylpropanoids.

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\*Corresponding author: [zazulfiya@gmail.com](mailto:zazulfiya@gmail.com)

## 1 Introduction

Medicinal plants such as *Echinacea purpurea* and *Rosa canina* contain important therapeutic constituents, particularly those beneficial for immune system regulation [1]. Additional investigation is required to develop safe and effective products based on *E. purpurea*'s bioactive molecules, which show immunomodulatory activity and other therapeutic effects [2]. High-pressure processing and

pulsed electric field techniques help preserve *R. canina* bioactive substances while increasing their bioavailability more efficiently than traditional thermal processes, as reported by Ozkan [3]. Combining ultrasound-assisted extraction with deep eutectic solvents as environmentally friendly extraction approaches enables efficient isolation of active compounds from *R. canina* fruits, according to Koraqi [4]. Processing strategies have a direct impact on both the quantity and accessibility of bioactive constituents [1]. Establishing standardized extraction protocols and optimizing parameters for various plant species remains essential for achieving consistent medicinal effects [3]; [1].

Current research highlights that compounds in Echinacea extracts modulate innate immune responses. Aqueous *E. purpurea* extracts enhance macrophage activation, increase IL-6 and TNF- $\alpha$  cytokine production, and trigger ERK1/2 and p38 signaling cascades in cultured human monocyte-derived macrophages [1]. These immunostimulatory activities arise from diverse bioactive molecules, including alkamides, caffeic acid derivatives, flavonoids, and polysaccharides [5]. These compounds significantly elevate immune cell activity, cytokine secretion, and phagocytosis [5]. In silico studies demonstrate that Echinacea species participate in essential biological pathways and molecular functions supporting immune responses through cytokine regulation and receptor binding, as highlighted by Choudhary. The immunomodulatory effects of Echinacea preparations depend on their phytochemical composition, which varies by species, extraction method, and plant material used [6].

Advancements in extraction technologies remain crucial for obtaining plant-derived bioactive compounds for pharmaceutical and nutraceutical use. Green extraction methods—such as supercritical fluid extraction and ultrasound-assisted techniques—are becoming increasingly favored alongside conventional solvent extraction [7]. The solubility, stability, and bioavailability of plant metabolites are enhanced when natural deep eutectic solvents (NADES) are used, according to Hikmawanti et al. [8]. Research on medical cannabis similarly stresses the necessity for improved extraction evaluation to create reliable and standardized products, according to Al Ubeed et al. [9]. Prior processing of plant material is essential to preserve bioactive compounds before extraction, as well as to facilitate their release. Structural modification of plant matrices via freeze-drying, microwave-vacuum drying, or enzymatic treatments helps liberate compounds bound within cell wall polymers [10].

This study employs HPLC, spectrophotometry, and elemental analysis to investigate the composition and physicochemical characteristics of the dry extract. The formulation was assessed for fractional distribution, bulk density, flow properties, angle of repose, and moisture levels to identify optimal pharmaceutical attributes. Analytical methods quantified key phenylpropanoid compounds—chlorogenic acid, rutin, caffeic acid, and quercetin—to determine the extract's essential bioactive profile. Elemental evaluation confirmed considerable levels of potassium, calcium, magnesium, and iron, which contribute to the extract's biological significance.

Findings show that although the dry extract retains a strong bioactive profile, excipients are required to improve flowability, as it does not meet standard pharmaceutical processing criteria on its own. The insights gained about dry extracts are important for industrial-scale manufacturing of herbal medicines and facilitate product standardization. This research aims to stabilize plant-based immunostimulants by developing formulations suitable for both tablets and capsules.

Overall, the study represents a notable contribution to herbal pharmacology by refining extraction methods that improve pharmaceutical application. It lays the groundwork for future product development and clinical research by providing stabilized, standardized dry plant extracts with reliable bioavailability. The findings highlight the importance of extraction technologies in preserving bioactive potential and supporting the wider integration of natural immunostimulants into modern medical practice.

## 2 Methodology

A comprehensive study was performed to develop and characterize the dry extract derived from *Echinacea purpurea* and rosehip fruits. The methodological approach followed a systematic workflow aimed at preserving high levels of bioactive constituents while ensuring pharmacological stability and suitability for pharmaceutical use. A polyextraction bismaceration technique was applied, in which sequential solvent exposure enabled the selective isolation of phenylpropanoids, flavonoids, and polysaccharides without notable degradation of active molecules.

The plant materials were collected during their peak biological activity and dried in a IIC-80-01CITY cabinet equipped with controlled hot-air circulation. An automated extractor (KD-2KY) was used to obtain the active compounds, after which a rotary vacuum evaporator removed the solvent under reduced pressure. The concentrated extracts were subsequently spray-dried using an Anhydro-2 nozzle-type system, maintained at controlled temperatures to ensure optimal moisture levels and stability.

Multiple analytical procedures were employed to assess the physicochemical characteristics of the resulting dry extract. A sieving method using mesh sizes from 3 mm to 0.25 mm was applied to determine the fractional distribution of 100 g samples. Bulk density was assessed using a tablet mold measuring 25 mm in diameter and 22.3 mm in height, while flowability and natural angle of repose were measured using the VP-12A instrument. Residual moisture—a critical factor for accurate pharmaceutical formulation—was determined using an Aczet MB 120 moisture analyzer.

Chemical composition analysis was performed on an Agilent Technologies 1200 series HPLC system equipped with a Zorbax Eclipse XDB-C18 column (4.6×250 mm, 5 μm). Gradient elution with phosphate buffer and acetonitrile at a 0.8 mL/min flow rate was monitored at 254 nm and 272 nm using diode-array detection. The HPLC method enabled identification and quantification of chlorogenic acid, rutin, caffeic acid, cynaroside, luteolin, and quercetin based on their peak areas.

A spectrophotometer set at 328 nm quantified phenylpropanoid compounds by determining chicoric acid content using a 0.1 M hydrochloric acid reference solution. Essential minerals—including potassium, calcium, magnesium, and iron—were measured using an ICP-MS system (AT 7500a). Spectrometric mineral profiling confirmed the biological relevance of these elements, which enhance the extract's pharmacological potential.

Statistical analysis ensured accuracy and reproducibility of all measurements, contributing to a reliable standardization of the extract. The methodology effectively preserved active compounds while improving physicochemical assessments, providing essential information for optimizing the dry extract for pharmaceutical applications.

## 3 Results

### 3.1 Determination of pharmaceutical technological properties.

The physicochemical evaluation of the dry extract provided detailed insights into its chemical composition, structural attributes, and its potential for pharmaceutical formulation. Fractional composition analysis revealed that a particle fineness level exceeding 50% negatively impacted flowability, compressibility, and dose uniformity—key parameters for producing consistent pharmaceutical products. Bulk density was measured at 0.495 g/cm<sup>3</sup>, while the natural angle of repose was found to be 71°, indicating poor flowability and strong interparticle cohesion.

When tested without modification, the extract's flow characteristics were insufficient for direct use in tablet or capsule production, demonstrating the need for granulation or incorporation of suitable excipients. In herbal medicine standardization, challenges often arise from the need to

optimize particle size and enhance flow properties, as these parameters are essential for ensuring accurate dosing and reproducible pharmaceutical performance.

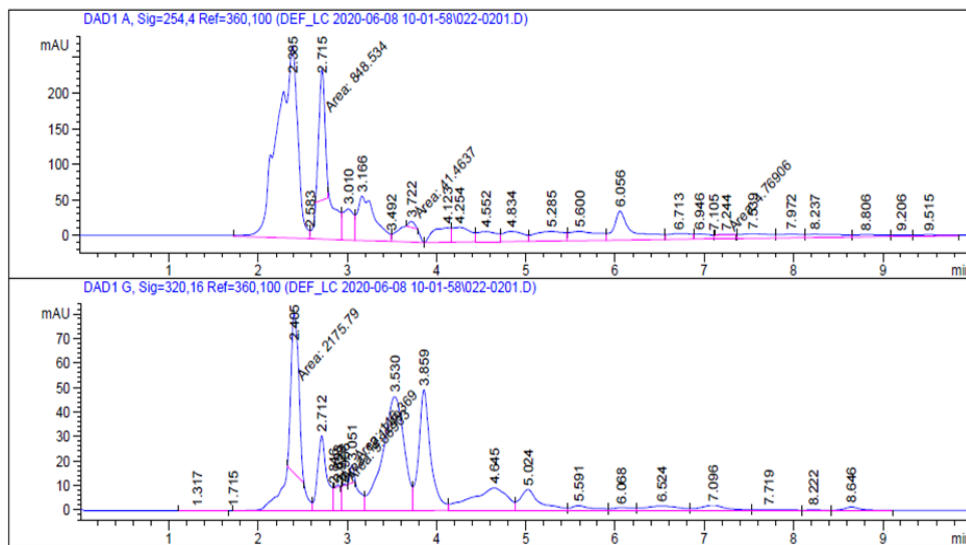
**Table 1. Physicochemical Properties of the Dry Extract**

No.	Parameter	Unit	Measured Value
1	Fractional composition	%	+3000 $\mu\text{m}$ (0%), -3000 +2000 $\mu\text{m}$ (1.2%), -2000 +1000 $\mu\text{m}$ (24.6%), -1000 +500 $\mu\text{m}$ (21.5%), -500 +250 $\mu\text{m}$ (49.8%), -250 $\mu\text{m}$ (2.9%)
2	Flowability	$10^{-3}$ kg/s	0.141
3	Bulk density	$\text{g}/\text{cm}^3$	0.495
4	Angle of repose	degrees	$71^\circ$
5	Residual moisture content	%	4.28

### 3.2 Determination of polyphenolic compounds

Analysis of the extract's chemical profile using HPLC identified six principal biologically active polyphenolic compounds: chlorogenic acid, rutin, caffeic acid, cynaroside, luteolin, and quercetin. Quantification of phenylpropanoids—measured as chicoric acid—showed a content of 1.35%, supporting the extract's immunomodulatory potential. The polyextraction bismaceration technique effectively preserved essential bioactive constituents from *Echinacea purpurea*, consistent with findings reported in earlier studies.

The HPLC chromatogram presented in Figure 1 illustrates clear separation of the active molecules, with distinct retention times and peak intensities corresponding to the quantitative values listed in Table 2. Chlorogenic acid emerged as the dominant compound in the extract, reaching 50.86 mg/g, while additional phenylpropanoid and flavonoid components were also distinctly represented in the chromatographic profile.



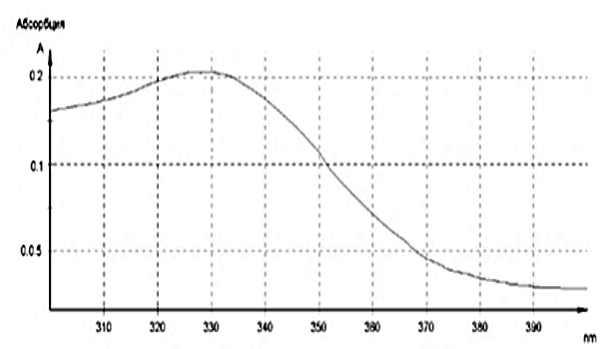
**Fig. 1.** The dried extract components reveal six bioactive compounds through HPLC separation analysis which includes both chlorogenic acid and rutin alongside caffeic acid and cynaroside and luteolin and quercetin.

**Table 2. Chemical Composition of the Dry Extract (HPLC Analysis)**

No	Identified Compound	Retention Time (min)	Peak Area (mAU*s)
1	Chlorogenic acid	2.405	427.75
2	Rutin	2.676	584.51
3	Caffeic acid	2.853	251.02
4	Cynaroside	2.977	444.06
5	Luteolin	4.187	7529.16

### 3.3 Determination of the amount of phenylpropanoids

The spectrophotometric reading at 328 nm confirmed quantitatively that phenylpropanoids remain present in the extract to preserve its therapeutic characteristics. The absorption spectrum shows its major peak located at 328 nm in Figure 2 in accordance with earlier findings on phenylpropanoid-rich plant extracts. The Echinacea-derived polyphenols demonstrate the predicted UV-Vis absorbance profile thereby validating their potential pharmaceutical usage as immunomodulators.



**Fig. 2.** The dry extract showed extensive absorption of UV-Vis light at 328 nm which validated its phenylpropanoid content.

### 3.4 Determination of macro- and microelements

Analysis by ICP-MS demonstrated the existence of vital nutrients in dry extract as potassium reached 50,000 mg/kg and calcium exceeded 18,000 mg/kg alongside magnesium at 12,000 mg/kg and iron at 2,500 mg/kg. The main elements detected in the extract actively support immune response functions alongside enzymatic activities while facilitating metabolic operations which improve the nutritional benefits and treatment potential. This high potassium and calcium content holds major importance because cellular signaling and immune system regulation, together with homeostasis depend on these elements (Table 3):

**Table 3. Elemental Composition of the Dry Extract (ICP-MS Analysis)**

No.	Element	Content (mg/kg)	No.	Element	Content (mg/kg)
1	<b>Li</b>	2.90	13	<b>Co</b>	1.60
2	<b>Be</b>	0.09	14	<b>Ni</b>	12.00
3	<b>Na</b>	240.00	15	<b>Cu</b>	5.10
4	<b>Mg</b>	12,000.00	16	<b>Zn</b>	15.00
5	<b>Al</b>	250.00	17	<b>S</b>	22.00
6	<b>P</b>	72.00	18	<b>Br</b>	60.00
7	<b>K</b>	50,000.00	19	<b>Sr</b>	510.00
8	<b>Ca</b>	18,000.00	20	<b>Mo</b>	1.20
9	<b>Cr</b>	12.00	21	<b>Ag</b>	0.35
10	<b>Mn</b>	50.00	22	<b>Ba</b>	55.00
11	<b>Fe</b>	2,500.00	23	<b>Au</b>	0.04
12	<b>I</b>	1.60	24	<b>Bi</b>	0.017

The examination of extract moisture content revealed it contains 5% residual moisture which protects the stability of the sample and impedes microbial growth. Process efficiency and compressibility of the extract require additional measures through the use of microcrystalline

cellulose and controlled granulation methods due to its high particle cohesion and hygroscopic properties.

The study confirms that polyextraction helps preserve bioactive ingredients and create a product with valuable mineral content thus making suitable for nutraceutical and pharmaceutical applications. The production of consistent medication requires additional development of formulation technologies and bioavailability research and product stability measurements to achieve therapeutic effectiveness at commercial manufacturing levels.

## 4 Discussion

The findings of this study provide important insights into the development of the standardized dry extract “Immunaship,” produced from *Echinacea purpurea* and rosehip fruits. The research aimed to establish an extraction method capable of preserving a high concentration of biologically active molecules while ensuring that the resulting extract met pharmaceutical criteria for use in solid dosage forms. The results confirm that the bismaceration polyextraction process successfully retains key phenylpropanoids and flavonoids, although the final product still requires excipients to overcome issues related to poor powder flow and formulation instability. These outcomes contribute valuable knowledge to the field of plant-derived immunomodulators by demonstrating how refined extraction processes support reproducibility and product standardization.

The study emphasized both the preservation of essential bioactive compounds and the evaluation of the extract’s technological characteristics. HPLC profiling identified six major compounds—chlorogenic acid, rutin, caffeic acid, cynaroside, luteolin, and quercetin—consistent with known pharmacological effects of *E. purpurea* and rosehip. The phenylpropanoid content, quantified as 1.35% chicoric acid, further supports the immunomodulatory potential of the extract, aligning with previous research on *Echinacea*-based formulations.

However, physicochemical assessment revealed significant technological limitations. With more than half of the material classified as fine powder, the extract displayed low bulk density (0.495 g/cm<sup>3</sup>) and a high angle of repose (71°), indicating poor flowability and weak compressibility. These characteristics suggest that granulation techniques or inclusion of excipients such as microcrystalline cellulose may be required to achieve uniform dosing in tablet or capsule manufacturing. Elemental analysis demonstrated high concentrations of essential minerals—50,000 mg/kg potassium, 18,000 mg/kg calcium, 12,000 mg/kg magnesium, and 2,500 mg/kg iron—enhancing both therapeutic and nutritional value. This mineral richness indicates potential applications beyond immune modulation, particularly in supporting metabolic and enzymatic processes.

Recent advances in *Echinacea purpurea* research have expanded understanding of its immunomodulatory, antimicrobial, anti-inflammatory, and antiviral effects. Bioactive constituents such as alkamides, caffeic acid derivatives, flavonoids, and polysaccharides have been shown to activate immune cells and stimulate cytokine production [5]. Some extracts, such as dichloromethane fractions, even exhibit anti-inflammatory potency surpassing certain pharmaceutical agents [1]. Although dried extracts display limited direct antimicrobial activity, they demonstrate strong immune-enhancing effects that support infection control [10]. Nonetheless, challenges persist in standardizing extraction methods and quantifying plant phytochemicals due to natural variability [5]. Further research is needed to establish therapeutic dosing and confirm clinical effectiveness of *E. purpurea* in diverse medical settings.

The present research advances the field by integrating polyextraction to capture a broad range of bioactive compounds while simultaneously assessing the formulation’s physical performance. Recognition of the extract’s mineral composition adds another dimension to evaluating its biological potential—an aspect often overlooked in earlier studies focusing primarily on flavonoids and phenolic compounds. Elevated potassium and calcium levels may indicate additional immunological or metabolic contributions. By combining chemical, mineral, and physicochemical evaluations, this study proposes a more comprehensive strategy for characterizing plant-derived immunomodulatory products.

Recent literature emphasizes the importance of innovative extraction technologies for preserving thermolabile bioactive compounds. Green approaches—such as natural deep eutectic solvents (NADES), supercritical fluid extraction, ultrasound-assisted extraction, and microwave-assisted extraction—offer advantages including improved stability, higher extraction efficiency, reduced solvent use, and enhanced bioavailability, [10–12]. These advancements are increasingly relevant as pharmaceutical and nutraceutical industries prioritize natural bioactive ingredients and environmentally responsible extraction methods.

Although the present extract shows promising therapeutic potential, further formulation improvements are needed for direct compression. Adjusting moisture levels, applying granulation processes, or incorporating flow-enhancing excipients may resolve issues of cohesion and poor flow characteristics. Given its high mineral content and immunomodulatory profile, the extract also holds promise for nutraceutical development, where combined phytochemical–mineral interactions may provide added health benefits.

While chemical and physicochemical properties were thoroughly evaluated, the bioavailability and pharmacokinetic behavior of the extract were not assessed. The *in vivo* performance of phenylpropanoids and flavonoids in solid formulations remains insufficiently understood, and human studies are required to determine absorption, metabolism, and therapeutic outcomes. The functional role of mineral components within the formulation was confirmed analytically but not explored biologically. Future research should investigate how minerals and flavonoids interact to influence immune responses.

Further studies should include comparative analyses with existing plant-based immunomodulators, thereby clarifying Immunaship’s potential advantages and limitations. *In vivo* trials on solid dosage forms are necessary to evaluate pharmacokinetics and optimize dosing. Long-term stability tests, development of advanced delivery systems—such as encapsulation or nanoparticle-based carriers—and studies examining mineral–polyphenol synergy could significantly expand therapeutic applications. Ultimately, clinical research will be needed to validate the extract’s efficacy in managing autoimmune disorders, viral infections, and other immune-related conditions.

Overall, this research contributes substantial knowledge to the standardization and formulation of plant-based immunomodulatory dry extracts. It demonstrates that polyextraction enables preservation of key bioactive compounds and highlights physicochemical barriers that must be addressed for successful pharmaceutical implementation. By integrating chemical, physical, and mineral analyses, the study provides a comprehensive framework for evaluating phytopharmaceuticals and emphasizes the need for continued investigation into bioavailability, stability, and clinical effectiveness.

## 5 Conclusion

Optimal extraction conditions for *Echinacea purpurea* were identified to develop the active pharmaceutical ingredient “Immunaship.” Through polyextraction optimization, researchers successfully produced a dry extract retaining key bioactive compounds—chlorogenic acid, rutin, caffeic acid, cynaroside, luteolin, and quercetin—and a phenylpropanoid content of 1.35% expressed as chicoric acid. Physicochemical testing revealed storage and formulation limitations, indicating the need for improved technological strategies and the addition of suitable excipients. Elemental analysis confirmed the presence of essential minerals, including potassium, calcium, magnesium, and iron, further supporting the extract’s biological and nutritional significance, calcium, magnesium, and iron further enhanced the extract’s therapeutic and nutritional value. The standardization of herbal medicines is increasingly important, and the present findings contribute essential scientific

criteria for optimizing solid dosage formulations based on plant-derived immunomodulators. However, challenges remain regarding the extract's distribution within the body, its pharmacodynamic behavior, and its long-term stability. These issues highlight the need for additional investigations, including dosage refinement, controlled laboratory experiments, and clinical studies, to fully validate its therapeutic potential and assess its suitability for large-scale pharmaceutical production.

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