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The Technological Study to Develop Granules from Plants Used in Traditional Mongolian Medicine

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Objective: To develop a herbal preparation for respiratory ailments from plants used in Mongolian medicine. **Method:** TLC, HPLC, chemical and spectrophotometric analysis were used for the quality and quantitative determination of biologically active compounds in plant raw materials, extracts and granules. The total and internal absorption coefficients of the plant raw materials, tapped density and flowability of the granules were determined using the method of I.A. Muravyev and V.D. Ponomarev. The quality parameters of the granules (appearance, particle size, moisture content, dispersion) were determined by the Chinese pharmacopoeia methods. **Results:** The highest amount of extractive matters was determined when extracting 2 mm powdered roots of *Glycyrrhiza uralensis* Fisch.ex DC. using 0.25% ammonia (34.46±3.01), 2 mm powdered roots of *Inula helenium* L. with 50% ethanol (56.69±2.83), and 2 mm powdered fruits of *Rosa acicularis* Lindl. with 40% ethanol (32.15±1.62). The glycyrrhizic acid content in the root of *Glycyrrhiza uralensis* Fisch.ex DC. was measured at 3.51±1.73%. Similarly, the inulin content in the root of *Inula helenium* L. was found to be 5.56±0.003%, and the ascorbic acid content in the fruits of *Rosa acicularis* Lindl. was also identified as 1.91±0.1%. After determining the extractive matters, particle size, total and internal absorption coefficients, and the content of majn biologically active compounds in the plant materials, liquid extracts were obtained from the plant raw materials, and thick extracts were prepared from these liquid extracts. The main substances in the liquid and thick extracts were identified and quantified. The glycyrrhizic acid content was 1.04±0.01% in the liquid extract and 2.87±0.08% in the thick extract; the ascorbic acid content was 0.47 ± 0.06% in the liquid extract and 0.73 ±0.06% in the thick extract; and the inulin content was 4.72±0.002% in the liquid extract and 15.07±0.002% in the thick extract. Five different models of granules were prepared from thick extracts using the wet granulation method. Model 1 granules were excluded from the study due to their irregular texture, clamminess, and inability to be sieved. The quality and technological parameters of the granule F2 model were superior to those of the other models ($P<0.001$). Granule model F2 contains 0.092±0.002% glycyrrhizic acid, 2.153±0.049% inulin, and 0.27±0.03% ascorbic acid. The prepared granules met the criteria for the microbiological test. **Conclusion:** It is suitable to extract the roots of *Glycyrrhiza uralensis* Fisch.ex DC., the root of *Inula helenium* L., and the fruits of *Rosa acicularis* Lindl. by powdering them into 2 mm particle sizes. Of the five models of granules prepared by wet granulation from plant extracts, model 2 was superior to the others in terms of technological and quality parameters. Sucrose was not suitable for granulation as an excipient.

Keywords: Licorice, Elecampane, Glycyrrhizic acid, Inulin, Ascorbic acid

Introduction

The use of herbal medicines, phytonutrients, or nutraceuticals continues to expand

worldwide, with many people now resorting to these products to treat various health challenges in different national healthcare settings.[1] According to the WHO definition, herbal medicine includes "herbs, herbal materials, herbal preparations and finished herbal products that contain as active ingredients, parts of plants, other plant materials or a combination thereof". There is an increasing demand for medicinal plants in developing and developed countries.[2] Mongolia is abundant in medicinal plants and has a rich experience and tradition of using plants for therapeutic purposes since ancient times.

Respiratory system diseases are on the rise in Mongolia, now ranking as the second leading cause of population morbidity and the primary cause of inpatient morbidity. The incidence of respiratory system diseases per 10000 population was 788.4 in 2021, 1766.7 in 2022, and 1930.8 in 2023, while the inpatient morbidity incidence was 160.6 in 2021, 508.0 in 2022, and 513.3 in 2023.[3] Many plants, including *Glycyrrhiza uralensis* Fisch.ex DC., *Inula helenium* L., and *Rosa acicularis* L. are widely used in traditional Mongolian medicine to treat respiratory diseases.

Glycyrrhiza uralensis Fisch. ex DC. (Fabaceae), an important medicinal plant in Mongolia, has a wide distribution across the country, occurring in nearly all botanic-geographical regions.[4] The roots and rhizomes of this plant are used to treat pneumonia, inflammation of the tracheal and pulmonary channels, cough with phlegm, asthma, brown phlegm in the stomach and intestines, vomiting, pulmonary tuberculosis, and other respiratory diseases.[5-8] It serves as an ingredient in 249 Mongolian–Tibetan traditional prescriptions and ranks fifth among all medicinal plants, being the main component of Sorool-4, Aglig-4, Lish-6, Zandan-8, Uzem-7, Zachun-13, Banjingarvo-15, Dali-16, Lotsadgunsel, and Samfilnorov traditional prescriptions.[5,9] The root and rhizome contain several biologically active compounds such as polysaccharides, organic acids, coumarin, 4.9-22.2% triterpenoids, 7-9.46% tannins, and 1.95-4% flavonoids. Modern research has demonstrated that the plant can reduce acute lung injury and has anti-inflammatory properties. The glycyrrhizic acid found in this plant exhibits anti-inflammatory effects in lung inflammation.[10,11]

Inula helenium L. (Asteraceae), a perennial herbaceous plant, has been cultivated in Dashigchilen soum of Bulgan province, Mongolia, since 1993. In Tibetan and Mongolian traditional medicine, the root of *Inula helenium* L. is included in 256 recipes under the name "Manu", ranking 21st in terms of frequency of use in recipes and 5th in frequency of use among Mongolian medicinal plants.[12,13] The plant has been reported to be an expectorant, anti-infective, and anti-inflammatory in various respiratory diseases, and an anti-helminthic agent.[14] Inulin, one of the main compounds found in *Inula helenium* L., has been shown to reduce lung inflammation and the production of associated cytokines in respiratory tract inflammation.[15] Rhizomes and roots contain inulin (up to 44%) and other polysaccharides, bitter substances, essential oil (up to 4.5%), saponins, resins, gum, mucus, a small amount of alkaloids, and helenin. Preparations from the rhizomes of this plant have an expectorant and anti-inflammatory effect, improve appetite, reduce intestinal motility, and decrease gastric acid secretion.[16]

Rosa acicularis L. (Rosaceae) is widely distributed in Mongolia. It treats fever caused by liver disease and poisoning, eliminates bile, enhances vitality, and is an ingredient in the Braivu-21 traditional prescription.[9] Its fruits are rich in vitamins, containing 4-10% ascorbic acid, 12-18 mg/% carotene, up to 18% sugar, 4.5% tannins, and 2% organic acids (malic, citric), as well as flavonoids such as rutin, astragalin, hyperoside, and quercimetrin.[9,12] It is used for alterations in the water-electrolyte balance, high blood pressure, vitamin deficiency, and ascorbic acid, which improves the body's resistance. The fruit is included in mixed liquid medicines with anti-bronchial asthma effects.[7] *Rosa acicularis* L. exhibits the most potent antioxidant activity (IC50 0.81±0.02 μg/mL) and anti-bacterial effects against *E.coli* and *S.aureus*.[17]

The utilization index of the root of the *Glycyrrhiza uralensis* Fisch. ex DC. is 0.36, while the root of the *Inula helenium* L. has a utilization index of 0.21. This indicates that these plant raw materials are widely used in Mongolian medicine. Additionally, the utilization index of the fruit of the *Rosa acicularis* L. in the forest-steppe region of Mongolia is 0.06.[18]

Research into the phytochemistry and pharmacology of plants utilised in traditional medicine, as well as pharmaceutical manufacturing technology that transforms dosage forms of traditional medicines into modern dosage forms, along with the development of herbal remedies based on these studies, is currently extensive in our country. Given the high prevalence of respiratory diseases in Mongolia, our researchers have developed and introduced several herbal medicines to treat these conditions. The rising incidence of respiratory diseases in Mongolia and the necessity to expand the range of domestically produced products

served as the foundation for this study. This study was conducted to develop herbal preparation for respiratory ailments from plants used in Mongolian medicine.

Materials and Methods

Plant material: The fruit of *Rosa acicularis* Lindl., the roots of *Glycyrrhiza uralensis* Fisch. Ex DC. and *Inula helenium* L. purchased from Natural Synergy Co., Ltd. were used in the study. The plants were identified by T. Munkh-Erdene, taxonomist of the *Botanical Garden*, Mongolian Academy of Sciences.

Liquid extracts, thick extracts, and granule models: Liquid extracts, thick extracts, and granule models prepared on the results of this study were used for the quantitative determination of biologically active main compounds. Granule models were used for technological and quality parameter analysis of granules.

Standards and chemicals: Reference glycyrrhizic acid (≥95.0%, SG.50531-10G, Sigma Aldrich, China), ascorbic acid (TL.02207917, DSM, China), inulin (Mk.I811905-50G, China), were used for the study. Solvents used for the HPLC study were of HPLC grade, and all other reagents and solvents were of analytical grade.

HPLC Analysis of Glycyrrhizic Acid

The analysis was made using the Chinese Pharmacopoeia.[19]

Preparation of Sample Solution

Plant material: 1.0 g of the powdered root of *Glycyrrhiza uralensis* Fisch. ex DC. was precisely weighed to an accuracy of 0.001 g and placed in a stopper conical flask, and 100 mL of 70% ethanol was added. The flask was tightly capped and weighed. Ultrasonicated for 30 minutes, cooled and weighed again, replenished the solvent loss with 70% ethanol, mixed well, filtered, and the filtrate was used for the analysis.

Liquid and thick extracts: 1 mL of the liquid extract and 1 g of the thick extract (precisely weighed to an accuracy of 0.001 g) of the root of *Glycyrrhiza uralensis* Fisch. ex DC. were placed in 50 mL and 100 mL volumetric flasks. 20 mL of mobile phase was added and put in an ultrasonic bath for 30 minutes. The mobile phase was added to the nominated volume, and 20 mL of the solution was placed in 25 mL volumetric flasks, respectively. The mobile phase was added to the nominated volume.

Granule: 1 g of prepared granules was precisely weighed to an accuracy of 0.001 g and placed in a 50 ml volumetric flask. 20 mL of mobile phase was added. After dissolving the granules, the mobile phase was added to the nominated volume.

Standard solution preparation: 10 mg of glycyrrhizic acid was precisely weighed to an accuracy of 0.001 g, placed in a 50 ml volumetric flask, and 45 mL of mobile phase was added. After standing for 5 minutes to remove gas bubbles, the mobile phase was added to the nominated volume.

Chromatographic procedures: The C18 (150 mm x 4.6 mm x 5 µm, Hypersil ODS) was used as the stationary phase. Methanol-ammonium acetate (0.2M)-glacial acetic acid (67:33:1) was used as the mobile phase. The total runtime: 10 min; flow rate: 1.0 mL/min; column temperature: 30°C; injection volume: 50 µL; UV detection wavelength: 250 nm. The samples and standard solutions were run at least 5 times each. All prepared samples and standard solutions were filtered through a 0.45 µm filter membrane before being injected into the HPLC instrument.

TLC Identification of Ascorbic Acid

1 g of dried and powdered fruit of *Rosa acicularis* Lindl. was extracted with 10 ml of methanol using ultrasonics for 30 minutes. 1 mg/mL methanol solution of standard ascorbic acid was prepared. The sample and reference solutions were applied to a silica gel 60 F254 plate (Merck) at 5µL at a 1.5 cm distance from the lower border of the plate. The development of the plate has been performed with a mobile phase of ethyl acetate:methanol (7:3, v/v). After drying at room temperature, the plate was visualised under 254 nm UV light.

Quantitative Determination of Ascorbic Acid

The analysis was made using the Russian Pharmacopoeia.[20]

Plant material: 5 g powdered fruit of *Rosa acicularis* Lindl. was precisely weighed to an accuracy of 0.001 g, and ultrasonicated for 10 minutes with 30 mL of distilled water. The extract was filtered, the first portion of the filtrate was discarded, 1 mL was accurately measured and placed in a 50 mL stopper conical flask, 13 mL of distilled water and 1 mL of 2% hydrochloric acid solution were added. The solution was titrated with 0.25 g/L 2,6-dichlorophenolindophenolate (monohydrate) solution until a persistent pink color appeared in 20 seconds. The titration was carried out for no more than 2 minutes.

Liquid and thick extracts: 1 mL of the liquid extract and 1 g of the thick extract of the fruit of *Rosa acicularis* Lindl. were placed in a 200 mL volumetric flask, respectively, and dissolved in 100 mL of distilled water. Distilled water was added to the nominal volume, the solutions were filtered, the first portion of the filtrate was discarded, 5 mL was accurately measured, and the analysis

was continued as mentioned above.

Granule: 1 g of prepared granules was precisely weighed to an accuracy of 0.001 g and placed in a 50 mL flask, 30 mL of distilled water was added, shaken for 10 minutes and filtered through filter paper. The first portion of the filtrate was discarded, 1 mL was accurately measured and placed in a 50 mL stopper conical flask, and the analysis was continued as mentioned above.

Chemical Analysis of Inulin

1 g of dried and powdered raw material was placed in a 50 mL round-bottomed flask, 20 mL of distilled water was added, and extracted for 30 minutes under reflux. The extract was cooled and filtered through filter paper. 2-3 mL of the extract was transferred to a test tube, 0.05 mL of 80% phenol and 5 mL of concentrated sulfuric acid were added, and the orange color was obtained when heated in a water bath at 25-30°C.

Spectrophotometric Analysis of Inulin

The analysis was made using the National pharmacopoeia monograph.[21]

Plant material: 1 g of the powdered root of *Inula helenium* L. was precisely weighed to an accuracy of 0.001 g, placed in a 50 mL round-bottomed flask, and extracted with 20 mL of distilled water under reflux for 1 hour, twice. The extracts were filtered and combined, and 3 mL of 10% lead acetate was added and mixed. After 10 minutes, 3 mL of 5% disodium hydrogen phosphate solution was added. After 5 minutes, filtered through a paper filter into a 100 mL volumetric flask and diluted to volume with distilled water (solution A). 1 mL of solution A was placed in a 25 mL volumetric flask and diluted to volume with distilled water (solution B). 5 mL of solution B was placed in a 25 mL volumetric flask, 0.1% resorcinol alcohol solution, 10 mL of 30% hydrochloric acid were added. The mixture was kept at room temperature for 10 minutes. Heated in a water bath at 70-80°C for 20 minutes, cooled, and diluted to volume with 30% hydrochloric acid. The absorbance of the solution was measured at 490 nm.

Extracts: 1 mL of liquid extract and 1 g of thick extract were placed in a 50 mL flask. 3 mL of 10% lead acetate was added, and the determination was carried out according to the above procedure.

Granule: 1 g of prepared granules was precisely weighed to an accuracy of 0.001 g and dissolved in 50 mL of distilled water, filtered, and 3 mL of 10% lead acetate was added to the filtrate, and the determination was carried out according to the method mentioned above.

Technological Study

The total and internal absorption coefficients: These parameters of the plant raw materials were determined using the method of I.A. Muravyev and V.D. Ponomarev.[22]

Appearance of the granules: Appearance was evaluated organoleptically. The granules should be round, cylindrical or irregular in shape, yellowish in color, and have a specific smell of plant extract.

Determination of the particle size composition of the granules: An accurately weighed 100 g sample is sieved through a 2.0 mm sieve, and the granules must pass completely. The granules' weight through a No. 5 sieve (180 μm) must not exceed 15% of the total weight.

Determination of the moisture content of granules: 1.0 g of sample was weighed to an accuracy of 0.001 and dried in an oven at a temperature of 100-105°C. The dried sample was cooled in a desiccator for 30 minutes and reweighed. The procedure was continued until a constant weight was achieved. The moisture content of the granules was calculated using the following formula. The moisture content should not exceed 2.0%.

$$W\% = ((a-b))/a \times 100$$

W – Moisture content of granules, %

a – Granule weight, g

b – Weight of granules after drying, g

Determination of granule flowability: 10 g of the granules was accurately weighed to an accuracy of 0.01 g and tested using an ERWEKA flowability tester. The funnel of this instrument has a conical section with a 60° angle, and the tip is cut off 3 mm below the bottom of the cone and is connected to a shaker. When the sampler was placed in the funnel and the start button was pressed, the funnel hole opened, and a stopwatch started simultaneously, and the time for all the powder to flow was recorded to the nearest 0.2 seconds. The following formula was used to determine the flowability.

$$Ку.ч = m/t$$

Ку.ч – Flowability of granules g/sec

m – Granule weight, g

t – Flow time, sec

Determination of tapped density of the granule: 5g was weighed accurately to 0.01g, poured into a graduated cylinder, and gently tapped until the volume was constant. Then,

divide the weight of the granule by its volume to find the tapped density.

P= M/V

P – tapped density, g/mm3

M – mass of the granules

V – volume of the granules

Determination of granules dispersion: 200 mL of hot water was added to 10 g of granules and stirred for 5 minutes; the granules should be dissolved completely or show slight turbidity without foreign matter.

Statistical Analysis

The experiments were repeated three times, and the data were reported as the mean±standard deviation. Analyses were performed using SPSS Statistics 26.0 software.

Results

Technological Parameters of Plant Raw Materials

The roots of *Glycyrrhiza uralensis* Fisch. Ex DC. with 1-3 mm particle sizes were extracted by 0.25% ammonia, the fruits of *Rosa acicularis* Lindl. by 40% ethanol, and the roots of the *Inula helenium* L. by 50% ethanol, and the amount of extractive matters was determined (Table 1).

Table 1. Extractive matters of plant raw materials

№	Plant raw materials	Particle sizes	Extractive matters, %	P value
1	Root of *Glycerrhiza uralensis*	1 mm	32.58±3.01	0.658
		2 mm	34.46±3.01	
		3 mm	32.81±1.47	
2	Root of *Inula helenium*	1 mm	55.27±2.93	0.828
		2 mm	56.69±2.83	
		3 mm	55.82±2.67	
3	Fruit of *Rosa acicularis*	1 mm	31.51±1.56	0.879
		2 mm	32.15±1.62	
		3 mm	31.66±1.58	

The results of determining the total and internal extraction coefficients of 2 mm raw materials are shown in Table 2.

Table 2. The internal and total absorption coefficients of the plant raw materials

Plant raw materials	Internal absorption coefficient	Total absorption coefficient
Root of *Glycerrhiza uralensis*	1.777±0.06	3.815±0.028
Root of *Inula helenium*	1.69±0.01	3.337±0.015
Fruit of *Rosa acicularis*	1.295±0.016	2.008±0.089

Determination of Biologically Active Compounds

Ascorbic acid was revealed in the fruit *Rosa acicularis* Lindl. using ethyl acetate-methanol (7:3, v/v) solvent system.

The spot in the chromatogram obtained with the test solution corresponds in Rf value and color to those obtained with the standard solution (Figure 1).

Figure 1. TLC of the fruit Rosa acicularis Lindl. (in UV 254 nm). 1.The fruit *Rosa acicularis* Lindl., 2. Reference ascorbic acid

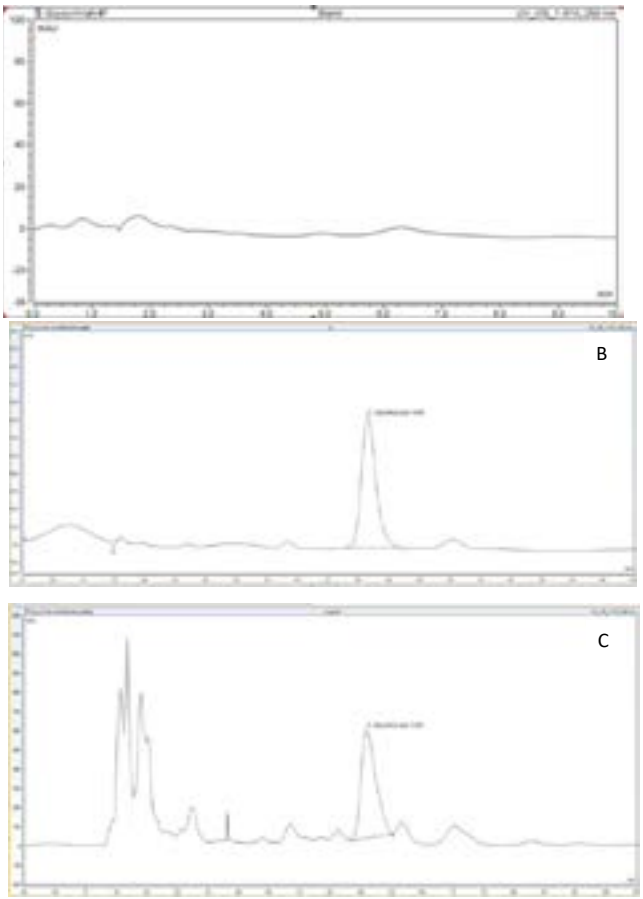

Figure 2. Figure 2. HPLC Chromatogram to reveal glycyrrhizic acid in the root of Glycyrrhiza uralensis Fisch. Ex DC. A.Chromatogram of blank solution, B.Chromatogram of standard glycyrrhizic acid, C. Chromatogram of the root of Glycyrrhiza uralensis Fisch. Ex DC.

The content of biologically active compounds in plant raw materials and extracts was determined by the Pharmacopoeia and Mongolian National Standard methods (Table 3).

Standard and Sample solutions were prepared according to the Section on the preparation of sample solution and standard solution, and 20 µL of each was injected into the HPLC system according to the chromatographic conditions given in the section on chromatographic procedures, and the chromatograms were recorded. A retention time was 5.65 min for glycyrrhizic acid, and glycyrrhizic acid was revealed in the root of *Glycyrrhiza uralensis* Fisch. Ex DC. (Figure 2).

A Technological Study to Prepare Extracts and Granules

After determining the extractive matters, particle size, total and internal absorption coefficients, liquid extracts were prepared from the plant raw materials and thick extracts were obtained from the liquid extracts. The fruits of *Rosa acicularis* were extracted with 50% ethanol, the roots of Inula helenium with 40% ethanol, and *Glycyrrhiza uralensis* with 0.25% ammonia solution.

The liquid extracts of roots of *Inula helenium* and fruits of *Rosa acicularis* were concentrated using a vacuum evaporator under the following conditions: temperature 60 °C, speed controller 54, pressure 650 mmHg. The liquid extract of *Glycyrrhiza uralensis* root was concentrated in a water bath, reducing 100 mL of liquid extract to 25 mL of thick extract. The main substances contained in the liquid and thick extracts were identified and quantified

Table 3. The content of biologically active compounds in plant extracts

Substance Name	Plant raw material	Liquid extract	Thick extract
Glycyrrhizic acid	3.51±1.73%	1.04±0.01%	2.87±0.08%
Ascorbic acid	1.91±0.1/%	0.47±0.06/%	0.73±0.06/%
Inulin	5.56±0.003%	4.72±0.002%	15.07±0.002%

Five different models of granules were prepared using the wet granulation method. Precisely weighed amounts of excipients were placed into a mortar, to which the thick extracts were gradually added while thoroughly mixing to form a homogeneous mass. The wet mass was extruded through a No. 2 sieve, and the prepared granules were dried at room temperature, resulting in five different formulations of granules.

Table 4. Composition of Granule models

Ingredients		Formulation code				
		F1	F2	F3	F4	F5
Active Ingredients	Thick Extract of Plant 1, mg	55	55	55	55	55
	Thick Extract of Plant 2, mg	175	175	175	175	175
	Thick Extract of Plant 3, mg	352	352	352	352	352
Excipient	Sucrose, mg	2418		-	-	-
	Glucose, mg	-	2418	-	-	-
	Sucrose, mg + Glucose, mg	-	-	1209+1209		
	Sucrose, mg + Lactose mg	-	-	-	1209+1209	-
	Glucose, mg + Lactose, mg	-	-	-	-	1209+1209
Total weight, mg		3000	3000	3000	3000	3000

Model 1 granules were excluded from the study because they had an irregular texture, were clammy, and could not be sieved.

Granule Quality Parameter Determination

The glycyrrhizic acid was revealed in granules (Figure 3), and the contents of glycyrrhizic acid, ascorbic acid and inulin in each granule model were determined (Table 5).

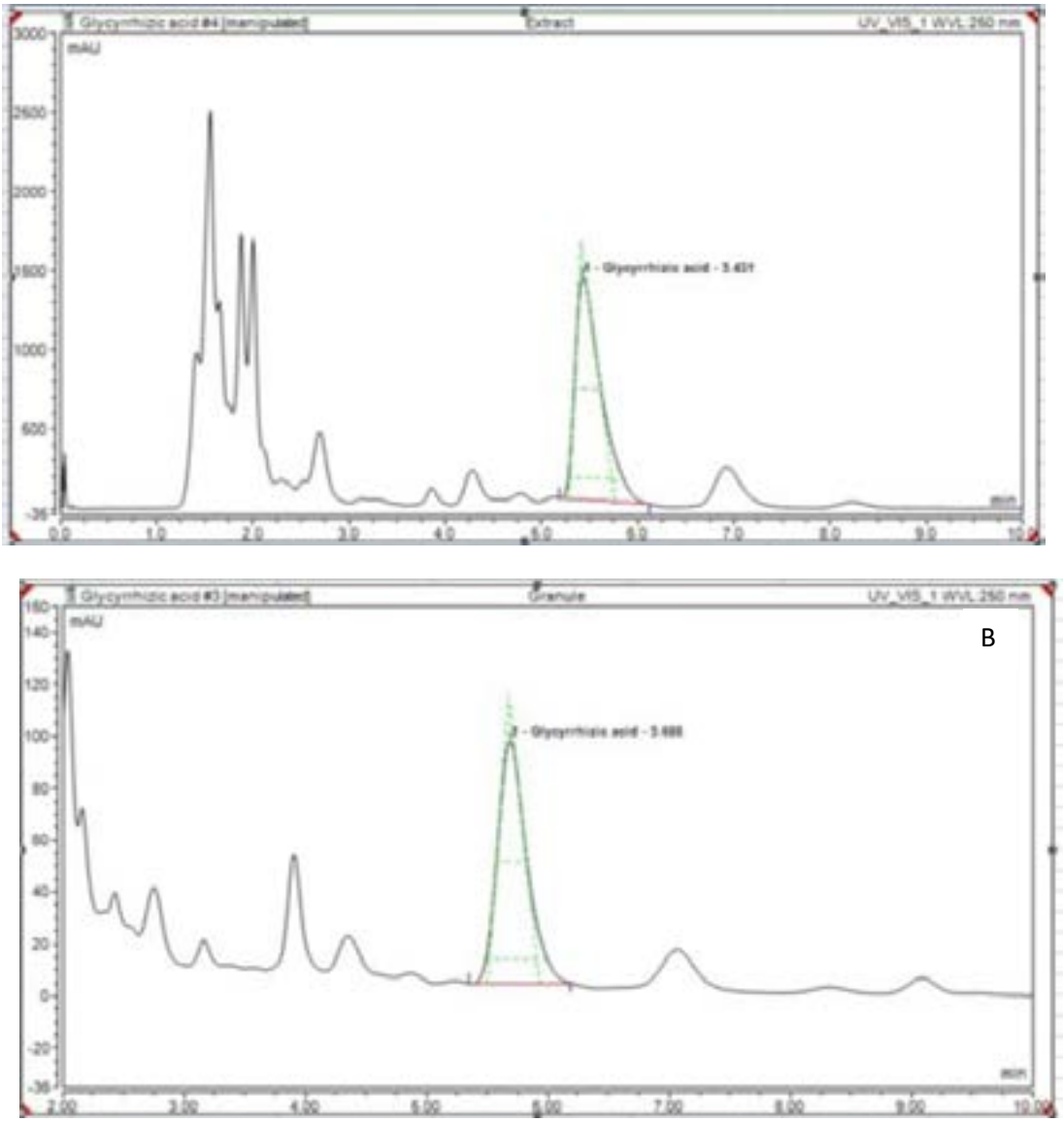

Figure 3. HPLC Chromatogram to reveal glycyrrhizic acid in the extract of *Glycyrrhiza uralensis* Fisch. Ex DC. and granules A. Chromatogram of liquid extract of root of *Glycyrrhiza uralensis* Fisch. Ex DC., B. Chromatogram of prepared granule model 2.

Table 5. The content of the biologically active compounds in the Granule models

Biologically active compounds	Models				P-value
	F2	F3	F4	F5	
Glycyrrhizic acid, %	0.092±0.002	0.0807±0.002	0.0798±0.001	0.0841±0.003	0.001
Ascorbic acid, %	0.267±0.028	0.25±0.05	0.183±0.029	0.233±0.057	0.182
Inulin, %	2.153±0.049	1.23±0.08	1.617±0.09	1.347±0.152	0.000

To determine the technological and quality parameters of the granules were determined (Table 6).

Table 6. Results of Granule Flowability Determination

Biologically active compounds	Models				P-value
	F2	F3	F4	F5	
Appearance:	Uniform	Uniform	Uniform	Uniform	
Texture	granules	granules	granules	granules	
Color	Light brown	Light brown	Light beige	Light beige	
Odor	Unique	Unique	Odorless	Odorless	
Taste	Bitterish	Mildly sweet	Bitter	Bitterish	
Particle Size, %	4.65±0.15	7.44±0.23	5.13±0.08	6.52±0.21	<0.001
Moisture Content %	1.32±0.79	1.91±0.87	1.46±0.4	1.36±0.64	0.617
Dispersion, minutes	0.29±0.05	1.42±0.05	2.55±0.28	1.07±0.32	<0.001
Flowability, g/sec	2.32±0.23	2.73±0.51	2.99±0.29	4.00±0.16	<0.001
Tapped density, g/sec	0.62±0.006	0.63±0.006	0.46±0.006	0.61±0.006	<0.001
Aerobic bacterial count, not exceeding 102	Less than	Less than	Less than	Less than	
Mould and yeast count, not exceeding 101	Less than	Less than	Less than	Less than	
E. coli, should not be detected	Not detected	Not detected	Not detected	Not detected	
Salmonella, should not be detected	Not detected	Not detected	Not detected	Not detected	

Discussion

Technological parameters, including the particle size of plant raw materials, the selection of solvents and extraction methods, influence the physicochemical aspects of extraction concerning yield, extract composition, and biological activity.[23] Reducing particle size is a crucial step in modifying the physical, chemical, functional, structural, and biological properties of raw materials, thereby enhancing the overall efficiency of the extraction process.[24,25] Therefore, it is necessary to determine the appropriate particle size before preparing the extracts from raw materials. In the frame of this study, the amount of extractive matter was defined using 1-3 mm powdered raw materials from three plants with suitable solvents. The most extractive matters were obtained from raw materials with a particle size of 2 mm, so this parameter was used in further study.

Glycyrrhizic acid is a triterpenoid saponin reported to possess multiple therapeutic properties, including anti-inflammatory, anti-ulcer, anti-allergic, antioxidant, anti-tumour, anti-diabetic, and hepatoprotective effects. It is used for the treatment of premenstrual syndrome and viral infections such as the common cold, viral hepatitis, human immunodeficiency virus (HIV), and acquired immunodeficiency syndrome.[26] The three major glycyrrhizic acid-producing species are *Glycyrrhiza glabra* L., *G. uralensis Fisch*., and *G. inflata Batal*.[27] The root of *Glycyrrhiza uralensis* Fisch. ex DC. is rich in glycyrrhizic acid, containing 31.1±0.2 mg/g.[28] Glycyrrhizic acid is optimally extracted with a 0.25% ammonia solution; therefore, this solvent was used

in the study, and the glycyrrhizic acid content in the root was determined to be 3.51±1.73 %.[29,30]

Inulin is a linear fructan (polysaccharide in nature) composed of fructosyl units [α(2 1) linkage] and usually contains one terminal glucose moiety [β(1 2 linkage] per molecule.[31] Studies have found that inulin possesses a wide array of biological activities, such as acting as a prebiotic to enhance the intestinal microbiome, regulating blood sugar, managing blood lipids, exhibiting antioxidant and anticancer properties, and aiding immune regulation, among others.[32] Preliminary clinical trials have elucidated the benefits of oral inulin supplementation in alleviating respiratory inflammation in adult asthmatics, improving asthma control and modulating the intestinal microbiome. This suggests a potential role for inulin as an adjunct in asthma treatment through short-chain fatty acids.[33,34] *Inula helenium* (elcampane) is one of the largest dicotyledonous herbaceous plants and serves as the richest source of inulin-type fructans, containing 19-44% of the inulin-type fructans.[35] Plant polysaccharides, such as inulin, are polar macromolecules that can be extracted using water or alcohol.[36,37] In this study, *Inula helenium* roots were extracted with 40% ethanol, and the inulin content was determined to be 5.56±0.003%.

Vitamin C, also known as L-ascorbic acid, is a water-soluble vitamin that is naturally present in some foods, added to others, and available as a dietary supplement. Unlike most animals, humans cannot synthesize vitamin C endogenously; thus, it is an essential dietary nutrient component.[38] Vitamin C is necessary for the body's numerous physical and chemical functions. It exhibits a range of biological and pharmacological activities, including antioxidant, anticancer, antidiabetic, anti-obesity, antihypertensive, and antihypercholesterolemic effects, as well as photo-protection, treatment in neurological diseases, enhancement of immunity, amino acid synthesis, and the repair of teeth and bones. Moreover, it can increase iron absorption and improve wound healing.[39] As a water-soluble vitamin, water is the primary and most effective solvent for ascorbic acid extraction. Other solvents, such as methanol, ethanol, and acetone, can also be used.[40,41] *Rosa acicularis* fruits are rich in ascorbic acid, with some studies reporting a content of 56.12±6.17 mg/g, and 4-10%.[12,42] In this study, *Rosa acicularis* fruits were extracted with 50% ethanol, and the ascorbic acid content was determined to be 1.91±0.1%.

Roots of *Glycyrrhiza uralensis*, *Inula helenium*, and *Rosa acicularis* fruits are rich in biologically active substances. In Mongolia, they serve as valuable raw materials for herbal preparations, and several studies have been conducted to produce medicinal and complementary products. Many individuals purchase raw medicinal plants and extract them themselves, which can lead to losing active ingredients if the extraction is not performed correctly. These raw materials are widely sold on the black market, where individuals buy and utilize plants without quality validation. Therefore, it is necessary to produce products from these plants. This study was conducted to develop herbal preparations using raw plant materials commonly used in our country.

D. Otgonsuren, et al. (2020) prepared granules from the root as part of a study to produce matrix tablets. Within the framework of that study, they examined the effect of granule diameter on quality and concluded that a diameter of 2 mm was suitable. The main compound in the developed matrix tablet is glycyrrhizic acid; each tablet contained 142.34±2.48 mg.[43] In this study, 5 granule models with a diameter of 2 mm were prepared, and technological and quality parameters were determined. Model 1 granules were excluded from the study because they had an irregular texture, were clammy, and could not be sieved, which indicated that sucrose is not suitable for preparing granules from these plants.

The study revealed that the quality and technological parameters of the granule F2 model were superior to those of the other models ($P < 0.001$). The prepared granule model F2 contains 0.092±0.002% glycyrrhizic acid. Ongoing pharmacological research on the prepared granules continues.

Conclusion

It is suitable to extract the roots of *Glycyrrhiza uralensis* Fisch, the root of *Inula helenium* L., and the fruits of *Rosa acicularis* Lindl. by powdering them into 2 mm particle sizes. Of the five models of extracts prepared by wet granulation from plant extracts, model 2 was superior to the others in terms of technological and quality parameters. Sucrose was not suitable for granulation as an excipient.

Author Contribution

A.L, S.Ts and P.S conceived the project and designed the research. A.L, J.D, A.B, M.B, S.Ts, Sh.A, S.Ts and P.S contributed to study conception, planning experiments and technical support. A.L, M.B, A.Ts and P.S conducted data analysis and data juterpre-tation, A.L, J.D, S.Ts, and P.S participated in the result discussion and technical support. A.L, J.D, S.Ts and P.S wrote the manuscript. All authors read and approved the final

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