



# Biological characteristics of *Megacarpaea gigantea* Regel fruits and their use in traditional medicine of Uzbekistan

D.T. Khamraeva, Nargiza K. Rakhimova, Rainer W. Bussmann, M.A. Halkuzieva

## Correspondence

D.T. Khamraeva<sup>1</sup>, Nargiza K. Rakhimova<sup>1</sup>, Rainer W. Bussmann<sup>2,3</sup>, M.A. Halkuzieva<sup>4</sup>

<sup>1</sup>Tashkent Botanical Garden named after F.N. Rusanov at the Institute of Botany of the Academy of Sciences of the Republic of Uzbekistan, 232 Bogishamol str., Tashkent, 100053, Uzbekistan.

<sup>2</sup>Department of Botany, State Museum of Natural History, 76135 Karlsruhe, Germany

<sup>3</sup>Department of Ethnobotany, Institute of Botany, Ilia State University, 0105 Tbilisi, Georgia

<sup>4</sup>National University of Uzbekistan named after M. Ulugbek, 4 Universitet str., Tashkent, 100174, Uzbekistan

\*Corresponding Author: hamraeva.dilovar@mail.ru

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## Abstract

**Background:** This article presents data on some biological, morphological, and anatomical features of the fruits of the valuable medicinal and honey plant *Megacarpaea gigantea* and their use in traditional medicine in Uzbekistan.

**Methods:** Standard methods were used to study the germination of *Megacarpaea gigantea* seeds in laboratory conditions. A written questionnaire was used to collect ethnobotanical data. The local population was surveyed with the consent of the respondents. Interviews were conducted in accordance with the Code of Ethics established by the International Society of Ethnobiology (ISE Code of Ethics, 2006).

**Results:** Due to the presence of fatty acids and other biologically active substances, *Megacarpaea gigantea* seeds are used internally as a medicinal remedy for kidney and gallbladder ailments, a fact that has been observed by local populations and tabibs over a long period of historical use. An analysis of herbarium specimens included in the electronic database of the National Herbarium of Uzbekistan, Institute of Botany, Academy of Sciences of the Republic of Uzbekistan, has identified the distribution areas of *Megacarpaea gigantea* in Uzbekistan (mountainous areas of Kashkadarya, Surkhandarya, Samarkand, Jizzakh, and Tashkent regions). The species is most found in the Samarkand and Kashkadarya regions, where the fruits are primarily collected by locals for ethnobotanical purposes. Three *Megacarpaea gigantea* seed samples, tested in laboratory conditions, failed to germinate due to pericarp sclerifications and high temperatures. A germination analysis of seeds in small containers sown in autumn and spring revealed significantly higher germination rates (up to 82-87%) in autumn, especially in clean sand. This is because the seeds sown in the autumn were subjected to natural stratification, their germination was at a satisfactory level, and with subsequent introduction work, *Megacarpaea gigantea* can be successfully grown based on the identified biological characteristics of the seeds.

**Conclusions:** The medicinal properties of *Megacarpaea gigantea* have been identified, and a seed germination experiment was conducted in laboratory conditions and small containers with a closed root system. The mucilaginous layer of the exotesta of the spermoderm plays a role in seed adhesion to the soil and accumulates moisture for embryo germination. The fatty oils in the myrosin cells of the embryo are adaptive features for its full growth and development in arid conditions

and have medicinal properties when consumed orally for gallstones and kidney stones due to their content of various beneficial fatty acids.

*Key words:* *Megacarpaea gigantea*, fruit, seed, seed germination, morpho-anatomical structure, traditional medicine.

## Background

Today, the importance of medicinal plants remains very high, despite the rapid development of synthetic pharmacology and biotechnology. Their role can be considered in pharmaceuticals, folk and traditional medicine, and elsewhere. Medicinal plants are not just a relic of traditional medicine, but a strategic resource for modern pharmacology, economics, and science. They remain a key source of new drugs and an important element of a comprehensive approach to human health. Furthermore, medicinal plants are part of biodiversity and cultural traditions, making their preservation particularly important. Approximately 60-70% of drugs on the modern pharmaceutical market are synthetic. Comparisons between synthetic and herbal drugs reveal both their advantages and disadvantages. The advantages of synthetic drugs include prolonged action, more selective effects on organs and systems, and precise dosing. Herbal drugs have fewer contraindications and side effects and are often less toxic to the body (<http://nashicveti.ru/stati/statya-lekarstvenniyerasteniya>).

It should be noted that many members of the *Brassicaceae* Burnett family have significant medicinal value, as they contain biologically active substances that influence metabolism, digestive function, and immunity, and possess antimicrobial and anti-inflammatory properties.

A rare Central Asian genus of this family, *Megacarpaea* DC., includes several rare and poorly studied species, found primarily in Central Asia (Pamir, Tien Shan, Hissar, and Hindu Kush). These species are perennial or biennial herbs, distinguished by their large fruits. Their medicinal value has not been fully elucidated, but in recent decades, information about their composition and potential uses has begun to emerge. Species of the genus have promising medicinal value due to their content of glycosinolates, flavonoids, and oils. In folk medicine, they are used as tonics and anti-inflammatory agents. Modern studies (Ijaz *et al.* 2023; Malik *et al.* 2023; Zhang *et al.* 2024; Bashir *et al.* 2025) confirm the antioxidant, antimicrobial, and potentially antitumor properties of species of the genus, but clinical evidence is still lacking.

In some regions of the Pamir and Tien Shan, decoctions and infusions of *Megacarpaea gigantea*, *M. delavayi*, and other species have traditionally been used as a remedy for colds; a root decoction for gastrointestinal disorders; and seed powder to stimulate appetite and improve digestion (Shen *et al.* 2009; Singh *et al.* 2022).

*Megacarpaea gigantea* is a rare representative of the genus *Megacarpaea*, growing on slopes and in subalpine and alpine meadows, typically at elevations of approximately 1000-3300 m above sea level. Native to Central Asia, it is found in the Pamir-Alai and Tien Shan mountains, and in certain areas of Western China (Xinjiang). Due to its limited range, *Megacarpaea gigantea* is considered a rare species and is listed as requiring protection in some national floristic lists (<https://www.plantarium.ru/page/view/item/23980.html>).

E.A. Kornelyuk (1974) describes the use of *Megacarpaea gigantea* roots as food and for treating weakness, as well as the consumption of young leaves in spring. In the Flora of the Tajik SSR (1978), it is described that fatty oils are found in the plant's seeds, and glycosides and alkaloids in the aboveground parts. The roots are also mentioned as being used as edible and in folk medicine as a tonic.

The plant's roots are reported to contain starch and were traditionally used as a turnip substitute. Limited medicinal use is noted (Pimenov *et al.* 1993).

*Megacarpaea gigantea* seeds are used to treat kidney disease and gallstones, as well as kidney inflammation (Khamraeva, 2023).

According to F.S. Sharopov *et al.* (2024), N-containing compounds (i.e., nitrogen-containing components) were found in the essential oil of *Megacarpaea gigantea*'s aboveground parts, which is unusual for the essential oils of many plants, including *Brassicaceae*. Scientists conducted antimicrobial/microbiological tests, and the oil demonstrated activity against several microorganisms.

There is considerable literature on the germination of seeds of members of the Brassicaceae family, but virtually no data on the biology of *Megacarpaea gigantea* seed germination in laboratory and field conditions.

Relatively good results were obtained in improving the germination of *Crambe maritima* L., a valuable Brassicaceae species, as generative propagation is hampered by the presence of a tough seed coat surrounded by a thick, corky pericarp, as well as a deep and prolonged dormancy period and low germination rates. Soaking *Crambe maritima* seeds in a gibberellic acid (GA) solution stimulated germination as early as the third day, and by the seventh day, germination rates reached 33.4-38.2%. However, when soaking seeds in a GA solution containing nanosilver at a concentration of 0.05-0.15 mg/L, germination exceeded 80% (Yurkova *et al.* 2019).

This study examines the use of *Megacarpaea gigantea* in folk medicine, its distribution in Uzbekistan, the biology of seed germination, and the morpho-anatomical characteristics of the fruit.

## Materials and Methods

*Megacarpaea gigantea* (giant large-fruited tree) is a perennial plant used for fodder, honey, and medicinal purposes (Fig. 1.a). It grows in fine-grained soils, on rocky slopes, and cliffs in the lower and middle mountain ranges. In Uzbekistan, it is distributed in the Tashkent, Samarkand, Kashkadarya, Jizzakh and Surkhandarya regions, and extends up to the middle mountain range of the Western Tien Shan (Kok-suv Range) and Pamir-Alay (Zerafshan, Aktau, Nuratau, and Hissar Ranges).

The plant has a large, carrot-shaped root (Fig. 1b). The stem is erect, robust, and glabrous, with extensive branching in the upper part, reaching 70-150 cm in height. The leaves are glaucous, bare, the lower stem leaves are oblong, pinnately parted, sometimes with lobed lobes, short-petiolate, the upper leaves are reduced, pinnately parted or entire, semi-clasping, sterile individuals are long-petiolate, obovate or almost rounded or polygonal-reniform, entire or, more often, palmately (sometimes deeply) parted. Peduncles with single curly hairs (Fig. 1c). Sepals are broadly oblong, mostly curly-haired, about 2.5 mm long. Petals are white, oblong or obovate, gradually narrowing into a short unguent, slightly more than ½ times longer than the sepals. There are 6 stamens. Fruit stems are bent downwards, thickened, bare, 1.5-2 cm long. The silicle with spherical wings. The valves of the silicle (sometimes a single locule develops) are often violet-colored, subelliptical, strongly flattened, with a non-inflated locule surrounded by a strong vein branching both inward and outward, and a wide reticulate-nerve wing enclosing almost the entire locule, 3-5 cm long; the stigma is subsessile or on a very short style. Blooms in April-May, fruits in May-July (Flora of Uzbekistan, 1955).

To collect ethnobotanical data, expeditions were carried out in the Samarkand and Navoi regions in 2021, using a written questionnaire. Local residents were interviewed via questionnaire with the consent of the respondents. Interviews were conducted in accordance with the Code of Ethics established by the International Society of Ethnobiology (ISE Code of Ethics, 2006).

We reviewed and georeferenced approximately 25 *Megacarpaea gigantea* herbarium specimens stored in TASH. Species record coordinates were imported into ArcGIS 10.5 and converted into a point map layer. The WGS84 geographic coordinate system was used as the reference database. Species distribution in Uzbekistan was delineated by the country's phytogeographic regions (Tojibaev *et al.* 2016). Seed germination was studied in the laboratory using standard methods (Nikolaeva *et al.* 1999).

Seeds were germinated in Petri dishes on filter paper in triplicate: 15 seeds in a thermostat, 20 seeds in a room, and 20 seeds in a refrigerator. The thermostat temperature was +25°C, the room temperature varied from +11°C to +20°C, and the refrigerator temperature was +3°C to +4°C. After the filter paper surface dried, it was moistened with distilled water. The experiments were conducted from November 2021 to April 2022.

When planting *Megacarpaea gigantea* seeds in late autumn (November 29-30, 2024) in small containers with closed root systems, we used a 2.5:2.5:1:1 ratio of organic fertilizer:soil:sand:vermiculite, or a second option of 100% sand. When planting in early spring (February 12, 2025), we used a 100% peat mixture.

*Megacarpaea gigantea* fruit cross-sections were stained with methylene blue and embedded in glycerol-gelatin using the standard method (Barykina, Chubatova 2005). A Canon A2300 camera was used to photograph the cross-sections.



a



b



c

Figure 1. *Megacarpaea gigantea*. a - general view of the plant, b - root and leaves, c - part of the inflorescence.

## Results and Discussion

### Ethnobotany

During research trips to the Samarkand and Navoi regions, we conducted an ethnobotanical survey among individuals engaged in the procurement and sale of medicinal herbs and tabibs. This research identified several species and medicinal mixtures used by the local population to treat a variety of ailments.

According to local tabibs and individuals selling various herbs and mixtures, the seeds of *Megacarpaea gigantea* (local name “Ravo”) have been used medicinally for many decades. People in the Samarkand and Navoi regions consume the seeds of this plant to treat kidney stones, gallstones, and kidney inflammation. Some tabibs recommend chewing one seed half an hour before meals for 1-3 months (Fig. 2). In addition, on the recommendation of other tabibs of the Samarkand region of the Akdarya region, for the treatment of kidney stones, it is necessary to consume 3 seeds twice a day at 6 a.m. and 6 p.m. during the peak activity of the kidneys for 10 days.



Figure 2. Seed package of *Megacarpaea gigantea* for sale

This survey was conducted primarily among men, as they are the ones who practice medicine or sell medicinal herbs at markets or in specialized stores. Their ages ranged from 28 to 61 years. In the Samarkand region, the survey was conducted in two districts - Kattakurgan and Narpai districts, and in the Navoi region in the city of Navoi. The local population purchases the seeds of the plant from merchants in the markets or from the tabibs themselves, who prescribe them a prescription for the treatment of a particular disease.

The fruit of *Megacarpaea gigantea* is a typical silicle, 2.5-4 cm long, 1.5-2.6 cm wide, their average values are  $3.0 \pm 0.012$  cm and  $2.1 \pm 0.014$  cm, respectively. N.T. Ul'chenko *et al.* (2001) found that *Megacarpaea gigantea* seeds contain a significant proportion of polyunsaturated 29.5% and monounsaturated 24.0% fatty acids, as well as a relatively high proportion of erucic acid 17.1%; the dominant components of neutral lipids in the seed are triacylglycerides with conventional fatty acids 89.7%; oxygen-containing triacylglycerides with triterpenols 5.9%; free fatty acids 0.7%; diacylglycerides with sterols 0.6% and other substances. Based on these authors' data, we believe that it is possible that the presence of the aforementioned fatty acids and other biologically active substances is the reason why the plant seeds are used internally as a medicinal remedy for kidney and gallbladder ailments, as has been observed by local populations and tabibs over a long period of historical use.

Furthermore, according to some sources (Sumnevich, 1942; Tsapalova *et al.* 2005), the roots of *Megacarpaea gigantea* are used as a vegetable by locals (Sakhobiddinov, 1948). Because the roots contain a lot of starch, they have long been consumed boiled or baked, like potatoes. They are also used to extract starch and distill alcohol.

The cooked tubers taste like rutabaga and can weigh 1 kg or up to 47.81 kg. Locals harvest the roots from June until the following spring (Sumnevich, 1942).

Chemical analyses have shown that the roots of *Megacarpaea gigantea* contain (in percent): starch - 42, protein - 16.5, carbohydrates - 16.4; and the leaves contain: protein - 12.4, starch - 26, carbohydrates - 13. *Megacarpaea gigantea* root has long been consumed by locals, fresh or cooked. The mountain population (mainly Tajiks) of Hissar prepared flour from the roots of *Megacarpaea gigantea* and baked flatbreads mixed with cereal flour or often only from *Megacarpaea gigantea* flour. *Megacarpaea gigantea* flour is also used as feed for cows after calving. *Megacarpaea gigantea* seeds contain 24% semi-drying oil suitable for human consumption. *Megacarpaea gigantea* makes good ensile and is readily consumed (dry, ensiled, and fresh) by all types of livestock. It is also a good honey plant. Its flowering period lasts 30-35 days. It is very ornamental in bloom and especially when fruiting (Khaidarov, 1965).

Thus, based on our analysis of the literature and our research data, the following can be identified:

1. Between the 1930s and 1970s, the majority of the population of Uzbekistan used *Megacarpaea gigantea* roots for food, as a vegetable or to obtain flour for baking.
2. Over time, beginning around the 1990s, tabibs began actively using long-forgotten, but passed down from their ancestors, folk remedies for treating illnesses. Therefore, for several decades, *Megacarpaea gigantea* seeds have been used to treat gallbladder and kidney diseases.

### Mapping

Based on an analysis of herbarium specimens included in the electronic database of the National Herbarium of Uzbekistan, the Institute of Botany, Academy of Sciences of the Republic of Uzbekistan, we identified the distribution areas of *Megacarpaea gigantea* across the country (Fig. 3). In Uzbekistan, the species is found in the mountainous areas of Kashkadarya, Surkhandarya, Samarkand, Jizzakh, and Tashkent regions. It is most commonly found in the Samarkand and Kashkadarya regions, where the fruits are primarily collected by local populations for ethnobotanical purposes.



Figure 3. Map of the distribution of *Megacarpaea gigantea* in Uzbekistan

### Seed germination biology under laboratory conditions and in small containers with a closed root system

To study *Megacarpaea gigantea* seed germination, we used three conditions: a thermostat, a room (with variable temperature), and a refrigeration chamber (Fig. 4 a, b, c). For best results, the seeds were first separated from the pericarp. The seeds were observed for several months, inspected every other day. Active moisture evaporation was observed in the

thermostat and variable temperature conditions. After 5-6 days, the seeds in the refrigeration chamber began to swell, while in the thermostat and variable temperature conditions, they swelled less significantly. The seeds were kept in the thermostat for only a month, during which time 90-98% of the seeds had rotted, which is likely due to the negative sensitivity of the seeds to high positive temperatures. From the 39th day, the seeds in the refrigeration chamber began to rot. On the 44th day, the seeds in the room condition also began to rot. By the end of February 2022, almost all the seeds from the three variable-temperature replicates had rotted. However, during March, about 30% of the seeds in the cold refrigeration chamber remained viable, and by the end of April, the remaining seeds also failed to germinate and rotted.

*Megacarpaea gigantea* seeds planted in small containers with closed root systems in late fall emerged on February 6-7, 2025. Seed germination was 82-87% in the sand medium, and 75% in the mixed substrate (Fig. 4 d). Seeds sown in early spring emerged on March 31, with a germination rate of 20-25%. The seedlings were transplanted into open ground, and as juveniles, they entered dormancy in the third ten-day period of May (Fig. 4 e).

Analysis of the germination rates of seeds sown in the fall and spring revealed significantly higher germination rates in the fall, especially in clean sand. This is because the seeds sown in the autumn were subjected to natural stratification, their germination was at a satisfactory level, and in subsequent introduction work it is possible to successfully grow *Megacarpaea gigantea* based on the identified biological characteristics of the seeds.

#### **Fruit morphology and anatomical structure**

The fruit is dry, single-seeded, formed from two carpels, syncarpous, indehiscent, and fractional (Fig. 5 a). Seeds are 15-17 mm long and 12-14 mm wide, oblong-flattened, yellow-green to yellow-brown (Fig. 5 b). The seed surface is matte and finely folded. The embryo is large, filling the entire seed, curved, and longitudinally folded, the axial part is somewhat shorter in length than the cotyledon leaves (Fig. 5 c). The axial part is 11 mm long; the cotyledons are 15 mm long. The cotyledons are folded parallel; the root is adjacent to their margins and located in the depression formed by the cotyledons.

The pericarp consists of three layers. The exocarp is single-layered; the cells are thickened, lignified, and vary in shape - rounded, elongated, and cubic (Fig. 5 d). The cell surface is angular, covered with a cuticle, and thicker in some areas. The mesocarp consists of two distinct parts: Part 1 consists of lignified cells up to 1-(2) layers; Part 2 consists of thin-walled parenchymatous cells, which are represented by large or small, shapeless cells with broken walls. The mesocarp contains vascular bundles, and the integrity of the parenchymatous cells can be noted at the sites of the bundles. The vascular bundles have several small vessels; the bundles themselves consist of large and small veins. Phloem is more developed than xylem. Above the bundles, there are small strands of small, densely located sclerenchymatous cells. Closer to the endocarp, the parenchymatous cells of the mesocarp are somewhat flattened in width and small. The endocarp is single-layered, the inner tangential walls are thicker than the outer ones, the cells are horizontally elongated, of varying sizes.

The spermoderm consists of the testa and tegmen (Fig. 5 e). The testa consists of three parts: the exotesta, mesotesta, and endotesta. The exotesta contains a pigment layer that is highly compressed and tangentially elongated. Beneath the pigment layer are cells with inclusions of mucus and starch, making the layers indistinguishable. Next follows the mesotesta, consisting of thin-walled parenchymatous cells with sinuous lateral and tangential walls, horizontally elongated cells, and indistinguishable layers. The endotesta is highly compressed, with obliterated lateral walls and highly flattened tangential walls, forming a solid, lignified layer. The tegmen is present as the remnants of a thin, highly obliterated layer.

The cotyledon is lanceolate in cross section, oblique on both sides on the lower surface, and slightly convex around the main procambial bundle (Fig. 6 a, b). There are numerous procambial bundles: one main one, small (23-30) and large (2) lateral bundles, which consist of phloem. Myrosin cells containing oils are located around the bundles. The abaxial epidermis is somewhat fine-celled than the adaxial one. The mesophyll is isopalisade, consisting of densely packed elongated-oval columnar cells in up to 9-11 rows (Table 1).



Figure 4. Germination of *Megacarpaea gigantea* seeds under various conditions. a - in a thermostat, b - in a refrigerator, c - in a room, d - seedling from a container in a mixed substrate, e - juvenile plant transplanted into open ground (May 12, 2025).

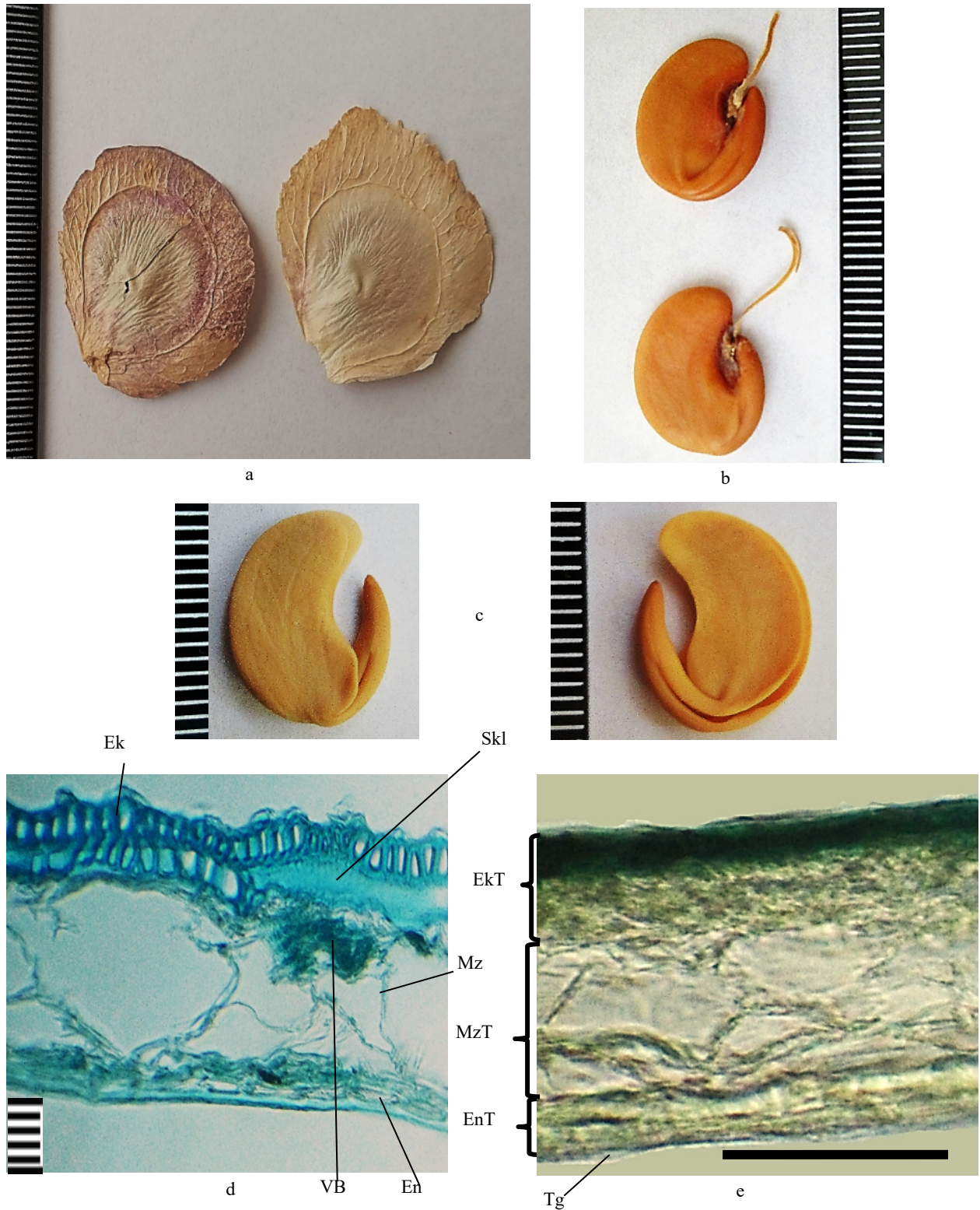


Figure 5. Fruit and seed structure of *Megacarpaea gigantea*. a - fruit, b - seed, c - embryo, d - pericarp structure, e - spermoderm structure.

Scale bar: a-c - 1 mm, d-e - 50 μm. Ek - exocarp, EkT - exotesta, En - endocarp, EnT - endotesta, Mz - mesocarp, MzT - mesotesta, Skl - sclerenchyma, Tg - tegmen, VB - vascular bundle.

Table 1. Quantitative structural characteristics of the embryonic cotyledon *Megacarpaea gigantea*

Indicators		
Epidermal cell height, $\mu\text{m}$	Abaxial	18,42 $\pm$ 0,61
	Adaxial	24,48 $\pm$ 0,96
Cotyledon thickness, $\mu\text{m}$	in the region of the main beam	921,19 $\pm$ 7,6
	on the side	622,38 $\pm$ 6,83
Number of rows of palisade tissue in the central part		10,8 $\pm$ 0,23
Palisade cells, $\mu\text{m}$	Height	59,58 $\pm$ 1,19
	Width	27,24 $\pm$ 1,04
	height to width ratio	2,19
Number of vascular bundles		27,71 $\pm$ 0,49

The hypocotyl is rounded-triangular in cross section (Fig. 6 c, d). The main procambial bundle is located in the central part, and on both sides, there are two large and one small procambial lateral bundle on one side. The hypocotyl is of a stem structure. The epidermis is single-layered, small-celled. The main parenchyma of the hypocotyl is round-oval, containing up to 26-30 rows of chlorophyll. The procambial bundles also have a sheath of myrosin cells.

The radicle is rounded-oval in cross section (Fig. 6 e, f). The root cap is two-layered, with smaller cells than those of the single-layer epidermis. The bark parenchyma is chlorophyll-bearing, rounded-oval, with up to 10-12 rows along the minor diameter and 10-14 rows along the major diameter. The procambial central cylinder occupies a small volume and is rounded-oval in shape. The radicle has clearly defined uniseriate endodermis and pericycle. The vascular system is diarchic.

The fruit is dry, one-seeded, formed from two carpels, syncarpous, indehiscent, disintegrating, fragmented. According to V.I. Dorofeev (2004 a, 2009), representatives of the tribe *Cremolobeae* R.Br. have a two-nut fruit (*Coronopus* Zinn, *Megacarpaea* DC., etc.). Each of the two valves of such a fruit is fused at its edges and encloses one ovule in a closed cavity. That is, the ovules are formed only in the valved part of the fruit, and the author suggests calling this fruit valvate (fructus valvatus).

The anatomical structure of the pericarp is characteristic of indehiscent fruits of species of the *Brassicaceae* family; therefore, in this particular species, one can note a structure related to the ecological conditions of growth. Representatives of humid regions have a not very dense mechanical layer of relatively thin-walled cells, while species from arid regions have a very thick mechanical layer of one or several rows of densely packed thick-walled cells (Dorofeev, 2004 b). Consequently, we noted sclerification of the exocarp and the upper part of the mesocarp, as well as thickening of the internal tangential walls of the endocarp. The internal part of the mesocarp consists of large or small amorphous parenchymatous cells with torn walls; in places of vascular bundles, the cell walls remain intact.

The spermoderm structure of various *Brassicaceae* representatives is so diverse that not only genera but also individual species are characterized by a specific structure. In species with a hard pericarp, the spermoderm is particularly delicate and lacks mechanical tissue (*Neslia* Desv., *Crambe* L., *Bunias* L.), while in species with poorly developed pericarp mechanical tissue (*Isatis tinctoria* L., *Raphanus raphanistrum* L.), it is almost normally developed (Alyavdina, 1931).

In the studied species *Megacarpaea gigantea*, the pericarp consists primarily of sclerified and slightly parenchymatous layers, which correlates with the delicate and thin layer of the spermoderm. According to our data, the spermoderm of *Megacarpaea gigantea* is divided into the testa and tegmen, and the testa itself is divided into the exo-, meso-, and endotesta. The exotesta is characterized by a pigment and mucilaginous layer, the cells of which are filled with starch, while the cells of the endotesta have lignified, flattened tangential and obliterated lateral walls. The tegmen is almost invisible, with traces of a thin layer remaining.

The embryo is large, filling the entire seed, complete, and divided into three distinct parts: the cotyledons, the hypocotyl, and the radicle. The taxonomy of the *Brassicaceae* family uses the position of the radicle relative to the cotyledons (Comparative Anatomy of Seeds, 1992). Compared to other representatives of the family, whose seeds are small - less than or up to 1 mm in *Sisymbrium officinale* (L.) Scop., *Lepidium ruderale* L., up to 3 mm in some species of the genera *Brassica* L., *Iberis* L., *Macropodium* R.Br., up to 8 mm in species of the genus *Lunaria* L. (Comparative anatomy of seeds, 1992), and in *Megacarpaea gigantea*, relatively large - up to 17 mm, respectively, and the embryo, in addition, the axial part of the embryo is equal in length to the cotyledons, which provides an advantage for the rapid development of seedlings in arid regions of mountainous areas.

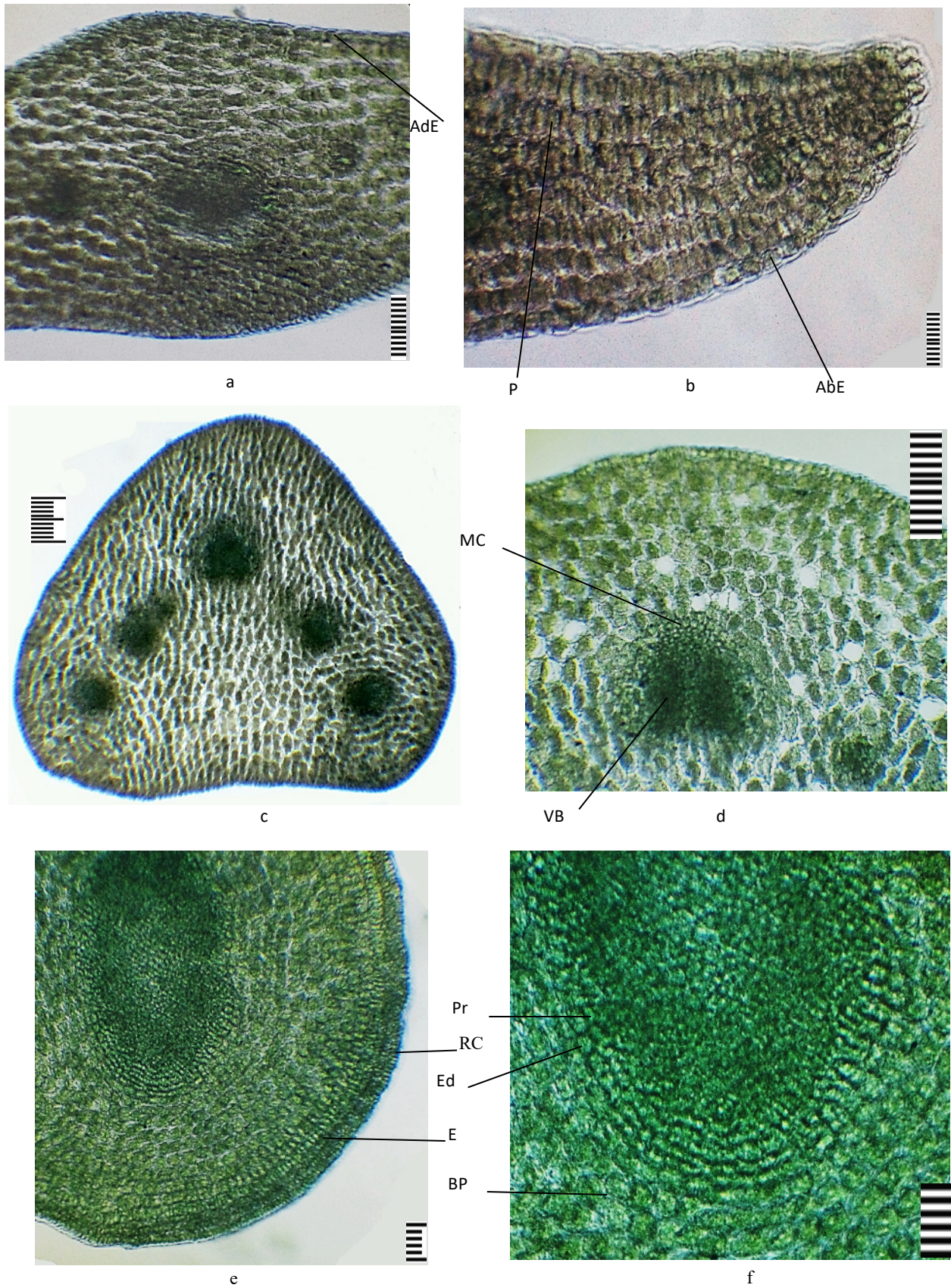


Figure 6. Structure of the *Megacarpaea gigantea* embryo. a, b - structure of the cotyledon, c, d - structure of the hypocotyl, d, e - structure of the radicle. Scale bar: a-d - 100  $\mu$ m, e - 50  $\mu$ m. AbE - abaxial epidermis, AdE - adaxial epidermis, BP - bark parenchyma, E - ectoderm, Ed - endoderm, MC - myrosin cells, P - palisade, Pr - pericycle, RC - root cap, VB - vascular bundle.

The cotyledon has an isopalisade mesophyll with numerous vascular bundles. The hypocotyl in cross section is round-triangular in shape, stem-like in structure. The radicle in cross-section is rounded-oval, with a diarch vascular system. In the axial portion of the embryo, the main parenchymatous tissue is chlorophyll-bearing. Myrosin cells (oil-containing cells) are present in the procambial bundles as a lining. The isopalisade nature of the mesophyll and the dense arrangement of palisade cells in the cotyledons, as well as chlorophyll-containing cells in the axial portion of the embryo, increase the amount of organic matter synthesizing.

Thus, the identified medicinal properties of *Megacarpaea gigantea* are of particular interest to the pharmaceutical industry, with the potential for targeted, in-depth research as a new treatment and preventative measure for gallstones, kidney stones, and inflammatory kidney diseases. Future studies will naturally require more in-depth phytochemical, pharmacological, toxicological, and other types of studies to identify the active ingredients with properties to dissolve salts and stones in the gallbladder and kidneys.

A laboratory seed germination experiment showed that *Megacarpaea gigantea* seeds failed to germinate due to sclerifications of the pericarp (the exocarp and upper mesocarp) and positive high temperatures. However, growing seeds in small containers with a closed root system at two planting times (late fall and early spring) showed high germination rates of up to 82-87% in the fall using ordinary sand as a substrate. Autumn-winter precipitation promotes the natural washing out of inhibitors (abscisic acid) in the seed and overcoming the physiological dormancy of the embryo.

Based on a comparative morphological and anatomical study of the spermoderm of species of the genus *Stroganowia* Kar. et Kir. (Karpova, Yakovleva, 2012), the authors drew conclusions about the degree of expression of the exotesta mucus layer and its adaptation for moisture accumulation. According to these authors, in some species, the outer cell walls rupture when moistened, and mucus is released beyond the cells, while in other species, they do not rupture, and when exposed to moisture, the exotesta cells increase in size. Species with rupturing outer walls of mucus-producing cells have a short growing season and early fruiting (May-June) and grow in arid lowlands, arid and subarid mid-mountains. Species with non-rupturing outer walls of mucus-producing cells grow in subarid and humid mountains and have later fruiting periods. *Megacarpaea gigantea* has a short growing season and early fruiting (May-June), growing in low- and mid-mountain areas. Based on the above results, it can be concluded that the mucilaginous exotesta layer of the *Megacarpaea gigantea* seed coat likely promotes better seed-soil adhesion and accumulates moisture for embryo germination. Furthermore, the fatty oils in the myrosin cells are adaptive features of the embryo, providing nutrients for its proper growth and development in arid conditions. The seeds are also consumed by people to help liquefy gallstones and kidney stones due to the presence of various beneficial fatty acids.

## Declarations

**Ethics approval and consent to participate:** All participants involved in the interview process gave their prior informed oral consent.

**Consent for publication:** Not applicable.

**Competing interests:** The authors declare that they have no competing interests.

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**Availability of data and materials:** The data was not deposited in public repositories but is available from the corresponding author upon request.

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