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# Micro- and ultramorphological features of the leaf cells of Myrtus communis L. as a parameter for the standardization of medicinal plant syrup are the basis for new herbal remedies

V. M. Odyntsova*[A,E,F], O. Ye. Matsehorova[A,B,C,D], S. I. Tertyshnyi[A,B,E,F], Yu. F. Polkovnikov[A,E,F]

Zaporizhzhia State Medical and Pharmaceutical University, Ukraine

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***E-mail:**
odyntsova1505@gmail.com

In the context of war, developing and standardizing new medicinal plants, such as *Myrtus communis* L., can significantly enhance the availability and effectiveness of medicinal products. The micro- and ultramorphological features of the leaf cells of this species could become crucial parameters for their identification and standardization, thereby facilitating the introduction of new, effective medications into practice.

**The aim of the work** is to study the morphological and anatomical structure and determine the general diagnostic microscopic features of leaves and the structure of meristem cells of common myrtle.

**Materials and methods.** Microscopic analysis of temporary leaf preparations of *Myrtus communis* L. was carried out using a Carl ZEISS "AxioStar Plus" and "Primo Star" microscopes with a photographic attachment for work in both direct and reflected light. The ultrastructure of leaf cells was additionally studied using transmission electron microscopy methods. Ultra-thin sections, 60 nm thick, were obtained on a Reichert Om 43 ultramicrotome. Sections were contrasted with a 1 % solution of uranyl acetate and lead citrate for 2 minutes in each solution at room temperature. Ultrathin sections were studied using a PEM-100-01 electron microscope at an accelerating voltage of 75 kV.

**Results.** The external features of common myrtle (*Myrtus communis* L.) leaves are described, including their shape, color, and type of veining. Anatomical features of the leaf include the presence of convoluted epidermal cells, anomocytic stomata located on the abaxial surface of the leaf, calcium oxalate crystals and druses, simple hairs on the midvein, and schizolysigenous secretory receptacles.

The ultrastructure study of common myrtle leaf cells revealed characteristic structural components of various cell types, including a nucleus with a nucleolus, chloroplasts with plastoglobules and starch grains, a Golgi complex with numerous dictyosomes, endoplasmic reticulum, mitochondria, lysosomes, oil droplets, and myrtle characteristic storage inclusions such as amyloplasts.

During electron microscopy, mature secretory receptacles were observed, with visible remnants of cells in the lumen. They are surrounded by cells with a high metabolic rate, as well as senescent cells that appear darker, with low organelle definition and tortuous walls.

**Conclusions.** The leaves of *Myrtus communis* L. have a hypostomatic leaf type, with the lower epidermis containing a significant number of uniformly arranged stomata of the anomocytic type. Simple unicellular hairs are present only on the central vein. Shared anatomical features with other species in the *Myrtaceae* family include the presence of druses and prismatic calcium oxalate crystals, along with schizogenous secretory receptacles that produce lipophilic substances.

The ultrastructure of meristem cells and cells adjacent to the secretory receptacles in *Myrtus communis* includes cell membrane, cytoplasm, nucleus, mitochondria, vacuoles, chloroplasts, Golgi complex with numerous dictyosomes, endoplasmic reticulum, lysosomes, oil droplets, and amyloplasts, which are starch-storing inclusions characteristic for the species. Mature secretory receptacles were found, within which cell remnants are surrounded by metabolically active cells and senescent, darker cells with poorly defined organelles and convoluted walls.

Recommended parameters for the standardization of *Myrtus communis* L. medicinal plant material: microscopic indicators include the anomocytic type of stomatal apparatus with hypostomatic placement, simple hairs, the presence of druses and prismatic calcium oxalate crystals, and schizogenous secretory receptacles. Ultramorphological indicators include cell membrane, cytoplasm, nucleus with nucleolus, chloroplasts with plastoglobuli and starch granules, Golgi complex with numerous dictyosomes, endoplasmic reticulum, mitochondria, lysosomes, oil droplets, characteristic storage inclusions (amyloplasts), and the presence of secretory receptacles.

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## Мікро- та ультраморфологічні особливості клітин листя Myrtus communis L. як параметр стандартизації лікарської рослинної сировини – джерела нових фітопрепаратів

В. М. Одинцова, О. Є. Мацегорова, С. І. Тертишний, Ю. Ф. Полковніков

В умовах війни вивчення та стандартизація нових видів лікарської сировини, зокрема *Myrtus communis L.*, можуть істотно покращити доступність та ефективність лікарських засобів. Мікро- й ультраморфологічні особливості клітин листя цього виду можуть стати важливими параметрами для ідентифікації та стандартизації, що сприятиме впровадженню нових ефективних медичних препаратів у практику.

**Мета роботи –** дослідження морфолого-анатомічної будови та визначення загальних діагностичних мікроскопічних ознак листя та будови меристемних клітин мирту звичайного.

**Матеріали і методи.** Мікроскопічний аналіз тимчасових препаратів листя *Myrtus communis* L. здійснили на мікроскопі Carl ZEISS «AxioStar Plus» та «Primo Star» із фотонасадкою для роботи у прямому й відбитому світлі. Ультраструктуру будови клітин листя додатково вивчали, використовуючи методи трансмісійної електронної мікроскопії. Ультратонкі зрізи завтовшки 60 нм одержували на ультрамікротомі Reichert Om 43. Зрізи контрастували 1 % розчином уранілацетату та цитрату свинцю протягом 2 хвилин у кожному розчині за кімнатної температури. Ультратонкі зрізи вивчали в електронному мікроскопі ПЕМ-100-01 при прискорювальній напрузі 75 кВ.

**Результати.** Описано зовнішні ознаки листя мирту звичайного: форму, колір, тип жилкування. Анатомічні особливості листка включають наявність звивистих епідермальних клітин, аномоцитних продихів, що розташовані на абаксіальній поверхні листка, кристалів і друзів оксалату кальцію, простих волосків на середній жилці, схізолізогенних секреторних вмістищ. Під час дослідження ультраструктури клітин листя мирту звичайного виявлено характерні структурні компоненти різних типів клітин, що включають ядро з ядерцем, хлоропласти з пластоглобулами та крохмальними зернами, комплекс Гольджі з численними диктіосомами, ендоплазматичний ретикулум, мітохондрії, лізосоми, краплі олії та характерні для мирту запасні включення – амілопласти. У результаті електронної мікроскопії виявлено зрілі секреторні вмістища, у просвіті яких були залишки клітин. Вони оточені клітинами з високим рівнем метаболізму та клітинами, що старіють, стають темними, з низькою чіткістю органел і звивистими стінками.

**Висновки.** Листя *Myrtus communis* L. має гіпостоматичний тип листової пластини; нижній епідерміс містить значну кількість рівномірно розташованих продихів з аномоцитним типом продихового апарату. Прості одноклітинні волоски виявлено тільки на центральній жилці. Спільні з іншими видами родини миртових анатомічні особливості – наявність друз і призматичних кристалів оксалату кальцію та схізолізогенних секреторних вмістищ, що продукують ліпофільні речовини. Ультраструктура клітин меристеми та клітин, що прилягають до секреторних вмістищ *Myrtus communis*, включає клітинну мембрану, цитоплазму, ядро, мітохондрії, вакуолі, хлоропласти, комплекс Гольджі з численними диктіосомами, ендоплазматичний ретикулум, лізосоми, краплі олії та характерні для мирту звичайного запасні включення – амілопласти. Виявлено зрілі секреторні вмістища, у просвіті яких містяться залишки клітин, що оточені клітинами з високим рівнем метаболізму та більш темними клітинами, що старіють, із низькою чіткістю органел і звивистими стінками. Рекомендованими параметрами для стандартизації лікарської рослинної сировини *Myrtus communis* L. є мікроскопічні показники, що включають аномоцитний тип продихового апарату з гіпостоматичним розташуванням, прості волоски, наявність друзів і призматичних кристалів оксалату кальцію та схізолізогенних секреторних вмістищ; ультраморфологічні – клітинна мембрана, цитоплазма, ядро з ядерцем, хлоропласти з пластоглобулами і крохмальними зернами, комплекс Гольджі з численними диктіосомами, ендоплазматичний ретикулум, мітохондрії, лізосоми, краплі олії; характерні для мирту запасні включення – амілопласти та наявність секреторних вмістищ.

**Сучасні медичні технології. 2024. Т. 16, № 4(63). С. 292-302**

Under martial law, amid a full-scale Russian invasion, it is crucial to provide aid to the wounded and to strengthen both the physical and mental health of the population, as the ongoing military actions can have a significant negative impact on public health. According to the Ministry of Health of Ukraine, the number of people who will experience negative mental health consequences due to the war is expected to rise daily. Preliminary forecasts suggest that approximately 15 million Ukrainians will need psychological support in the future. Mental disorders can adversely affect physical health, increasing the prevalence of cardiovascular diseases, diabetes, arthritis, asthma, and cancer; in cases of severe trauma, these risks may manifest 10–15 years earlier than the population average [1]. Therefore, it is crucial to employ simple, effective, and safe medicinal products, with herbal remedies playing an important role.

Treating the wounded during war requires substantial resources, including medications for infection prevention, pain relief, and wound healing. Many medicinal plants possess potent therapeutic properties that can effectively treat various diseases and injuries. Studying these properties and developing new medical preparations from plant-based materials can enhance the effectiveness of medical care. Additionally, the use of plant raw materials can reduce reliance on imported drugs and ensure a steady supply of essential medical supplies.

Common myrtle is a valuable medicinal plant belonging to the myrtle family (*Myrtaceae*). It has two subspecies: *Communis* and *Tarentina*, which differ in their morphological features [2]. Common myrtle (*Myrtus communis* L.) is the only species found in Europe. It is an evergreen shrub, ranging from 0.5 to 6.0 meters in height, characterized by opposite leaves, rough bark, white flowers (with five to nine petals), and berries. Depending on the genotype, these berries can be pigmented (dark blue or dark red) or non-pigmented (white) at the ripening stage, with various shapes such as spherical, elliptical, ovoid, or pear-shaped [3]. Plants with pigmented fruits belong to the melanocarpa variety, while those with non-pigmented fruits are classified as leucocarpa. The melanocarpa variety, which is widely found both in the wild and in cultivation, is commonly used as raw material in the liquor industry [4].

Some characteristics of the myrtle bush, such as its abundant summer flowering, evergreen leaves, persistent fruits, and the presence of multi-colored mutations, make it suitable for decorative use [4].

Various components of *Myrtus communis* leaves have been found to be pharmacologically active. The essential oil from the leaves of *M. communis* has been the subject of numerous chemical and pharmacological studies. It has been established that 1,8-cineole, linalool, and α-pinene are the main components of the essential oil, and they are present in varying quantities in the raw materials from different parts of *Myrtus communis L.*, regardless of geographical factors (such as temperature, soil quality, and day length), time of collection, or species genotype [5,6,7].

Myrtle essential oil has antibacterial properties. It can inhibit the formation of biofilms by *Staphylococcus aureus* and disrupt cell biofilm metabolism in all studied strains (*E. coli*, *P. aeruginosa*, *P. carotovorum*, *L. monocytogenes*), with the exception of *Staphylococcus aureus*. Additionally, the oil has shown cytotoxic and antiacetylcholinesterase activities [5].

Myrtle essential oils have gained attention as potential ingredients in functional foods and nutraceuticals due to their benefits for weight management, antioxidant status, and antilipidemic effects. This was demonstrated in a study where laurel and myrtle essential oils were administered intragastrically to rats over a period of two weeks. The treatment led to weight loss, reduced glycolytic activity, improved lipid parameters (including cholesterol, triglycerides, low-density lipoprotein cholesterol (LDL-C), and very low-density lipoprotein cholesterol (VLDL-C)), and improved indicators of atherogenicity. These effects contribute to the protection of the cardiovascular system [8].

Plant extracts from myrtle berries and leaves have attracted the interest of both consumers and researchers due to their high concentration of phenolic compounds. These compounds are involved in absorbing reactive oxygen species, which helps in the prevention and treatment of various diseases associated with aging [9]. A fraction enriched with polyphenols, obtained from the leaves of *Myrtus communis*, has significant anti-inflammatory, antioxidant, wound healing, and anti-leukemic potential [10]. Therefore, myrtle herbal preparations could offer a new, effective, and safe alternative to current treatment methods.

Proper standardization is crucial for determining the quality of medicinal plant raw materials, especially considering the diversity in myrtle's geographical distribution, environmental growth conditions, availability of chemotypes, and varieties [3,4,11]. In addition to evaluating the phytochemical quality indicators of plant raw materials and the pharmacological actions of phytochemicals derived from them, it is essential for pharmacognostic studies to understand the morphological and anatomical characteristics of plants used as medicinal raw materials. This knowledge aids in the standardization and quality control of the product, ensuring the effectiveness and safety of medicines.

The presence of secretory receptacles containing essential oil is a defining feature of the *Myrtaceae* family [12,13]. These secretory receptacles produce compounds that protect plants from herbivores and pathogenic microorganisms. The structure and development of the secretory cavities in *Myrtus communis* L. have been studied in both young and mature leaves using light and scanning electron microscopes [14,15,16]. Additionally, the flowers of *Myrtus communis* L. are also rich in essential oil secretory receptacles, which are distributed across all floral organs (sepals, petals, corolla, stamens, ovary, and leaf). In the flowers of *Myrtus communis*, unicellular papillae located at the top of the ovary, closer to the base of the stamens, and hairy trichomes have also been identified [17].

Cleber J. da Silva, Luiz Cláudio de A. Barbosa, and colleagues analyzed the frequency and determined the morphological types of secretory receptacles using light and scanning electron microscopy in 52 species of the *Myrtaceae* family. Conical secretory receptacles were observed in three tribes (*Leptospermeae, Myrteae*, and *Melaleuceae*), while the euryform type was found in five tribes (*Leptospermeae, Syncarpieae, Myrteae, Syzygieae,* and *Melaleuceae*) [18]. The ultrastructure of secretory receptacle cells in flowers was described by Rafael R. Pimentel, Natália P. Barreira, and others using light and electron microscopy. These cells feature a well-developed smooth endoplasmic reticulum, dictyosomes with adjacent vesicles, numerous mitochondria, and starch-containing plastids [19].

Determination of morphology and anatomy of the vegetative parts of plants is crucial for their identification and classification, as well as for evaluating the quality of medicinal raw materials. However, the ultrastructural features of common myrtle cells have not yet been thoroughly studied. This information could be critically important for the accurate identification and utilization of new types of plant raw materials, especially in wartime conditions.

## Aim

The aim of the work is to study the morphological and anatomical structure and determine the general diagnostic microscopic features of leaves and the structure of meristem cells of common myrtle.

## Materials and methods

The object of the research is fresh and dried plant material of common myrtle grown under controlled conditions at the Department of Pharmacognosy, Pharmacology, and Botany of Zaporizhzhia State Medical and Pharmaceutical University. Microscopic research was conducted in the Phytochemical Laboratory

**Fig. 1.** Appearance of *Myrtus communis* L. leaves.

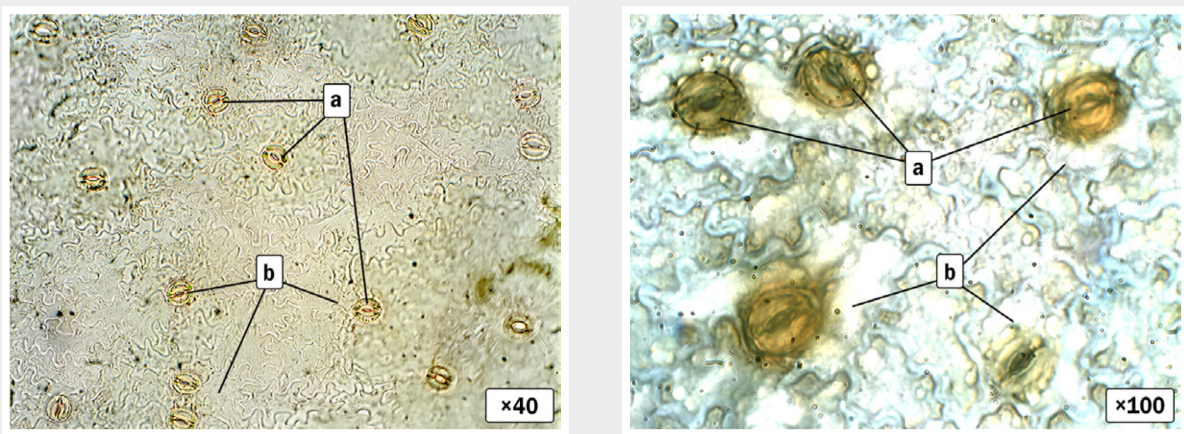


**Fig. 2.** Fragment of the lower epidermis of the leaf. **a:** stomata; **b:** near stomatal cells.

of the Educational and Scientific Medical and Laboratory Center with a vivarium at Zaporizhzhia State Medical and Pharmaceutical University. Illumination of the microscopic preparations involved heating the samples for 2–3 minutes in a 3–5 % aqueous solution of sodium hydroxide, avoiding excessive softening. After heating, the material was washed 2–3 times with distilled water, and then a microscopic specimen was prepared [20,21].

Carl ZEISS "AxioStar Plus" and "Primo Star" microscopes (objectives ×4, ×10, ×20, ×40, ×100) with an AxioCam ERc 5s digital camera were used for observations in both direct and reflected light. Anatomical studies were conducted with statistically significant sample sizes (at least 10 specimens per object). During the microscopic examination of medicinal plant raw materials, attention was given to the type of leaf plate, the structure of epidermal cells, the presence and type of stomata, as well as the characteristics of hairs and glands. To identify the localization of the essential oil, a histochemical reaction was performed with Sudan III solution, which stains the receptacles in an orange-red color.

Object counts per unit area were conducted with tenfold replication. Statistical analysis was performed using Microsoft Excel 2010 software.

The ultrastructure of leaf cell structures was further examined using transmission electron microscopy methods in the Electron Microscopy Laboratory of Zaporizhzhia State Medical and Pharmaceutical University, on a transmission electron microscope "PEM-100-01" (Selmi, Ukraine) at an accelerating voltage of 75 kV. Plant material chopped into 2 × 3 mm fragments, was fixed in a 2.5 % solution of glutaraldehyde prepared in a 0.1 M phosphate buffer, with the addition of acrolein at a final concentration of 1 %. The inclusion of acrolein was necessary due because of the insufficient and slow penetration of the fixative containing only glutaraldehyde through the leaf epidermis. Acrolein, which penetrates more deeply and reacts faster than other aldehydes, improves the preservation of ultrastructural details when used in combination with glutaraldehyde fixatives [22]. The time between sample preparation and electron microscopic examination was up to 5 minutes, and fixation was performed for 4 hours at +40 °C.

After washing the fixative three times with 0.1 M phosphate buffer, the material was treated for 6 hours in a 1 % solution of $OsO_4$ in 0.1 M phosphate buffer. The plant material was then washed through a series of increasing concentrations of alcohol, starting from 30 % to 96 %, with each concentration processed at room temperature for 15 minutes. Subsequent processing involved treatment with a solution of 100 % alcohol-acetone in successive ratios (3:1, 1:1, and 1:3) for 15 minutes each. The final dehydration step consisted of two 20-minute treatments in

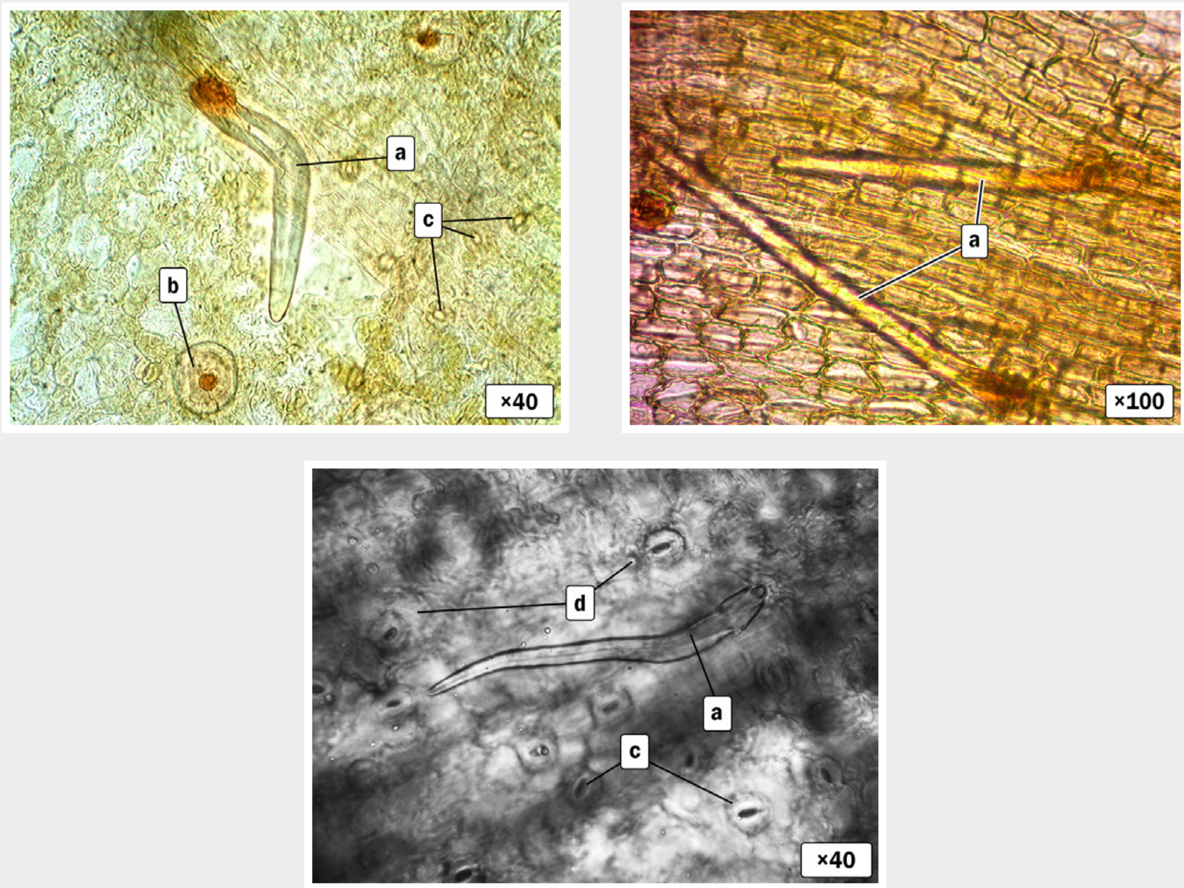


**Fig. 3.** Fragment of the epidermis of the middle vein of a leaf. **a:** trichomes; **b:** secretory container; **c:** stomata; **d:** near stomatal cells.

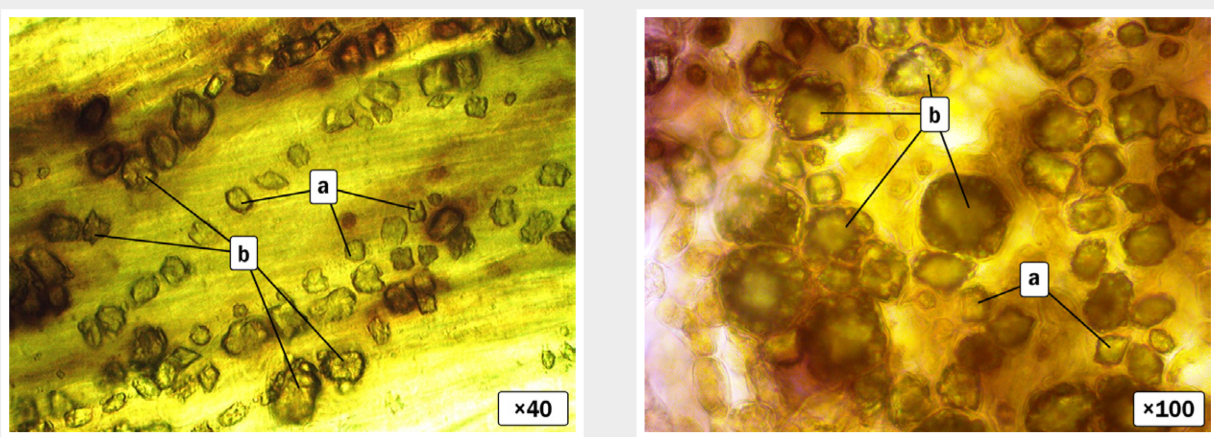


**Fig. 4.** Drusen and calcium oxalate crystals. **a:** calcium oxalate crystals; **b:** calcium oxalate drusen.

pure acetone. For embedding, the material was infiltrated with epoxy resin (Epon), ensuring proper composition, sequence, and duration of processing according to the resin's specifications [23].

Ultrathin sections, each 60 nm thick, were prepared using a Reichert Om 43 ultramicrotome. The sections were contrasted with a 1 % solution of uranyl acetate and lead citrate, each for 2 minutes at room temperature. These ultrathin sections were then examined with a PEM-100 electron microscope, operating at an accelerating voltage of 75 kV. The microstructure of the leaf cells was described using the terminology summarized by Byung-Ho Kang et al. [24].

## Results

The leaves of *Myrtus communis* L. are simple, opposite, and either sessile or slightly sessile. They are lanceolate, elliptical or ovoid in shape *(Fig. 1)*. The apex of the leaves is pointed, while the base ranges from acute to rounded. The leaves feature

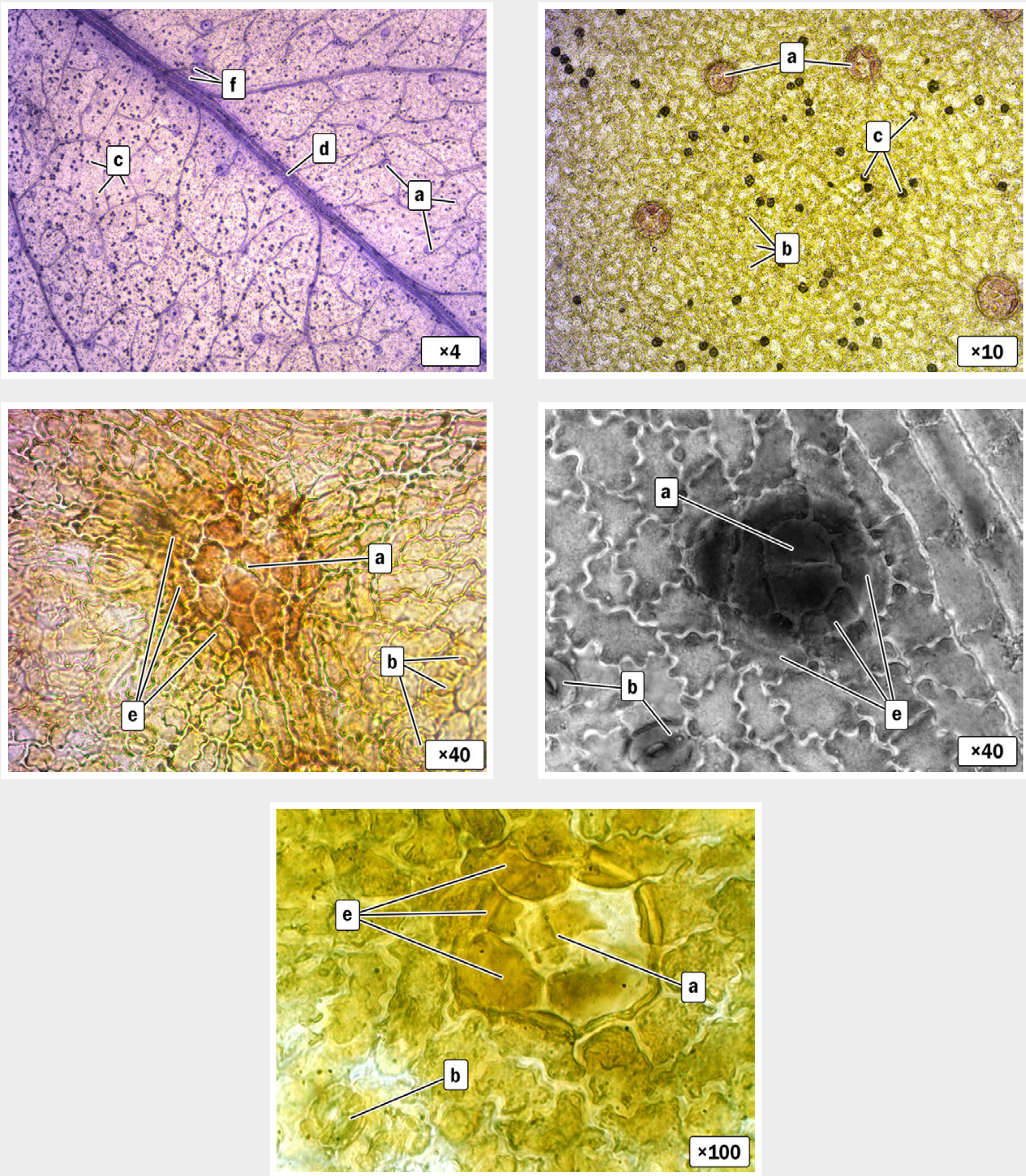


**Fig. 5.** Schizolysigenous secretory receptacles. **a:** schizolysigenous secretory receptacle; **b:** stomata; **c:** calcium oxalate drusen; **d:** central vein; **e:** epithelial cells located above the receptacles; **f:** trichomes.

numerous secondary and tertiary net veins with brochidromous (pinnate-loop-like) venation. Although the venation is not very prominent on the exterior, there is a noticeable depression just above the midvein. The upper surface of the leaves is dark green, whereas the lower surface is a lighter green.

During the microscopic study, surface micropreparations of various parts of the leaf plate, specifically the upper and lower epidermis, were examined. Myrtle leaves are hypostomatic, with stomatal complexes that are anomocytic and evenly distributed on the abaxial surface at a density of 228 ± 73 units/mm$^2$. These stomatal complexes are oval to round in shape and are surrounded by 3 to 5 epidermal cells (*Fig. 2*).

The abaxial surface of the leaf consists of convoluted epidermal cells. The epidermis on the upper side of the leaf plate features strongly tortuous, thickened walls. The cells are either isodiametric or slightly elongated in shape. On the midvein of

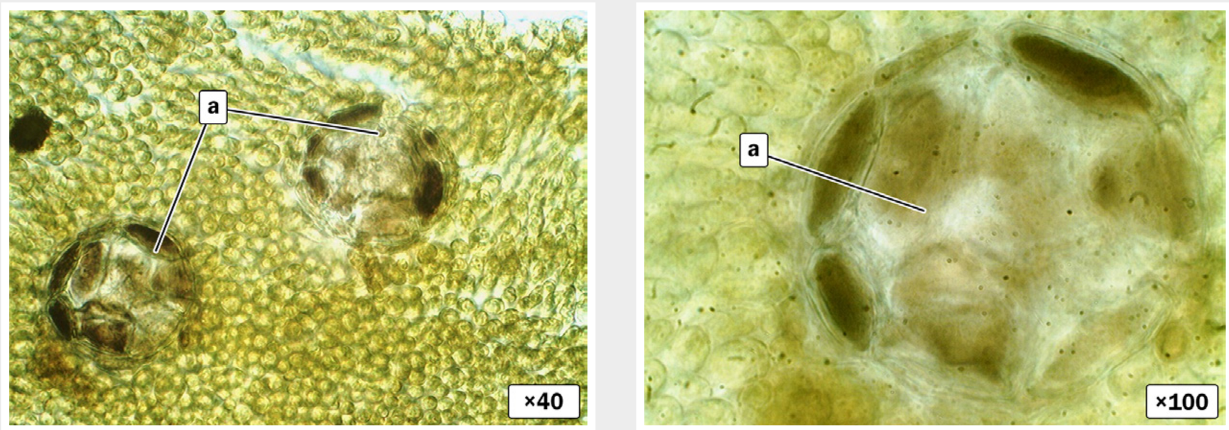


**Fig. 6.** Idioblasts with resinous oil content. **a:** idioblast.

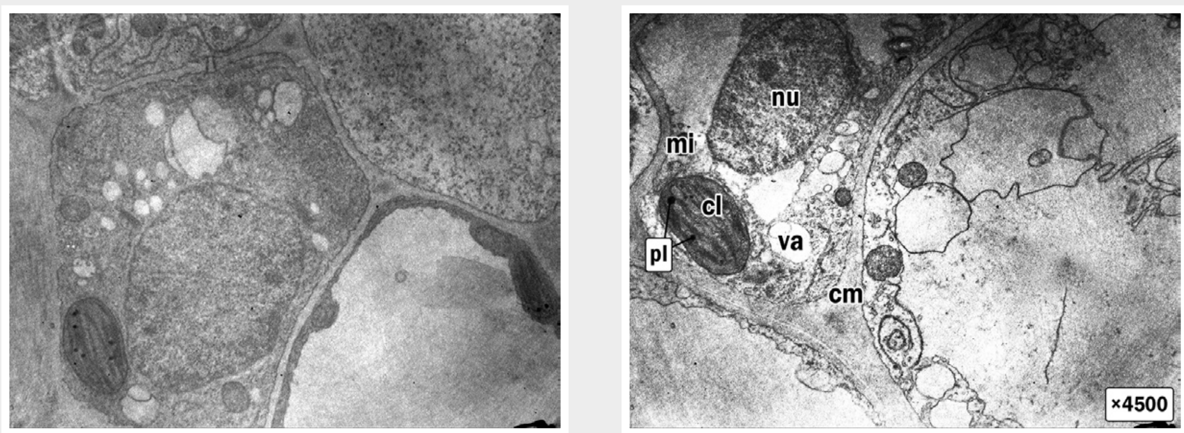


**Fig. 7.** Transmission electron microscopy image of meristem cells of common myrtle. **nu:** nucleus; **va:** vacuole; **mi:** mitochondrion; **cl:** chloroplast; **cm:** cell membrane; **im:** intercellular; **pl:** plastoglobules.

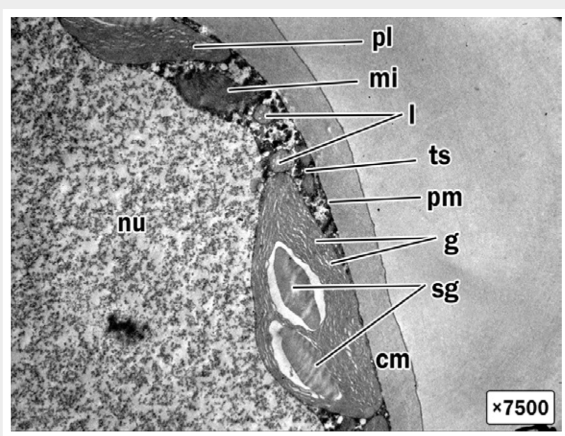


**Fig. 8.** Transmission electron microscopy image of common myrtle meristem cells with chloroplasts containing starch grains. **nu:** nucleus; **ts:** cytoplasm; **va:** vacuole; **mi:** mitochondrion; **cl:** chloroplast; **cm:** cell membrane; **pm:** plasma membrane; **l:** lysosomes; **g:** face; **pl:** plastoglobule; **sg:** starch grains.

the abaxial surface, there are a few scattered trichomes. These trichomes are simple, unicellular, non-glandular hairs that are conical, slightly wavy, and single *(Fig. 3)*.

The leaf of common myrtle contains a significant amount of crystalline calcium oxalate inclusions, which are represented by both drusen and prismatic crystals. These inclusions are distributed across the entire surface of the leaf plate at a density of 144 ± 49 units/mm$^2$ *(Fig. 4)*.

In the mesophyll of the leaf, spherical secretory receptacles are present, displaying a typical schizolysigenous pattern *(Fig. 5)*.

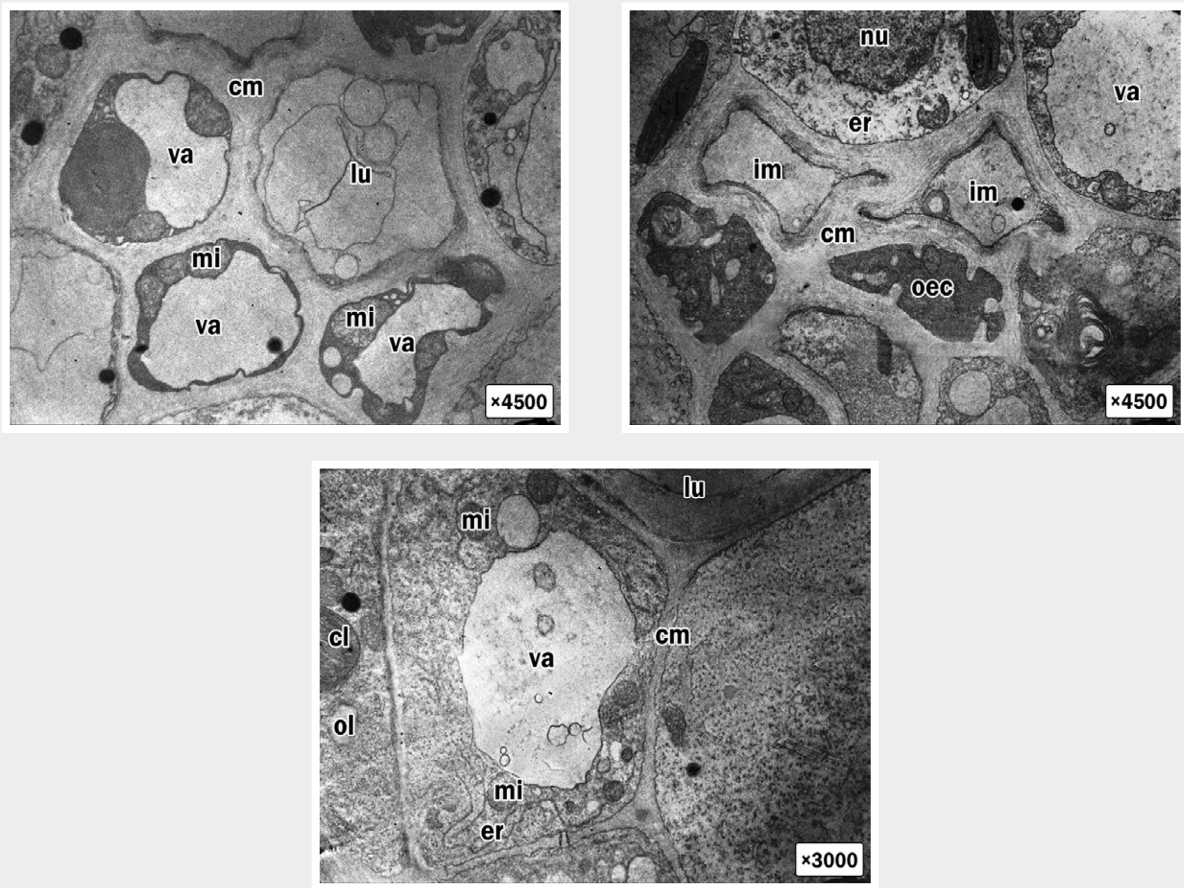


**Fig. 9.** Transmission electron microscopy image of common myrtle epithelial cells in contact with the secretory container. **nu:** nucleus; **va:** vacuole; **mi:** mitochondrion; **cl:** chloroplast; **im:** intercellular; **cm:** cell membrane; **lu:** lumen; **oec:** senescent epithelial cells; **ol:** drops of oil; **er:** endoplasmic reticulum.

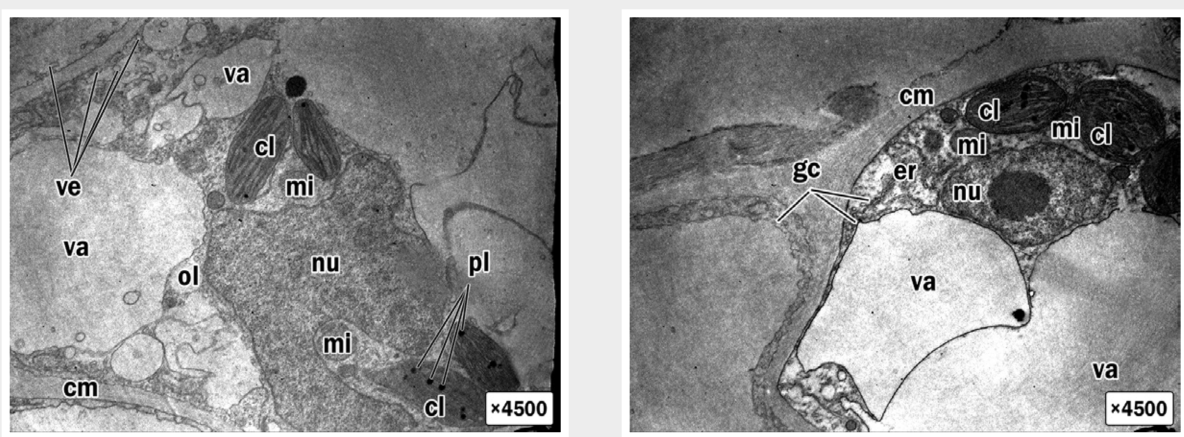


**Fig. 10.** Transmission electron microscopy image of common myrtle parenchyma cells in contact with the secretory container. **nu:** nucleus; **va:** vacuole; **mi:** mitochondrion; **cl:** chloroplast; **cm:** cell membrane; **ve:** vesicles; **gc:** Golgi complex; **ol:** drops of oil; **pl:** plastoglobule; **er:** endoplasmic reticulum.

The presence of epithelial cells surrounding these cavities indicates that their development is schizogenic, involving cell division rather than dissolution, which characterizes the lysigenous type. Histochemical testing with Sudan III reveals that the secretory receptacles of *Myrtus communis* primarily produce lipophilic compounds. The specific density of secretory receptacles per unit area is 5 ± 1 units per mm². In addition to the essential oil containers, dark brown idioblasts containing resinous oil are also present *(Fig. 6)*.

When studying the ultrastructure of common myrtle leaf cells, characteristic structural components of various cell types were identified. The ultrastructure of typical meristematic cells

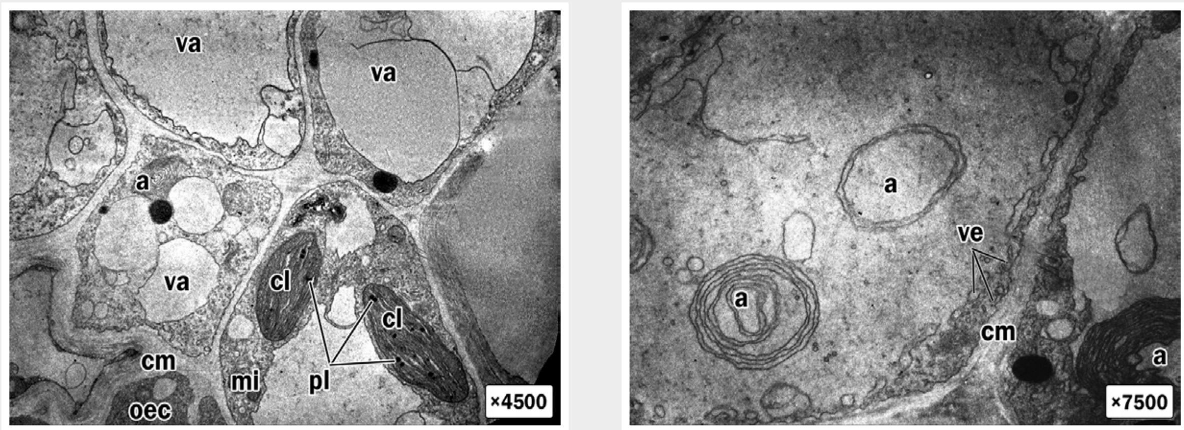


**Fig. 11.** Transmission electron microscopy image of common myrtle cells containing spare inclusions – amyloplasts. **a:** amyloplasts; **va:** vacuole; **mi:** mitochondrion; **cl:** chloroplast; **cm:** cell membrane; **ve:** vesicles; **pl:** plastoglobule; **oec:** senescent epithelial cells.

in common myrtle is characterized by very thin walls *(Fig. 7)*, which merge to form small intercellular spaces in the central region. Each meristematic cell contains a prominent nucleus with a nucleolus. The cytoplasm is rich in polyribosomes, mitochondria, and Golgi complexes with numerous dictyosomes, from which many vesicles are formed. Vacuoles are small and contain membranes or electron-dense bodies. Additionally, smooth and rough endoplasmic reticulum, lysosomes, oil droplets, and plastids are present. Plastids, specifically chloroplasts, are spherical or oval in shape *(Fig. 8)*. Like the nucleus and mitochondria, chloroplasts are surrounded by a double membrane. The internal environment, or stroma, is a protein matrix permeated by membranes known as lamellae. These lamellae are interconnected to form thylakoids. Thylakoids, tightly adhered to each other, create facets within the chloroplast. The chloroplasts also contain lipid droplets called plastoglobules, and excess carbohydrates produced during photosynthesis can be stored as starch grains.

During electron microscopy, mature secretory receptacles were found, in the lumen of which remnants of cells are visible *(Fig. 9)*. During the secretory process, high metabolic epithelial cells and senescent signaling cells are found side by side in the same epithelium. Senescent epithelial cells have loose convoluted walls and a retracted protoplast. The cytoplasm of such cells becomes very dark and retracts, and the visualization of organelles becomes impossible. These changes end with protrusion of the degenerated epithelial cell into the lumen or cell fragmentation.

The membranes of the parenchyma cells surrounding the secretory receptacles are characterized by thicker walls. These cells contain an oval or irregularly shaped nucleus with distinct nucleoli and a substantial amount of cytoplasm, which includes both small and large vacuoles *(Fig. 10)*. The cells also feature typical chloroplasts, mitochondria with well-developed cristae, oil droplets, and numerous vesicles near the plasma membrane. The cells are tangentially elongated. A distinctive feature of common myrtle leaf cells is the presence of spare inclusions called amyloplasts, located in the cytoplasm *(Fig. 11)*. These amyloplasts are simple, concentric, round or oval-shaped starch grains, characterized by well-defined layering and a central formation in the shape of a circle or point.

## Discussion

Although *Myrtaceae* species are rich in essential oils and other chemical compounds, detailed information on the leaf anatomy of *Myrtus communis* L. is scarce. The results of this study reveal that *Myrtus communis* L. shares several anatomical features with other species in the family. These features include drusen (calcium oxalate crystals) and schizolysigenous secretory receptacles. The secretory receptacles develop from single cells, initially originating schizogenically but ultimately becoming lysogenic during maturation, leading to the disintegration of all secretory cells within the gland lumen [14,15,25].

In addition to the genetically determined characteristics common to the family, *Myrtus communis* exhibits specific anatomical and ultrastructural features that may be linked to its environmental origin and reflect various survival strategies [17,26].

It was determined that the epidermal cells have a tortuous shape, and the leaves are equipped with trichomes in the form of simple hairs scattered on the abaxial surface of the midvein. The stomata are anomocytic and hypostomatic, located on the abaxial side of the leaf blade. This evolutionary adaptation allows the plant to better control water loss and gas exchange, protecting the leaves from environmental stressors [27]. For common myrtle, which grows in Mediterranean regions with high solar activity, this adaptation is particularly important for maintaining water balance and supporting optimal physiological processes.

In addition, some ultrastructural features of chloroplasts and other organelles may reflect adaptations to high solar radiation conditions. For instance, the presence of large and bulky starch grains in chloroplasts could be indicative of more intensive photosynthesis. The abundance of plastoglobules observed in the chloroplasts of the mesophyll in *Myrtus communis* L. may be related to oxidative stress, which could help the plant cope with high levels of insolation [28].

Starch grains and oil droplets in the cells of *Myrtus communis* L. probably represent an energy reserve. This strategy provides an uninterrupted source of energy for synthesis and secretion of essential oil.

Electron micrographs illustrate the features of meristem cells and the presence of secretory receptacles. Young meristem cells are characterized by dense cytoplasm and a large number of organelles, including a nucleus with a nucleolus, plastids, a Golgi complex with numerous dictyosomes, endoplasmic reticulum, and mitochondria. As cells mature, vesicles fuse with vacuoles or plasma membrane, which becomes noticeably tortuous and thickened. Plastids become less numerous, exhibiting dense stroma and large starch grains. These plastids, with their well-developed internal membranes and starch grains, facilitate photosynthesis and provide the energy required for the biosynthesis of secretory compounds, as observed in glandular trichomes of various species [29].

The secretory receptacles feature a well-developed parenchyma shell with thicker cell walls and initial signs of cell degradation, such as nuclear fragmentation and mitochondrial proliferation. Dictyosomes are well developed and produce several vesicles visible in the peripheral cytoplasm near the convoluted plasma membrane. In addition, vacuoles containing secretions form and fuse with the plasma membrane in a continuous process of vacuole formation and essential oil release, similar to the process described by M. O. Mercadante-Simões and E. A. S. Paiva [30].

Based on ultrastructural studies of mature cavities, several indicators of cell senescence have been identified. These include cells with dark cytoplasm and reduced clarity of organelles, swollen membranes, nuclei with irregular contours and vesiculation, tortuous cell walls, and loss of contact with neighboring cells. These features correspond to with programmed cell death and represent a natural aspect of plant development [31].

Common myrtle leaf cells are distinguished by the presence of spare inclusions known as amyloplasts. The structural characteristics of these amyloplasts are species-specific and are valuable for comparative anatomical analysis of medicinal plants and their raw materials.

These data can be used for identification of medicinal plant raw materials of common myrtle and contribute to the development and implementation of promising phytopreparations based on *Myrtus communis* L. into medical practice.

## Conclusions

1. The leaves of *Myrtus communis* L. have a hypostomatic leaf type, with the lower epidermis containing a significant number of uniformly arranged stomata of the anomocytic type. Simple unicellular hairs are present only on the central vein. Shared anatomical features with other species in the *Myrtaceae* family include the presence of druses and prismatic calcium oxalate crystals, along with schizogenous secretory receptacles that produce lipophilic substances.

2. The ultrastructure of meristem cells and cells adjacent to the secretory receptacles in *Myrtus communis* includes cell membrane, cytoplasm, nucleus, mitochondria, vacuoles, chloroplasts, Golgi complex with numerous dictyosomes, endoplasmic reticulum, lysosomes, oil droplets, and amyloplasts, which are starch-storing inclusions characteristic for the species. Mature secretory receptacles were found, within which cell remnants are surrounded by metabolically active cells and senescent, darker cells with poorly defined organelles and convoluted walls.

3. Recommended parameters for the standardization of *Myrtus communis* L. medicinal plant material: microscopic indicators include the anomocytic type of stomatal apparatus with hypostomatic placement, simple hairs, the presence of druses and prismatic calcium oxalate crystals, and schizogenous secretory receptacles. Ultramorphological indicators include cell membrane, cytoplasm, nucleus with nucleolus, chloroplasts with plastoglobuli and starch granules, Golgi complex with numerous dictyosomes, endoplasmic reticulum, mitochondria, lysosomes, oil droplets, characteristic storage inclusions (amyloplasts), and the presence of secretory receptacles.

**Prospects for further research** are to continue pharmacognostic studies of *Myrtus communis* L. leaves.

**Information about the authors:**
Odyntsova V. M., PhD, DSc, Professor of the Department of Pharmacognosy, Pharmacology and Botany, Zaporizhzhia State Medical and Pharmaceutical University, Ukraine.
ORCID ID: 0000-0002-7883-8917
Matsehorova O. Ye., Postgraduate student of the Department of Pharmacognosy, Pharmacology and Botany, Zaporizhzhia State Medical and Pharmaceutical University, Ukraine.
ORCID ID: 0009-0002-7912-1392
Tertyshnyi S. I., MD, PhD, DSc, Professor, Head of the Department of Pathological Anatomy and Forensic Medicine, Zaporizhzhia State Medical and Pharmaceutical University, Ukraine.
ORCID ID: 0000-0003-3856-4234
Polkovnikov Yu. F., MD, PhD, Associate Professor of the Department of Pathological Anatomy and Forensic Medicine, Zaporizhzhia State Medical and Pharmaceutical University, Ukraine.
ORCID ID: 0009-0000-0680-9730

**Відомості про авторів:**
Одинцова В. М., д-р фарм. наук, професор каф. фармакогнозії, фармакології та ботаніки, Запорізький державний медико-фармацевтичний університет, Україна.
Мацегорова О. Є., аспірант каф. фармакогнозії, фармакології та ботаніки, Запорізький державний медико-фармацевтичний університет, Україна.
Тертишний С. І., д-р мед. наук, професор, зав. каф. патологічної анатомії і судової медицини, Запорізький державний медико-фармацевтичний університет, Україна.
Полковніков Ю. Ф., канд. мед. наук, доцент каф. патологічної анатомії і судової медицини, Запорізький державний медико-фармацевтичний університет, Україна.

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