Stem and Leaf Anatomy of 
*Althaea* L. (Malvaceae) Species 
Growing in Turkey

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*Introduction*

Malvaceae family comprising of 80 genera and more than 1000 species, is essentially cosmopolitan in distribution, however most strongly represented in open, sunny habitats of warm temperate and seasonally dry tropical regions. The genus *Althaea* L. is also widely distributed in the Mediterranean and Irano-Turanian phytogeographical regions, Mediterranean Europe, North America, northern Africa, the Caucasus, Southwest and Central Asia, southern Russia and Afghanistan. *Althaea* species are annual or perennial herbs known vernacularly as “marshmallows”\(^1\), \(^2\).

Four *Althaea* species occur in Turkey: *A. cannabina* L., *A. armeniaca* Ten., *A. officinalis* L. and *A. hirsuta* L.. The species of this genus are known as “hatmi” which are widely abundant in Turkey, grow up to 1-2 metre(s). They have palmately divided leaves with 3-7 lobes and red, lilac or white petals to 16 mm. Anthers are dark purple. Fruits are schizocarps split up into one-seeded mericarps when mature. They

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grow widely on the banks of rivers and field borders\textsuperscript{3}. The whole plants, but especially the roots, are abounded with mucilage\textsuperscript{4}.

\textit{Althaea} species have been the basis for countless medicines since Egyptian antiquity. The generic name, \textit{Althaea}, is derived from the Greek, altho (to cure), due to its healing properties. Owing to the high mucilage content, the plants were used commonly for soothing internal and external inflammations, sore throats, minor wounds and chapped skins\textsuperscript{5}.

These species are also used for many purposes also in Turkish folk medicine. The infusion prepared by the flowers and leaves of \textit{A. officinalis} is used in ailments of the lungs and as a demulcent. The root decoction is used as diuretic; counters excess stomach acid; oral, esophageal and peptic ulcerations and gastritis. It is also applied externally to bruises, sprains, skin inflammations and splinters as an emollient, as a protective and wound healing agent\textsuperscript{6}. A work conducted to investigate the Turkish folk medicinal plants revealed that, the flowers and leaves of \textit{Althaea} species are generally used to cure common cold and cough in Anatolia\textsuperscript{7}. A strong tea prepared from the flowers of \textit{A. hirsuta} together with the quince leaves is drunk to heal sore throat and bronchitis in Niğde. Also, flowers of this plant are boiled in milk to prepare a kind of poultice for wounds and sprains in the environs of Ankara\textsuperscript{8}. In Central Anatolia, mashed fresh herb is put on the wounds. In Iğdır province, \textit{A. cannabina} is called as “şahmehlemi” and a poultice prepared by its root is applied externally to soothe the calcifications\textsuperscript{9}.

Literature search showed that, the genus has been the subject of scant biological activity investigations: The crude methanol and aqueous extracts of aerial parts of \textit{A. officinalis} and \textit{A. cannabina} have been investigated for their antibacterial activity by using disk diffusion assays against 137 strains belonging to 52 bacteria species. The results showed that; methanol extracts of both species tested exhibited significant antibacterial activity\textsuperscript{10}. Rouhi and Ganji, tested the effect of \textit{A. officinalis} on cough associated with ACE inhibitors in hypertensive patients. The results revealed that, the plant clearly showed a beneficial effect in most of the subjects when compared with the placebo group\textsuperscript{11}. Another study evaluated the
antioxidant properties of ethanolic extract of marshmallow (*A. officinalis*) flowers using different antioxidant tests. As a consequence, the extract exhibited strong total antioxidant activity.

Present study aims at providing detailed comparative anatomical information for the genus, which is hitherto unavailable among the Turkish species. These will complement the morphological descriptions.

**Material and Method**

Fresh materials were collected during field trips conducted in 2003 and 2004 (Table I). The species were identified according to the morphological descriptions in Flora of Turkey and the East Aegean Islands. Voucher specimens were deposited in Gazi University, Arts and Sciences Faculty, Biology Department Herbarium (GAZI) with the stated GAZI Herbarium numbers.

<table>
<thead>
<tr>
<th><strong>TABLE I:</strong> Sources of fresh materials used for the study</th>
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<tr>
<td><strong>Althaea cannabina</strong> L.</td>
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<tr>
<td>C3 Konya: Akşehir-Gelendost, 5 km to Gelendost, 945 m, 08.07.2004, garden borders</td>
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<tr>
<td><strong>Althaea armeniaca</strong> Ten.</td>
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<tr>
<td>A8 Erzurum: Şenkaya, Penek Village, 1173 m., 19.08.2005, streamsides, pastures, <em>E. Uzunhisarcıklı</em> 2204 (GAZI)</td>
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<tr>
<td><strong>Althaea officinalis</strong> L.</td>
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<tr>
<td>A1 Tekirdağ: Malkara-Tekirdağ, 30. km, 22.07.2006, 165 m, field borders, <em>E. Uzunhisarcıklı</em> 2189 (GAZI)</td>
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<tr>
<td><strong>Althaea hirsuta</strong> L.</td>
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<tr>
<td>A4 Kastamonu: Pınarbaşı, Kaval-Nalbantoğlu District, 900 m, 25.06.2003, roadsides, <em>U. Özbek</em> 1558 (GAZI)</td>
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In this study, the anatomical studies were carried on the leaf and stem samples of these species preserved in 70% alcohol. Free hand transversal (T.S.) and superficial sections (S.S.) were taken, stained and
mounted in Sartur Reagent \cite{13} and chloralhydrate (50\%) solution. Because of the higher density of indumenta of abaxial surfaces, only the superficial sections of the adaxial surfaces of the leaves were used. The photographs were taken by a camera-attached Leica DM 4000B type microscope, in JPEG format. All drawings were made using a U-Da 2K 17149 sketching prism attached to Olympus BX50 microscope. Some written sources also contributed to the interpretation of the anatomical data we obtained during our study.\cite{14-18}

Results

With reference to the images taken, it is visually apparent that the anatomical structures of three perennial species; *A. cannabina*, *A. armeniaca* and *A. officinalis* are fairly similar. There are only minor differences that can be used in the differentiation of these species. Only the annual, *A. hirsuta* is somewhat dissimilar in terms of both anatomical structure and the size of the organs. Therefore, all the data obtained will be given collectively under the related titles.

![Figure 1A: Althaea cannabina, stem (T. S.) Big picture, left: 1) epidermis, 2) collenchyma, 3) sclerenchyma, 4) phloem, 5) xylem, 6) ray, 7) pith. Small pictures, right (left to right, up to down): sclerenchyma, collenchyma, cluster crystals-mucilage cell in cortex, xylem, pith, diagram.](image-url)
Figure 2A: *Althaea armeniaca*, stem (T.S.) Big picture, left: 1) non-glandular trichome, 2) epidermis, 3) collenchyma, 4) parenchyma, 5) sclerenchyma, 6) phloem, 7) xylem, 8) ray, 9) pith. Small pictures, right (left to right, up to down): mucilage cell in cortex, collenchyma, sclerenchyma, xylem, starch in pith, diagram.

Figure 3A: *Althaea officinalis*, stem (T.S.) Big picture, left: 1) non-glandular trichomes, 2) epidermis, 3) collenchyma, 4) parenchyma, 5) sclerenchyma, 6) phloem, 7) xylem, 8) ray, 9) pith. Small pictures, right (left to right, up to down): collenchyma, sclerenchyma-phloem-cambium, sclerenchyma, ray, parenchyma, diagram.
Epidermis: The same tissue types were observed in the species with slight differences in layers and arrangement. For all species, epidermis is composed of a single layer of rectangular or isodiametric, tightly-packed cells in transverse sections. The aerial plant surface is covered with a thin, non-cellular cuticle. Epidermis has cells with convex outer walls in *A. armeniaca*, *A. officinalis* and *A. hirsuta*, hence the cuticle is not smooth. The glandular and non-glandular trichomes occur on stem as epidermal outgrowths. Non-glandular trichomes are generally tufted or stellate, as the tufts of single celled hairs are with acute apices and straight cuticles. Glandular trichomes are short with a unicellular stalk and a multicellular head.

Superficial stem sections exhibit that, *A. armeniaca* and *A. officinalis* have denser indumenta than the other two species. Stellate hairs can be recognized one by one on the stem of *A. cannabina* while *A. hirsuta* is differentiated by the unicellular, big scattered hairs. Glandular trichomes are fewer. The shape of epidermal cells are generally prolonged and polygonal with straight walls in surface view.
Intercellular spaces do not occur between ordinary epidermal cells; the only spaces present are the stomatal pores. All stems have low stomatal frequencies. Each stoma has 3-4 surrounding subsidiary cells.

**Cortex:** In transverse sections; adjacent to the epidermis the cortex starts with 2-4 layers of chlorenchyma cells in all four species. Under this photosynthetic layer, the mechanical tissue, angular collenchyma occurs as a continuous cylinder. Collenchymatous tissue constitutes one fourth of cortex in *A. cannabina* and *A. armeniaca*; about the half in *A. officinalis* and *A. hirsuta*. The remainder of cortex is composed of parenchyma cells of different sizes (6-9 celled layers in *A. cannabina* and *A. armeniaca*; 4-5 in *A. officinalis*; 2-4 in *A. hirsuta*).

Cortical parenchyma contains mucilage cells which are rather big in *A. armeniaca*. Cluster crystals are dotted around the cortex except in *A. hirsuta*. The rough, intermittent cluster crystal line between the chlorenchyma and collenchyma cylinders is a remarkable characteristic of the perennial species. No starch granules are detected.

**Vascular cylinder:** Phloem sclerenchyma fibres extend into the cortex parenchyma as the lumps of different shapes forming a proximate circle which is interrupted by the medullary rays. Two-layered arrangement of the fibres is also observed in some cases. Differently in *A. hirsuta*, only fewer fibres (1-4) with thinner walls constitute smaller groups. The phloem is composed of crushed, small, irregular cells. Some cluster crystals are scattered in phloem. Phloem layer of *A. hirsuta* is relatively thinner and contains no crystals. Between the phloem and xylem layers, cambium with 3-4 layers of thin-walled, crushed rectangular cells is clearly observed especially in *A. officinalis*, but not in others.

Xylem elements compose a thick and concentric cylinder interrupted by medullary rays in *A. cannabina*, *A. armeniaca* and *A. officinalis*. Contrary in *A. hirsuta*, they occupy a thin ring forming sequential domes project into the pith. Generally, vessels with large
central spaces are few, but tracheids with small central spaces are in compact groups. In *A. cannabina* and *A. armeniaca*, vessels mostly occur in the form of radially continuous, uniseriate rays. But, their distribution does not fit this pattern in *A. officinalis* and *A. hirsuta*. The vessel frequency increases towards the pith. The rays with 6-9 cell-wide are rather distinctive in *A. cannabina* and *A. armeniaca* while they are less dense in *A. officinalis*. The rays in *A. hirsuta* are very short and hardly visible.

Pith, the central parenchymatous region of stems, is composed of thin walled, large, rounded cells. Some of these cells are transformed into mucilaginous cells. These mucilaginous cells are fewer but bigger than the ones in cortical parenchyma. Cluster crystals are scattered on the piths of all four species. The cluster crystals in the pith of *A. hirsuta* are mostly located intercellularly.
Figure 1B: *Althaea cannabina*, leaf (T.S.) Lamina, upper left: 1) non-glandular trichome, 2) adaxial epidermis, 3) palisade mesophyll, 4) spongy mesophyll, 5) abaxial epidermis, 6) glandular trichomes. **Midrib, upper right:** 1) non-glandular trichome, 2) adaxial epidermis, 3) palisade mesophyll, 4) spongy mesophyll, 5) collenchyma, 6) xylem, 7) phloem, 8) abaxial epidermis, 9) glandular trichome. **Small pictures, below (left to right):** non-glandular trichome-collenchyma, xylem-phloem-cluster crystals, parenchyma, diagram.

Figure 2B: *Althaea armeniaca*, leaf (T.S.) Lamina, upper left: 1) non-glandular trichome, 2) glandular trichome, 3) adaxial epidermis, 4) palisade mesophyll, 5) spongy mesophyll, 6) abaxial epidermis. **Midrib, upper right:** 1) non-glandular trichome, 2) adaxial epidermis, 3) collenchyma, 4) xylem, 5) phloem, 6) parenchyma. **Small pictures, below (left to right):** adaxial epidermis-palisade mesophyll, spongy mesophyll-abaxial epidermis, mucilage cell, non-glandular trichome-glandular trichome, diagram.
Figure 3B: *Althaea officinalis*, leaf (T.S.) Lamina, upper left: 1) non-glandular trichome, 2) adaxial epidermis, 3) palisade mesophyll, 4) spongy mesophyll, 5) abaxial epidermis, 6) mucilage cell, 7) cluster crystals. **Midrib, upper right:** 1) non-glandular trichome, 2) glandular trichome, 3) adaxial epidermis, 4) palisade mesophyll, 5) spongy mesophyll, 6) collenchyma, 7) xylem, 8) phloem. **Small pictures, below (left to right):** adaxial epidermis—palisade mesophyll, non-glandular trichomes, glandular trichome—abaxial epidermis—collenchyma, mucilage cell, diagram.

Şekil 4B: *Althaea hirsuta*, leaf (T.S.) Lamina, upper left: 1) adaxial epidermis, 2) palisade mesophyll, 3) spongy mesophyll, 4) mucilage cell, 5) abaxial epidermis, 6) glandular trichome. **Midrib, upper right:** 1) non-glandular trichome, 2) glandular trichome, 3) adaxial epidermis, 4) collenchyma, 5) xylem, 6) phloem, 7) abaxial epidermis, 8) cluster crystal. **Small pictures, below (left to right):** adaxial epidermis—collenchyma, phloem—xylem—cluster crystals, mucilage cell, glandular trichome on midrib, diagram.
LEAF (Figures 1B, 2B, 3B, 4B, 5A, 5B, 5C, 5D)

Blade

Epidermis: In transverse sections; both upper and lower epidermis are composed of a single layer of rectangular or isodiametric and tightly-packed cells in all species. Outer surface of the leaf is covered with a thick cuticle. Epidermis cells have convex outer walls hence the cuticle is not smooth. Some of the ordinary epidermal cells of A. hirsuta leaf, are remarkable with the outer walls projecting outward. In the leaf epidermis of A. armeniaca and A. officinalis, some mucilaginous epidermal cells penetrating into the mesophyll, are also observed. The shape and the density of the glandular trichomes are similar to those of the stem. Non-glandular trichomes are generally as the tufts of unicellular hairs with acute apices and straight cuticles. There are also unicellular single and twin hairs.
Superficial sections of the adaxial leaf surfaces (because of the higher density of indumenta of the abaxial leaf surfaces, only the upper epidermis of the leaves were investigated superficially) of the species reveal that non-glandular trichomes are very dense in *A. cannabina* and *A. officinalis*, loose in *A. armeniaca*. *A. hirsuta* is characterized by the long, unicellular simple-celled non-glandular trichomes distributed few and sparse on the entire leaf surface. Epidermal cells are polygonal with rubbed corners and small when observed superficially. Their walls are slightly wavy. Around the stomata, generally 3-4 subsidiary cells are determined. The high density of the trichomes also disabled us to compare the distribution of stomata of leaf surfaces.

**Mesophyll:** The mesophyll is not homogenous; on the contrary it is clearly divided into two distinct regions, termed palisade and spongy tissues. Palisade mesophyll is typically adaxial. Palisade cells -which are as two layers in *A. cannabina*, *A. armeniaca* and *A. officinalis*; one in *A. hirsuta* - are anticlinally elongated and posses relatively few intercellular air spaces. By contrast, spongy mesophyll is typically located on the abaxial side of the leaf and consists of variously shaped cells with more air spaces between them. Hence the leaves of these four species are dorsiventral. In *A. hirsuta*, it is difficult to differentiate the palisade and spongy cells because the mesophyll is composed of the cells with various shapes and relatively high amount of intercellular spaces. Cluster crystals are interspersed in the mesophyll.

**Midrib**

The midrib anatomy of all four species were observed to be similar with minor differences. Transversal sections show that, epidermis of midrib are the extents of the epidermal cells from the blade. The only difference is the size of epidermal cells of the midrib, they are smaller than those of the blade. The abaxial surface of the leaf midrib of *A. hirsuta* is composed of big epidermal cells with projecting outer walls. Hence the cuticle is not smooth. Epiderma has the similar trichomes with those of stem and blade with a higher frequency on lower surface. High trichomes density on abaxial surface of midrib in *A. officinalis* is remarkable.

Glandular trichomes generally occur near to the vein. Under the upper epidermis, a projecting prominent part consisting a group of collenchymatic cells is an important characteristic of the leaves. This projection is very big in *A. armeniaca* while smaller in *A. cannabina* and
A. officinalis and totally absent in A. hirsuta. This formation suddenly interrupts the palisade parenchyma of the blade. Between this prominence and the vascular bundle, parenchymatous and mucilaginous cells can be observed. A crescent-shaped vascular bundle is present in the middle of the midrib. Above this, among the parenchymatic cells, a few fibres with thinner walls can be perceived. The vascular bundle is composed of lignified radiating xylem and an arch of phloem consisting of thin-walled, compactly arranged, small cells. The radially ranked cluster crystals in phloem are remarkable. The vascular bundle is also encircled by cluster crystals. The rest of the midrib is composed of parenchymatous and big mucilaginous cells. Under the midrib, close to the lower epidermis angular collenchyma cells are also observed. Cluster crystals are interspersed in the midrib. A. hirsuta has the same general characteristics summarized above for other Althaea species, but it is different with regard to the number and the density of the cells in the tissues investigated.

Discussion

This paper presents a comparative anatomical study of four Althaea species growing in Turkey. Species have the general family characteristics of Malvaceae; stellate and tufted hairs, multicellular glandular trichomes, mucilage cells, cluster crystals, dorsiventral leaves etc. as previously recorded by Metcalfe and Chalk. In a work on Abutilon theophrastii which is also a Malvaceae member, similar results were obtained. The major difference is the presence of multicellular glandular trichomes on A. theophrastii Medik. Regarding to the data obtained, stem and leaf anatomy of these species have generally the same tissue types. The evidence from anatomical studies shows that only small variations exist among the Althaea species. Among the four species, the structural differences of the only annual of these four, in A. hirsuta the number and the arrangement of the cells that compose the tissues are conspicuous. This was probably due to the general smaller size structure of this plant relative to the other species.

The current study as an attempt to provide anatomical data on Turkish Althaea species will complement the morphological descriptions, which always overlap. But due to the slightness of the differences between the species, the data obtained only have value in the characterization of the species and have not much taxonomical importance.
Summary

Stem and Leaf Anatomy of Althaea L. (Malvaceae) Species Growing in Turkey

Species of Althaea are annual or perennial herbs and are known vernacularly as “hatmi”. They have a broad distribution. In Turkey, four Althaea L. species (A. cannabina L., A. armeniaca Ten., A. officinalis L., A. hirsuta L.) grow naturally on the river and road banks, preferring moist and sandy soils. Their rootstock and leaves are rich in mucilage. They are commonly used in traditional medicine as a soothing tea for cough, peptic ulcers and inflammation of the mucosa of mouth, throat and stomach. In this study, anatomical characteristics of stem and leaf of Turkish Althaea species were investigated for the first time, thoroughly. They all showed typical Malvaceae elements but exhibited slight differences. The results were demonstrated by photographs and sketches.

Key Words: Althaea species, A. cannabina, A. armeniaca, A. officinalis, A. hirsuta, Malvaceae, anatomy

Özet

Türkiye’de Yetişen Althaea (Malvaceae) Türlerinin Gövde ve Yaprak Anatomisi


REFERENCES
