

Anatomical Studies of Medicinal Plant *Fumaria densiflora* in Iraq

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Abstract

The anatomical characters of the leaf, stem and fruits of *Fumaria densiflora* of Papaveraceae family were studied by scanning electron and light microscopy. The results showed that the wall cells of adaxial and abaxial epidermis was thick with straight- sinuate anticlinal cell walls. Both surface have stomatal types of anomocytic, anisocytic and hemiparacytic. Leaf mesophyll consists of 1- 2 layers of palisade cells under the superior epidermis thickness rang 121.44 um and 3 or 6 layers of spongy tissue under the palisade layer. Cross sections of stems are pentagonal- shaped in outline and having five prominent angles. *Fumaria* fruits are tetragonal in shaped (fruit ribs are four). The external area included 2-4 layers of chlorenchyma cells as well as several layers of hypodermal collenchyma cells were recognized below the epidermis. Laticifer tubes could be seen in the sclerenchymatous sheath of the vascular bundles, the fruit wall, placenta and internal parenchyma layers.

Keywords: Papaveraceae, *Fumaria densiflora*, leaves, stem, fruits.

Introduction

The family Papaveraceae is widely distributed in temperate and subtropical regions of the Northern hemisphere, especially the Mediterranean, western, central and eastern Asia and south western parts America (Takhtajan, 2009), it is comprising about 26 - 42 genera and 690 - 800 species in the world (Judd *et al.*, 1999; Sans *et al.*, 2006). The Papaveraceae family are herbaceous plants, but the family also includes some woody shrubs and a genus of small tropical trees. They are economic plants and may be grown as ornamentals and pharmaceutically important plants (Sans *et al.*, 2006; Brezinova *et al.*, 2009).

The genus *Fumaria* L. (Papaveraceae) is a small herb plants comprises 60 species, it is distributed in the temperate regions of the world and weeds in arable land in Western Europe. 6 *Fumaria* species have been reported from Iraq (Townsend and Guest, 1980). *Fumaria* contains some chemical compounds such as alkaloids, flavone (fumaritine, fumariline, fumaric acid and rutin (Tripathi *et al.*, 1994; Kurma and Mishra, 1997; Rajopadhye and Upadhye., 2011). So that, it has been pharmacological activities like cardiovascular, antidiarrheal, blood purifier, anti-allergic agent and hepatoprotective activity (Goetz *et al.*, 2009; Paltinean *et al.*, 2015).

The first studies of the anatomical features of the *Fumaria* genus, made by (Solereeder, 1908; Metcalfe and Chalk, 1950). They reported that some anatomical features of leaves, midrib and fruit are diagnostic value. Anatomy of *Papaver somniferum* studied by (Dickinson and Fairbairn 1975). Structure of wood in Papaveraceae reported by Carlquist and Zona (1988). Azizian and Alishahi Norani (1997) studied anatomical characteristics of fruit and blade leaf with emphasis on latex tubes in species of *Glaucium*. In Argentina were studied the anatomical features for the leaves of two species *Fumaria officinalis* L. and *Fumaria capreolata* L. (Lujan *et al.*, 2004). Rahmatpour *et al.*, (2010) studied basal leaf midrib region and peduncle anatomy of 15 species of the genus *Papaver* L. In India, several studies described morphological and anatomical characters for the species *Fumaria indica* Hausskn. (Gupta and Rao, 2012) and *Fumaria vaillantii* Loisel. (Rajopadhye and Upadhye, 2011).

Many features such as vascular bundle position, thickness of carpel layers, mericarp surface and ornamentations in transversal section studied by (Budantsev & Lobova 1997; Sukhorukov, 2007). Fruit anatomy of Papaveraceae has studied by some researchers (Liu *et al.* 2006; Souza *et al.* 2008; Ebrahimzadeh, 2008). Keshavarzi *et al.* (2011) study root, stem and fruit anatomy of some species of *Fumaria* (Papaveraceae) species in Iran and reported that the shape of stem and the number of vascular bundles has shown variations, as well as the rib thickness, wing shape and wall texture of fruits. and xylem shape are of diagnostic importance. A comparative anatomical study of stem, midrib of basal leave and fruit of some species studied by Chaleshtori and Attar (2012). While Paltinean *et al.*, (2015) studied the histo-anatomical features of vegetative organs belonging to five *Fumaria* species. Tavakkoli (2016) described leaf epidermis micro-characters of two taxa of *Glaucium* in Iran.

The aim of present paper is a study of the anatomical characteristics of the leaves and stems and fruits of *Fumaria densiflora* in Iraq.

Materials and methods

Fresh material of whole plant was collected from northern region of Iraq, during 2017 -2018. fresh material of leaves was fixed 48 hours in formalin acetic acid alcohol solution (FAA) and preserved in 70% alcohol. The

cuticles were prepared by macerating the leaves in Jeffrey's solution (equal parts of 10% chromium trioxide solution and concentrated nitric acid), and therefore mounted in safranin stained glycerin jelly.

The epidermis characteristics of the sample were examined using scanning electron microscope. As well as, the samples were examined with Olympus CH4 light microscope and photographed with Digital camera type DCE-2. Stomatal index was calculated as mentioned by (Ditcher, 1974). Anatomical terms used are cited from (Radford *et al.*, 1974; Ditcher, 1974; Esau, 1965). For determination of stomatal index using the formula, stomatal index (%) = $(S/S+E) \times 100$ where, S and E are the number of stomata and epidermal cells respectively in microscopic view field. stomatal index (%) can be calculated for both the surfaces of leaves. Data of stomatal index for some crops are presented in (Table 1).

Results and Discussion

Epidermal cells

The results showed that the wall cells of adaxial and abaxial epidermis was thick with straight- sinuate anticlinal cell walls (Figure 1). The epidermal cells of upper and lower epidermis of leaves are elongated, polygonal, triangle or isodiametric. The dimension of cells is 200-75 × 27.5-20 um of adaxial surface and 100-75× 37.5-17.5 um on abaxial surface (Table 1). Both surface have polygonal, rectangular and circle with straight- curved anticlinal walls on adaxial and abaxial surfaces. Both surface have stomatal types of anomocytic, anisocytic and hemiparacytic (Figure 1). The cuticle surface of *Fumaria densiflora* on the upper and lower epidermis is noticed under SEM observations. It is covered with granular and striations wax (Figure 1). Larger number of epidermal cells is recorded on the upper epidermis ranging between 335.22 and 354.10 cells/mm² in adaxial and abaxial epidermis respectively. (Table 1). Scanning electron microscope showed that stomata of *Fumaria densiflora* was sunken, and the surface of epidermis have thick cuticle (Figure 3).

Table (1) Measurements of leaf epidermis of *Fumaria densiflora*.

Characters		Measurements (um)
adaxial epidermis cells	Length	(200-75) 162.50
	Width	(27.5-20) 24.16
abaxial epidermis cells	Length	(100-75) 87.45
	Width	(37.5-17.5) 25.11
adaxial epidermis stomata	Length	(40-32.5) 36.66
	Width	(30-20) 26.25
abaxial epidermis stomata	Length	(40-37.50) 38.75
	Width	(22.5-20) 20.83
Number of cells	Adaxial epidermis	(532-210) 335.22
	Abaxial epidermis	(501-250) 354.10
Number of stomata	Adaxial epidermis	(73-44) 55.33
	Abaxial epidermis	(75-41) 57.31
Stomatal index	Adaxial epidermis	14.16
	Abaxial epidermis	13.93

Stomatal complexes

Stomata are semi-rounded or elliptic shaped present on either side (Amphistomatic leaves) then often more numerous on the abaxial epidermis (Figure 1). The results showed three types of stomata complex's, ranunculaceous type (anomocytic type), anisocytic and hemiparacytic type. Guard cells are kidney shaped.

Length of stomata on adaxial epidermis was 36.66 um, while it was 38.75 um in abaxial epidermis. Number of stomata on adaxial epidermis was ranging between 73-44 stomata/mm² in upper epidermis and 75-41 stomata/mm² in lower epidermis (Table 1). Stomatal index percent on the adaxial surface 14.16 %, while it was 13.93% on abaxial epidermis. (Table 1; Figure 4). Similarity characters found in other species of Brassicaceae family (Metcalf and Chalik, 1950). The differences in stomatal complex characters indicated the differentiation and adaptation to the ecological environments.

Leaf anatomy

Leaf sections of *Fumaria densiflora* (Figure 2) revealed that a lamina with a bifacial structure. the epidermis is covered with thick cuticle ranging 4.16 um. The leaf mesophyll consists of 1- 2 layers of palisade cells under the superior epidermis thickness rang 121.44 um and 3 or 6 layers of spongy tissue under the palisade layer, with large intercellular cavities. The vascular bundle is surrounded by parenchymatic cells, and scattered throughout the mesophyll (Figure 2, Table 2)

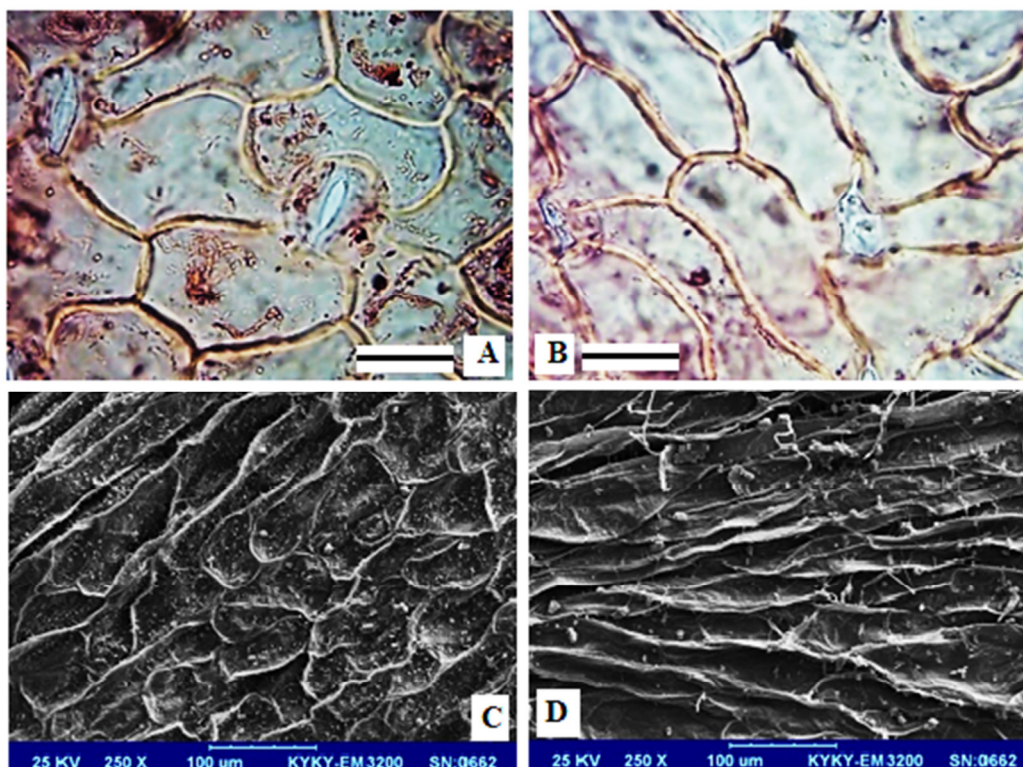


Figure (1) Epidermis structure of *Fumaria densiflora*.

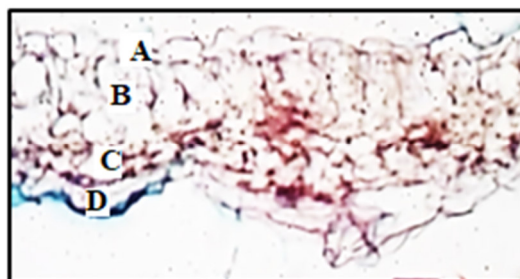


Figure (2): leaf Anatomical characteristics of *Fumaria densiflora*

Table (2): Measurements of leaf and stem of *Fumaria densiflora*.

Longitudinal section of leaf		Cross section of stem	
characters	value	characters	value
Lamina thickness	(237.5-137.40) 196.87	Stem diameter	(2375-1750) 2145.11
Cuticle thickness	(7.5-2.5) 4.16	Cuticle thickness	(15-5) 10.40
Thickness Palisade layer	(250-85) 121.44	Epidermis thickness	(25-12.5) 19.68
Thickness Spongy layer	(130-84) 110.22	Thickness cortex	(75-25) 50.51
Thickness of mid rib	(300-195) 237.50	Phloem thickness	(37.5-25) 29.58
Thickness of vascular bundle	(50-37.5) 42.51	Xylem thickness	(170-50) 104.22
		Central stem diameter	(170-50) 104.22

Stem anatomy

The cross sections of stems are pentagonal- shaped in outline (Figure 3; Table 2), having five prominent angles, raised out as corners. The species has one prominent edges sharpened and four attenuated edges. Thickness of stem between 2375-1750 um (Table 2). The anatomical structure of the stem is characterized by the presence of single layer epidermis with thin – walled, circle, oblong and rectangular parenchymatous cells, covered with thin cuticle (10.40 um); cortex composed of 2 to 4 layers of tubular (Lacunar) collenchyma tissue (Figure 3 C, D). Vascular bundles distributed in parenchymatous ground tissue, single or double in each edge, collateral, arranged in a ring. Each vascular bundle is protected by a well-developed sclerenchyma arch. Xylem consist of vessels, tracheid's, fibers and xylem parenchyma, phloem is 2 to 5 layered, formed of sieved tubes and companion cells.

Laticifer tubes in the species could be seen in collateral vascular bundle, cortex and sclerenchymatous sheath (Figure 3). Stem hollow, pith parenchymatous cells are cylindrical and delineate inside a central lacuna. Many researchers reported that the difference in the number of vascular bundles significant important in the different species of *Fumaria* species (Kiliç *et al.*, 2006; Keshavarzi *et al.*, 2011). Our results agreed with (Keshavarzi *et al.*, 2011; Paltinean *et al.*, 2015) that the collenchymas density varied in the angles. Our study proved that stems characters the *Fumaria* species

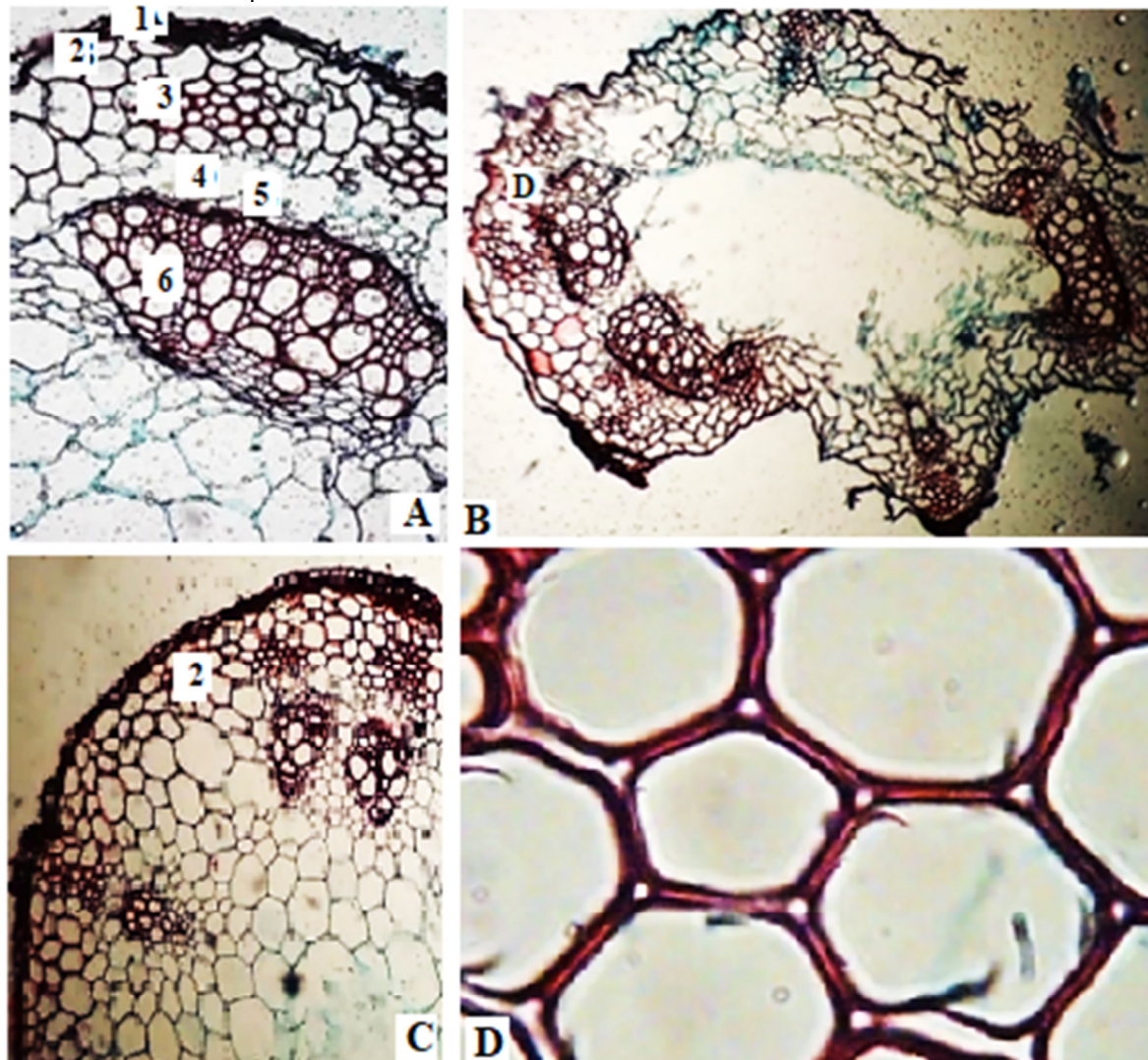


Figure (3): stem anatomical characteristics of *Fumaria densiflora*
A- Part of stem including vascular bundle B- Whole stem C- Collenchyma tissue D- tubular collenchyma. 1- Epidermis 2- collenchyma 3- sclerenchyma 4- Phloem 5- Laticifer 6- xylem

Fruit anatomy

Fumaria fruits are tetragonal in shaped (fruit ribs are four). A cross section of fruit showed the placenta in the internal surface with large cavities. Exocarp includes a layer of small regular epidermis cells with thin cell walls, epidermal cell thickness varied from 10 to 43µm Cuticular thickness was 12.33 µm. The external area included 2-4 layers of chlorenchyma cells as well as several layers of hypodermal collenchyma cells were recognized below the epidermis (Figure 4). Mesocarp of thin walled non-lignified parenchymatous cells, Inner parenchyma layers were superseded by sclerenchymatous cells were observed in the internal region, thickness of sclerenchyma tissue of fruit wall is ranging 70 µm. Laticifer tubes could be seen in the sclerenchymatous sheath of the vascular bundles, the fruit wall, placenta and internal parenchyma layers (Figure 3). Vascular bundles are the main transport channels of water and nutrients in the fruit, length of vascular bundles in fruit wall was 67µm. Placenta was heart shaped and had a vascular bundle, many researchers reported that fruit characters important to separate the species of Papaveraceae (Rahmatpour *et al.*, 2010; Chaleshtori and Attar 2012; Paltinean *et al.*, 2015).

Many researchers reported that the identification of *Fumaria* species is very difficult or impossible which due to similar morphological characters, the variability present in their vegetative and reproductive features and the occurrence of inter-specific hybridization, in addition the strong morphological similarity may reflect their close phylogenetic relationship (Liu *et al.* 2006; Souza *et al.* 2008; Murphy, 2009; Keshavarzi *et al.*, 2011 Păltinean *et al.*, 2013).

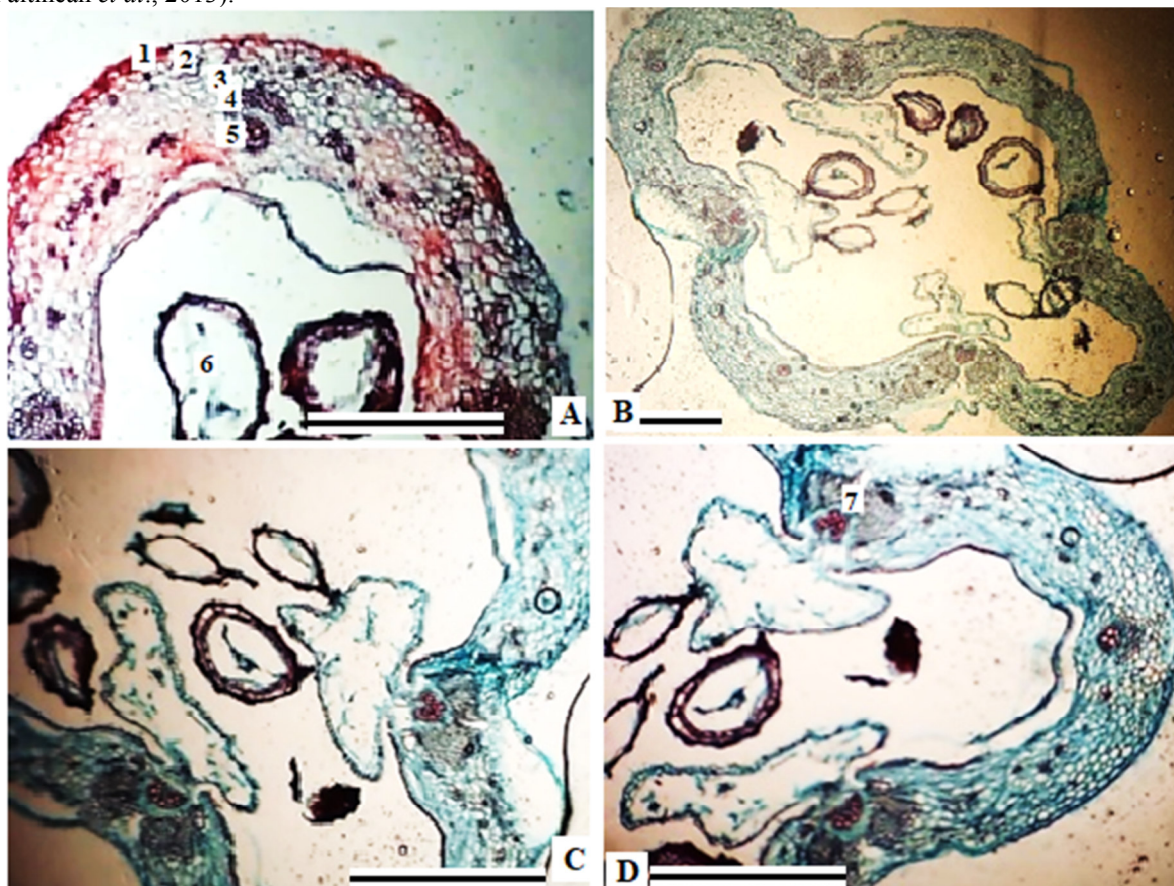


Figure (3): Anatomical characteristics of *Fumaria densiflora* fruits.

- 1- Epidermis 2- Chlorenchyma layer 3- Parenchyma cells
- 2- 4- Sclerenchyma cells 5- Xylem 6- Cavity 7- Placenta

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