

Endocarp morphology of Iranian *Celtis* (Celtidaceae-Cannabaceae)

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Abstract

Endocarp morphology of 4 species of Iranian *Celtis* was examined using light and scanning electron microscopes. Macro- and micro-morphological characters were included endocarp shape, color, size, surrounding rim, ornamentation and SEM structure of the outer layer of the endocarp. Endocarp morphology of the examined specimens exhibit variation in all characters. Endocarp shape varies from globular to ovoid-acuminate. Endocarp size ranges between (5.5×5×4.5 mm) and (8×6×5.5 mm). Endocarp color varies from milky to russet. The results of SEM investigation of the outer endocarp show holes with 5-25 μ diameters. Iranian *Celtis* Can be distinguished by the means of endocarp morphology but other characters are also needed.

Keywords: *Celtis*; Endocarp; Iran; Morphology; SEM

Introduction

Celtidaceae (formerly Ulmaceae-Celtidoideae) (Elias, 1970; Ueda et al., 1997) (now Cannabaceae) (Sytsma, 2002; whittemore, 2005) comprise ca. 150 species classified in 9 genera, distributed in the Northern Hemisphere (Sattarian, 2006). *Celtis*, with about 70 species in the family is distributed primarily in the temperate and tropical areas (Demir et al., 2002). Some are used for timber and reforestation (Sattarian, 2006). In the flora of Iran, *Celtis* with 4 species (*C. australis* L, *C. caucasica* Willd, *C. glabrata* ex P Steven, *C. tournefortii* Lam), distributed in Alborz and Zagros mountains in different ecological setting (Khatamsaz, 1990). In the world, there are many different opinions among botanists in this genus because of the morphological similarities (Sattarian, 2006) and lack of comprehensive study in this genus (Whittemore, 2005).

Morphological Similarities between genera are undeniable (Ziegenhagen, 2005) but some characters are very useful to identify species. Fruit and endocarp (inner fruit walls) feature are useful in distinguishing Ulmaceae. Fruits in the Celtidaceae-Cannabaceae are fleshy drupes and endocarps are usually globose (Manchester, 1989). Reticulate surface

sculpturing is found in *Celtis*, *Peteroceltis*, *Trema*, and *Parasponia* (Sattarian, 2006). Seed coat features vary among the genera (Takaso and Tobe, 1990). Most botanists agree that data concerning the macro- and microstructure of fruits and seeds are very significant for the classification of Angiosperm taxa. During the last decades, scholars have applied scanning electron microscopy (SEM) to morphological studies of seeds and small fruits (Javadi and Yamaguchi, 2004; Minuto et al., 2006; Sattarian, 2006). By consideration on different opinions about Iranian *Celtis* (Sabeti, 1976; Gahraman, 1990; Khatamsaz, 1990), this present study surveyed the role of endocarp morphology in classification of Iranian *Celtis*.

Materials and Methods

In this present study, most of endocarp material was taken from herbarium vouchers, especially from herbarium at the research institute of forests and rangelands (TARI). Some specimens were collected at sites of *Celtis* in Iran too. The dried fruits were boiled in water for 10 min. and brushed clean, then rinsed in water with bleach for 10 min. to obtain clean endocarps. These were first examined by binocular (B). Subsequently endocarps were mounted on stubs with double adhesive tape. The stubs were sputter-coated with gold-palladium for 2-3 min. After coating, the specimens were examined with a XL30 (Philips - Swiss) scanning electron microscope (Figure 1 and 2). All photomicrographs were taken at SEM laboratory of Tarbiat Modares University, Tehran, Iran.

Results

Endocarp shape

The shape of endocarp showed variation among Iranian *Celtis*. Most endocarp varies from globular, ellipsoid to ovoid. They are ellipsoid -acuminate in *Celtis australis* and ovoid-acuminate in *C. glabrata*. Shape of endocarp in *C. caucasica* and *C. tournefortii* vary from globose to ellipsoid. *C. caucasica* and *C. tournefortii* can not be identified by the means of the endocarp shape.

Two classes of endocarp epidermis surface can be distinguished: smooth and rough. *C. glabrata* has a smooth epidermis and *C. australis*, *C. caucasica* and *C. tournefortii* have rough epidermis. The endocarp epidermis surface is a good character, useful to separate *C. glabrata* from the rest of Iranian *Celtis*.

Endocarp size

The size of endocarp also varies. It ranges from the smallest one (5.5×5×4.5 mm) in *Celtis glabrata* to the largest one (8×6×5.5mm) in *C. australis*. It is about 7×6×6 mm in *C. caucasica* and about 5.5×5.5×5 mm in *C. tournefortii*.

Endocarp color

The endocarp colors are diagnostic and of systematic interest among Iranian *Celtis*. A milky endocarp is seen in *Celtis glabrata* while cream-brown colored is seen in *C. australis*. Endocarp color varies from brown to russet for *C. caucasica* and *C. tournefortii*. Endocarp color is variable in *C. caucasica* and *C. tournefortii*.

Ridge

The number of ridges on endocarp is a significant character in Iranian *Celtis*. *C. glabrata* can be identified by the two main ridges while the rest of Iranian *Celtis* has four main ridges. The endocarp ridges are prominent in Iranian *Celtis*.

Endocarp ornamentation

Endocarps of Iranian *Celtis* species often have a polygonal sculpture. This structure is formed by the ridges and cross-connections between the edges. Polygonal sculpture is found in *C. australis*, *C. caucasica* and *C. tournefortii* while *C. glabrata* has a non-polygonal shape and smooth surface. The apex in *C. glabrata* has a few sculptures.

Shape of outer layer of the endocarp

There are holes with different sizes in the outer layer of the endocarp in Iranian *Celtis*. A description of endocarp surface (shape of outer layer of the endocarp) is presented (Table 2) and shown on the SEM photographs (Figure 1 and 2).

Table 1. Endocarp morphology of Iranian *Celtis* spp.

Taxon	<i>C. australis</i>	<i>C. caucasica</i>	<i>C. glabrata</i>	<i>C. tournefortii</i>
Size(mm)	8×6×5.5	7×6×6	5.5×5×4.5	5.5×5.5×5
Color	Cream- light brown	Brown- russet	Milky	Brown- russet
Shape	ellipsoid-acuminate	Globose	ovoid-acuminate	Globose - ellipsoid
Texture	Rough	Rough	Smooth	Rough
Ridge	Four ridges	Four ridges	Two ridges	Four ridges
Sculpture outline	Polygonal Isodiametric	Polygonal not-isodiametric	Not polygonal	Polygonal not-isodiametric
Ratio diam/length	6/5	6/7	5/5.5	5.5/5.5

Table 2. Shape Description of outer layer of the endocarp.

Taxon	Description of endocarp surface (shape of outer layer of the endocarp)
<i>C. australis</i>	Rough layers with different size of holes(>10μ), prominent surface sculpturing
<i>C. caucasica</i>	Rough layers with different size of holes(10-25 μ), prominent surface sculpturing
<i>C. glabrata</i>	Smooth surface with different size of holes (10-20 μ), similar to beehive
<i>C. tournefortii</i>	Rough layers with different size of holes(5-20 μ), prominent surface sculpturing

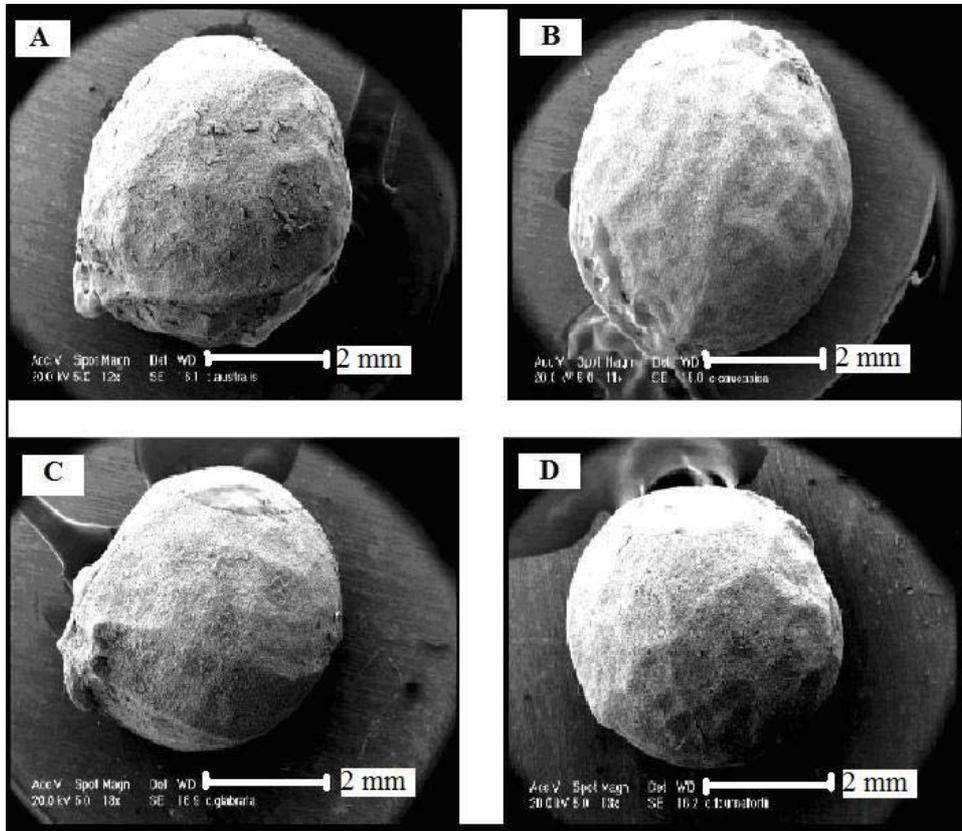


Figure 1. A: Ellipsoid -acuminate endocarp of *Celtis australis*. B: Globose endocarp of *C. caucasica*. C: Ovoid-acuminate endocarp of *C. glabrata*. D: Globose - ellipsoid endocarp of *C. tournefortii*.

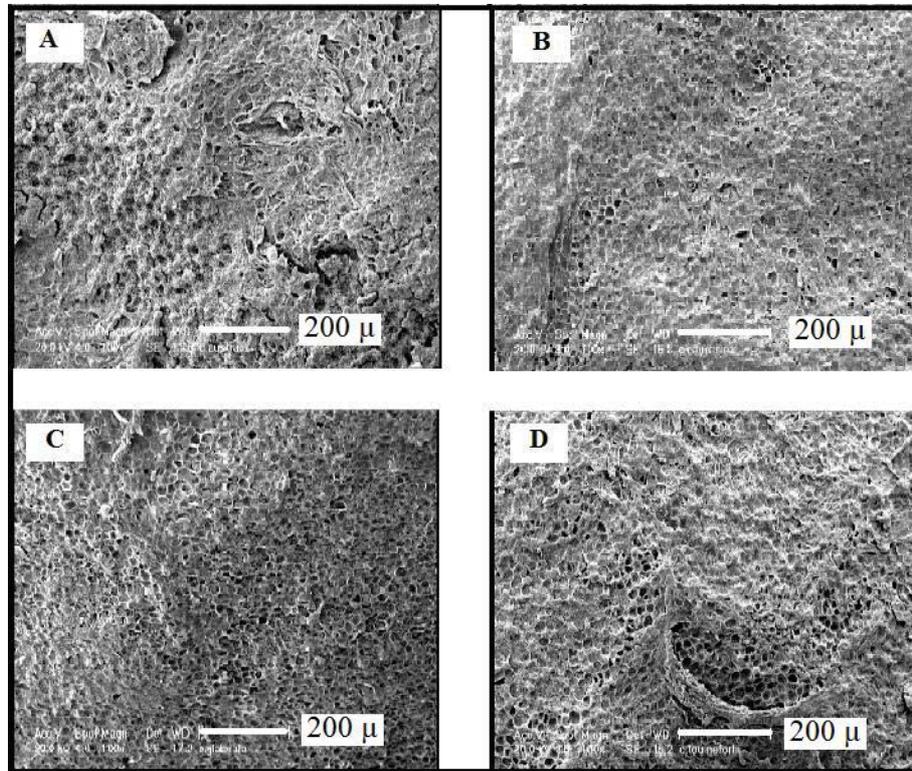


Figure 2. A: Outer layer of the endocarp with holes $>10\mu$ in *Celtis australis*. B: Outer layer of the endocarp with holes (10-25 μ) in *C. caucasica*. C: Outer layer of the endocarp with holes (10-20 μ) in *C. glabrata*. D: Outer layer of the endocarp with holes (5-20 μ) in *C. tournefortii*.

Discussion

The results of present study show that variety in endocarp characters is seen in the *Celtis* just as the other results from the African *Celtis* showed this variation (Sattarian, 2006). The endocarp shape varies from globular, ellipsoid to ovoid. The size of endocarp ranges from small (5.5×5×4.5 mm) to large (8×6×5.5mm). The endocarp color varies from milky, cream, brown to russet and helps to separate species. The number of ridge on endocarp is very useful characters for identifying *Celtis*; for instance *C. glabrata* has two ridges. Endocarp ornamentation is significant character for Iranian *Celtis* and varies from smooth surface to rough surface. The outer layers of the endocarp differ, cover with polygonal holes but size of holes differ from 5 μ to 25 μ . General results prove that endocarp morphology is efficient for distinguishing species of Iranian *Celtis*. There are similarities between, *C. tournefortii* and *C. caucasica* from the aspect of endocarp characters so it is necessary that more characters such as leaf and pollen morphology are needed for separation.

KEY TO IRANIAN *CELTIS* BASED ON ENDOCARP CHARACTERS

- 1 a** Endocarp with two main ridges, ovoid-acuminate, smooth, milky *C. glabrata*
2 b Endocarp with four main ridges, other colors
- 2 a** Endocarp ellipsoid-acuminate, rough, cream-light brown, 8*6*5.5 mm *C. australis*
3 b Endocarp globose-ellipsoid, brown
- 3 a** Size 7*6*6 mm *C. caucasica*
b Size 5.5*5.5*5 mm *C. tournefortii*

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