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## COMPARATIVE ANATOMICAL INVESTIGATIONS ON SOME SPECIES OF THE GENUS *ANGELICA* L.

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**Abstract:** The genus *Angelica* L. (Apiaceae) consists of some 90–110 species throughout the world, many with therapeutic potential. In Romania the genus is represented by three species: *A. archangelica* L., *A. sylvestris* L. and *A. palustris* (Besser) Hoffm.. Possessing high concentrations of bioactive compounds such as mono- and sesquiterpenes (mainly  $\alpha$ - and  $\beta$ -pinene,  $\alpha$ - and  $\beta$ -phelandrene) and coumarins, various taxa of the genus have been relatively well characterized from a phytochemical point of view and various bioactivities have been described for extracts from such taxa. However, anatomical features have received much less interest, except for characters of the fruits. Meanwhile, a comparative description of the indigenous Romanian species is lacking in the literature and may prove useful if microscopic discrimination among them is required. The current study compares the three species at the level of different organs, underlining both similarities and differences.

**Keywords:** *Angelica archangelica* L., *Angelica sylvestris* L., *Angelica palustris* (Besser) Hoffm., anatomy.

### Introduction

With more than 90 species described in the literature, the genus *Angelica* (Apiaceae) is relatively large, with established importance since more than half of its species have traditional uses as therapeutic resources. Meanwhile, more than 10 species are included in commercial products with various indications [9]. The research on the various taxa is mainly biochemically oriented and has revealed anti-tumour [5], antibacterial [7], antifungal [12] and other bioactivities of the compounds contained in different types of extracts investigated. The anatomy of the different species is, quantitatively, less represented in the literature we have surveyed, and the available data concern mainly *A. archangelica* [10,11], *A. sylvestris* [6] and some Asian species [1]. For *A. palustris*, anatomical details are scarce indeed, and a comparison in this respect for the three Romanian indigenous taxa is needed. Considering that two of the species present in the Romanian flora, *A. archangelica* and *A. sylvestris*, are regarded as medicinal plants, and also the lack of information about *A. palustris*, we feel it is useful to describe the comparative anatomy of the three species. It should be noted that *A. palustris* is a rare European species listed on Annex II of the EU Habitats Directive, and is local in Romania, where its conservation status is regarded as Vulnerable.

### Material and Methods

Plants were collected from wild populations, at the fruiting stage, and a specimen from each species deposited at the Faculty of Biology Herbarium, and authenticated by Prof. Nicolae Ștefan from the Faculty of Biology. Razor-cut sections were obtained using a hand microtome. Subsequently, the sections were stained using a dual coloration technique with iodine green and ruthenium red. The organs used for anatomical investigations were the root (in the case of *A. archangelica*, due to insufficient material, the collet was used), the stem (in the median longitudinal region), the base of the leaf rachis and the foliole. For each of the taxa, six individuals were analyzed in order to evaluate possible individual variations (the number of individuals examined was limited by the size of the populations). Observations were made using

a Olympus microscope with built-in camera which allowed photographs to be taken. Additionally, permanent slides were obtained using a mixture of glycerine and gelatine as the embedding medium.

### Results

The main differences between the three species, at the level of the organs investigated, are summarized in Table 1. Also, some similarities for each organ in the three taxa are included.

**Table 1: Comparative anatomical aspects of three *Angelica* taxa**

Species/organ	<i>A. archangelica</i> L.	<i>A. palustris</i> (Besser) Hoffm.	<i>A. sylvestris</i> L.
<b>Root (collet for <i>A. archangelica</i>)</b>	- irregularly shaped air cavities - extremely narrow medullary rays - reduced numbers of small diameter woody vessels among the woody parenchyma cells (Photos 1,2)	- secondary medullary rays 7- to 16-layered, made of cells having all walls very thin, cellulo-pectic, very rich in starch (Photo 3)	- the libriform tissue is missing from the secondary wood - the secondary medullary rays in the range of secondary phloem are very large (7- to 13-layered) due to the size of the component elements (Photo 4)
	- secretory ducts within the phloem		
<b>Stem</b>	- irregular air cavities within the breadth of the parenchymal cortex - sometimes, these cavities can be observed in the range of secondary phloem (Photo 5)	- secretory ducts have collector channels surrounded by 2 layers of cells, especially for ducts next to isles of hypodermal collenchyma - secondary vascular bundles with arch-shaped libriform tissue which encompasses 3-5 small vessels (Photo 6,7)	- smaller bundles in respect of the number of vessels (Photo 8)
	- in all three species, the transition from the primary to the secondary structure is made according to the <i>Helianthus</i> model		
<b>Base of rachis</b>	- the upper (internal) side shows 3 ribs (2 obviously taller, approximately equal, centering a third rib, with 1/3 the height of the others) - in hypodermal position, each rib has a multilayered angular collenchyma (8-11 layers) (Photo 9)	- a 3-rib arrangement is missing (2 taller, centering a smaller one), instead the upper side shows several, relatively tall and wide ribs - within the basic parenchyma, high numbers of secretory ducts and collateral open type vascular bundles occur, placed at mid-distance between the two epidermides (Photos 10,11)	- the hypodermal collenchyma is pole-shaped, while some cells in the basic parenchyma have slightly thickened and lignified walls (Photo 12)
	- secretory ducts occur around some of the vascular bundles; 'twin bundles' occur, with the xylem strands facing each other		
<b>Foliolate</b>	- on the adaxial-abaxial flanks and in the abaxial region, 5 isles of hypodermal collenchyma occur, each one having next to it one secretory	- the palisade tissue presents cells in the second layer less tall and with small air spaces between them (Photo 15)	- the median vein also shows a ridge on the abaxial face (Photo 16)

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<p>duct, the one at the axial face obviously larger          - beneath the upper epidermis, a palisade cells layer takes up approx. 1/3 of the mesophyll height;          between the palisade cells layer and the first lacunae-type layer, a layer of funnel-shaped cells exist (collecting cells)          (Photos 13,14)</p>		
<p>- the structure is bifacial heterofacial</p>		

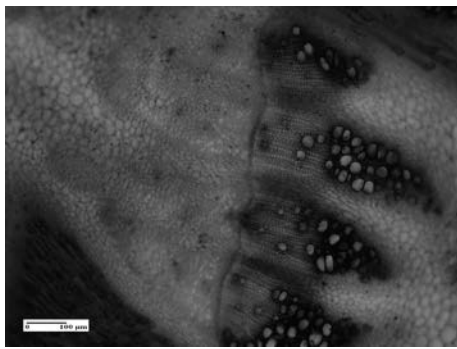


Photo 1: *A. archangelica* – collet (cross-section)

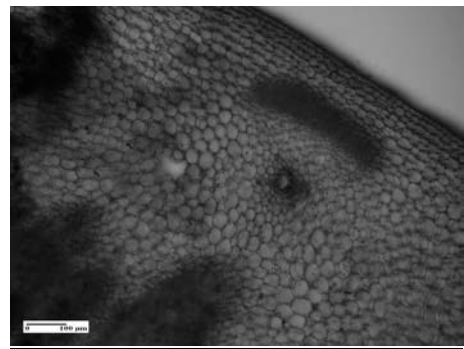


Photo 2: *A. archangelica* – collet (cross-section)

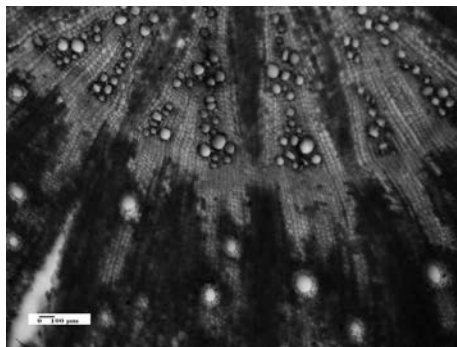


Photo 3: *A. palustris* – root (cross-section)

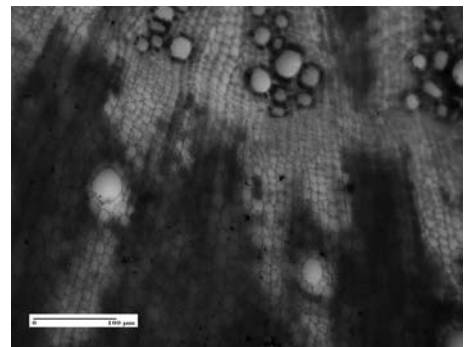


Photo 4: *A. sylvestris* – root (cross-section)

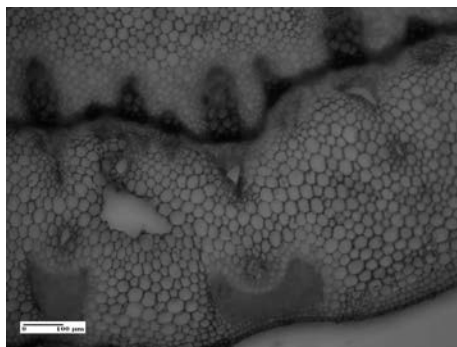


Photo 5: *A. archangelica* – stem (cross-section)

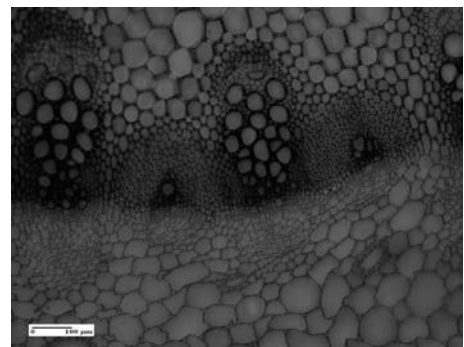


Photo 6: *A. palustris* – stem (cross-section)

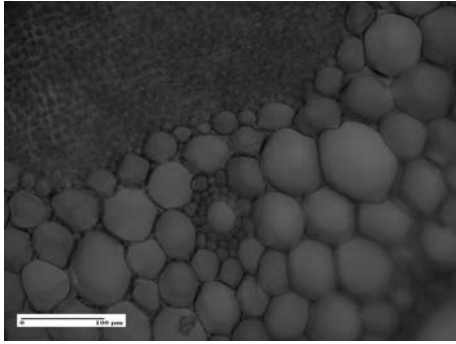


Photo 7: *A. palustris* – stem (cross-section)

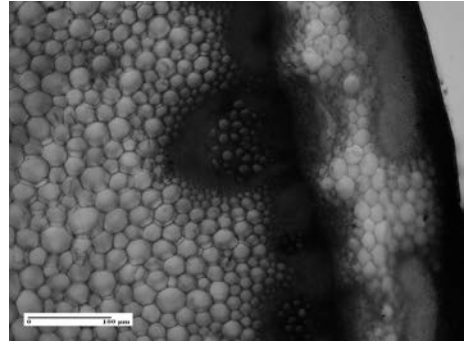


Photo 8: *A. sylvestris* – stem (cross-section)

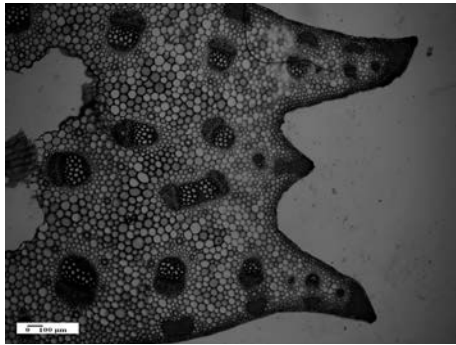


Photo 9: *A. archangelica* – rachis base (cross-section)

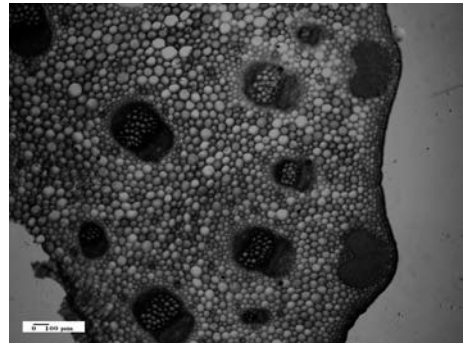


Photo 10: *A. palustris* – rachis base (cross-section)

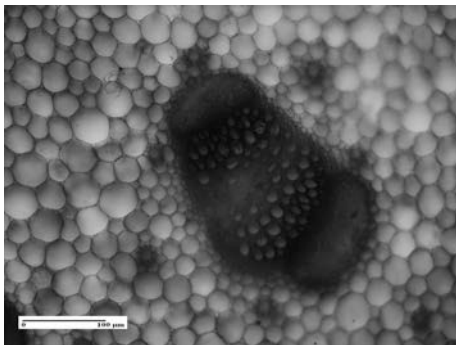


Photo 11: *A. palustris* – rachis base (cross-section)

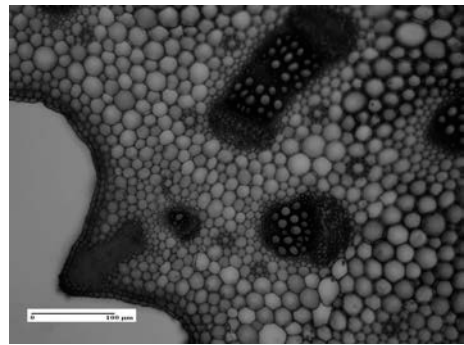


Photo 12: *A. sylvestris* – rachis base (cross-section)

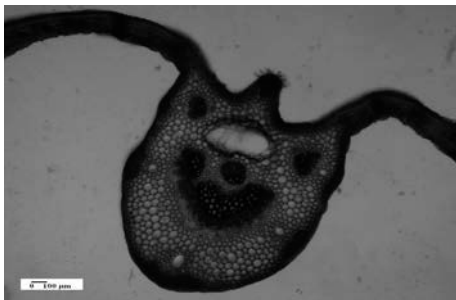


Photo 13: *A. archangelica* – foliole (cross-section)

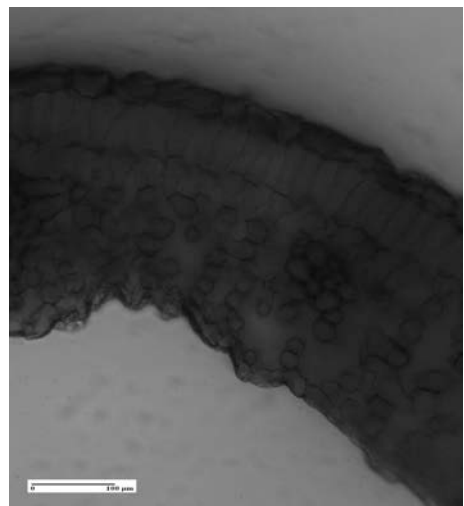


Photo 14: *A. archangelica* – foliole (cross-section)

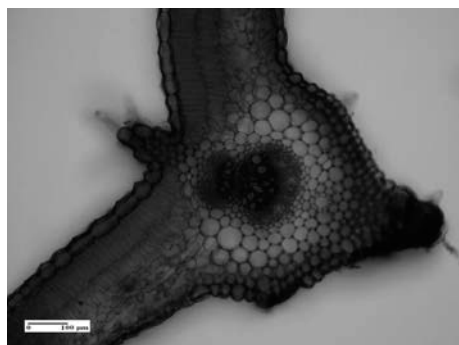


Photo 15: *A. palustris* – foliole (cross-section)

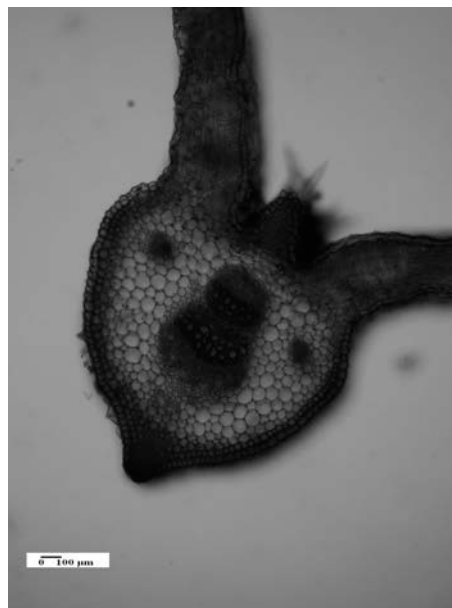


Photo 16: *A. sylvestris* – foliole (cross-section)

### Discussion

At the level of the organs investigated, our observations are in agreement with previous studies. The types of tissues encountered and their disposition are consistent with those already described, such as the epidermis, a collenchyma strand, secretory ducts, vascular strands, other secretory ducts within the outer pith in the stem or the peridermis, a cortical parenchyma, a secondary cortical area comprising the medullary rays, a cambial area and vascular strands in the root [3]. The presence of cortical parenchyma in the stem and the similar secretory system in the stem and leaf were also described earlier [2]. Secretory ducts in the phloem and the partly disorganized cortical tissue in the root were also noted [8]. The internal structure of the leaf conforms to the bifacial heterogeneous type [4]. It must be noted that characteristic features such as those above are more or less common to many species of *Apiaceae*. Referring to the species investigated by us, we may confirm aspects such as the air cavities in the stem of *A. archangelica* or the arrangement of ribs on the rachis of the same species [6]. However, for the other two species investigated, the literature offers far fewer data for comparison, especially at the level of the organs considered. Thus, we consider some of the observed aspects useful for differentiating between species, such as the width of the medullary rays in the root. The arrangement of the ribs of the rachis is different for *A. archangelica* and *A. palustris*, while it shows some similarities between *A. archangelica* and *A. sylvestris*, although the pole-shaped hypodermal collenchyma in the latter leaves little room for confusion. Within the foliole, the five isles of collenchyma and accompanying secretory ducts present in *A. archangelica* clearly set this species apart, as do the funnel-shaped cells underneath the row of palisade cells. While there are two layers of palisade cells in both *A. palustris* and *A. sylvestris*, the latter shows additional vascular strands on the flanks and also a ridge on the abaxial face. Another noteworthy aspect that might be considered is the transitional model from primary to secondary structure in the stem for all three taxa.

### Conclusions

While confirming some of the anatomical data in the literature, our study also points out some features, both shared and different in the three indigenous Romanian *Angelica* taxa. Such

traits could be used to distinguish these species, complementing morphological aspects as necessary. Moreover, especially for *A. palustris* but also for *A. sylvestris*, the elements described might help to better characterize the species. Considering that observations might be made at the level of other organs as well, future investigations may well observe other notable features of these taxa.

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#### INVESTIGAȚII ANATOMICE COMPARATIVE ASUPRA UNOR SPECII ALE GENULUI *ANGELICA* L.

##### (Rezumat)

Genul *Angelica* este reprezentat la nivel mondial prin cca. 100 de specii, numeroase având valențe terapeutice. Compoziția chimică a acestor specii include metaboliți secundari de tipul cumarinelor și a uleiurilor esențiale, iar activitățile farmacologice sunt deosebit de variate în ceea ce privește extractele obținute din astfel de plante. În România, genul este reprezentat prin 3 specii, *A. archangelica*, *A. sylvestris* și *A. palustris*, primele două fiind recunoscute ca plante medicinale. Deși studiile asupra acestor specii sunt relativ numeroase, ele sunt preponderent axate pe investigații fitochimice, analizele anatomice fiind mai puțin reprezentate. Pentru *A. palustris*, literatura oferă foarte puține date în ceea ce privește anatomia, iar o comparație la acest nivel între cele 3 specii lipsește, putând fi utilă dacă ținem cont de asemănările morfologice și de includerea unor astfel de specii în preparate terapeutice comerciale. Studiul redă o serie de diferențe și de similitudini între cele 3 specii la nivelul a diferite organe, putând servi la diferențierea speciilor pe criterii anatomice.