Morphology and Histology of the Nectary in Hungarian Local Pear Cultivars

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Abstract
The topography, morphology and histology of the nectary of 12 Hungarian pear cultivars in a Hungarian cultivar collection (Újfehértó) were studied over the past 3 years. The intrafloral nectary was receptaculo-ovarial, lining the adaxial surface of the plate-like receptacle and the apical part of the ovary. The gland was automorphic on the apical part, and in some cases also on the basal part, protruding out of the receptacular tissue. A narrow zone of the nectariferous tissue stretched along the style, allowing nectar accumulation in the gap between the style and the nectary. The pear nectary was covered by a smooth cuticle, the thickness of which varied slightly between cultivars and from season to season. In the medial longitudinal section of the flower the epidermal cells were palisad-like or square-shaped, sometimes papillate. Guard cells of nectar stomata could be found either at the level of the epidermal cells (mesomorphic type) or sunken a few cell rows below the epidermis (xeromorphic type). Below the stomata, among the cells of the glandular tissue, nectar-storing intercellular cavities of varying sizes could be found. The glandular tissue consisted of small, dark-staining cells. In some cultivars the nectariferous tissue could be well distinguished from the nectary parenchyma, consisting of larger, light-staining cells. In other cultivars a mosaic-like structure could be observed, where glandular cells were mixed with parenchyma cells, with no sharp distinction between the two tissue types. In some taxa there was a correlation between the size of the nectary and nectar production, which may be important in cultivar selection.

INTRODUCTION
Nectaries have been classified by several researchers on the basis of their topography (Kartashova, 1965; Fahn, 1979; Schmid, 1988), the main categories being reproductive and extrareproductive nectaries. The morphology and histology of nectaries in Rosaceae species was dealt with in detail in the works of Frei (1955), Kartashova (1965) and Szilva (1969). According to these authors, the nectary in the Rosaceae family is mostly receptacular. It consists of three histologically distinct parts: the epidermis, the glandular tissue and the nectary parenchyma. The nectary of several Rosaceae taxa cultivated in Hungary has been described by Orosz-Kovács (1989a, b; 1991; 1993a, b), Orosz-Kovács et al. (1990, 1990/91, 1995) and Scheid-Nagy Tóth (1991, 2000). A detailed characterisation of nectary surface, cuticle ornamentation, stoma position and glandular tissue structure has been given by the above authors.

The aim of the present investigation was to study and describe the topography, morphology and histology of the nectary in some Hungarian pear cultivars, which are part of a gene bank and may serve as an important source for future breeding purposes. Another goal of the study was to determine relationships between the structural features of the nectary and nectar production, insect attraction, as well as ecological requirements of the studied cultivars.
MATERIALS AND METHODS

Cultivars Studied
Studies were made of the nectary of twelve Hungarian pear cultivars grown in the gene bank of the Research and Extension Centre for Fruitgrowing, Újfehértó, Hungary, between 1998 and 2000.

The pear cultivars that were studied were the following: ‘Bajai 6’, ‘Bőtermő Nyári Kálmán’, ‘Clapp’, ‘Fillér’, ‘Jó szürke’, ‘Mosoly’, ‘Nagyasszony’, ‘Nyári, Dunaföldvár’, ‘Őszvi vajkörte’, ‘Pb 242’, ‘Viki’ and ‘Zánkai magonc’. The majority of the studied cultivars was derived from *Pyrus communis* L., while ‘Pb 242’ was derived from *Pyrus betulifolia* Bge.

Histological Studies
At least ten flowers of each cultivar were fixed in the 1:1:1 mixture of ethanol:glycerine:distilled water. For the histological study of the nectary, flowers were dehydrated in acetone and xylol, then embedded in paraplast. Longitudinal sections 3-5 µm thick were cut with a sledge or rotary microtome. Preparations were stained with toluidine-blue.

The following parameters of the nectary were measured by Image Tool 1.27; size and thickness of nectary, thickness of nectary cuticle and glandular tissue, size and shape of epidermal cells, and size of the nectar chamber.

Scanning Electron Microscopy
Flowers were fixed in 0.2 M glutaraldehyde, and then washed in 0.1 M Na-cacodilate buffer. Post-fixation was done in osmium-tetroxide. Following dehydration in a graded ethyl alcohol series, samples were critical-point dried in iso-amyl-acetate. Samples were gold-coated in a Yeol sputter coater and examined with a Hitachi S-2360 N scanning electron microscope.

RESULTS AND DISCUSSION

Topography and Morphology of Pear Nectary
The floral nectary of pear is receptacular-ovarial, lining the adaxial side of the plate-like hypanthium and the apical part of the ovary. The nectary of the studied cultivars was automorphic, since the gland protruded out of the receptacular tissue at the apical part (Fig. 1.) in each cultivar, and in some cases at the basal part as well. The nectariferous tissue also continued along the style, in some cultivars as far as the base of the style. Since nectary stomata could also be found at this part, the secreted nectar could be stored longer in this protected area. The accumulated secretion product is important for insect attraction, simultaneously, however, increasing the chance of infection by bacteria, e.g. *Erwinia amylovora*.

Size and Thickness of the Nectary
During the three years of study, the size of the whole nectary varied between 0.5 and 3.3 mm². Each year a large gland (> 2 mm²) was found in ‘Jó szürke’, ‘Nagyasszony’ and ‘Viki’. The smallest nectaries were measured in ‘Fillér’ and ‘Zánkai magonc’ (0.5-1.3 mm²). Cultivars with large flower diameter usually possessed a large nectary (1999: $r^2 = 0.6965$; 2000: $r^2 = 0.6439$).

Similarly to apple cultivars (Orosz-Kovács, 1989a; Orosz-Kovács et al., 1990; Scheid-Nagy Tóth, 1991), a correlation was found between the size of the nectary and the amount of nectar (2000: $r^2 = 0.7447$), as well as, between the nectary size and the sugar concentration of the secretion product (2000: $r^2 = 0.6324$). Supposing that the above correlation can be confirmed with data from several years, nectar production under optimal conditions can be predicted on the basis of nectary size. This could provide
valuable information concerning insect attraction and the apicultural value of pear cultivars.

The total thickness of the nectary reached high values in the abovementioned cultivars with large nectaries (e.g. ‘Viki’: > 600 µm annually), while cultivars with small nectaries usually had a thin nectary (350-400 µm).

**Nectary Surface**

As described earlier for other pears (Orosz-Kovács, 1993a; Orosz-Kovács et al., 1995; Werysko-Chmielewska and Konarska, 1995; Farkas et al., 1997, 1999), the nectary epidermis of the studied pear cultivars was smooth, with no ornamentation, and covered with a cuticle that became thinner at the cell borders (Fig. 2.). The mostly sunken stomata refer to xeromorphy, which is usually accompanied by conspicuous cuticle ornamentation in other Rosaceae taxa (Orosz-Kovács, 1989b, 1993a, b; Orosz-Kovács et al., 1990/91, 1995; Nagy Tóth et al., 1995).

**Nectary Epidermis**

1. **Cuticle.** The thickness of the cuticle varied slightly over the three years of study; the average values for cultivars were in the ranges: 1.26-2.21 µm, 1.34-2.58 µm and 1.84-2.51 µm in 1998, 1999 and 2000, respectively. These values were smaller than those measured in other Rosaceae taxa, like apple: 3-3.5 µm (Scheid-Nagy Tóth, 2000) or in sweet and sour cherry, where the thickness of the cuticle can reach 6 µm (Orosz-Kovács, 1991). The above data contradict the observation that in open, exposed flowers, like in pear, the nectary epidermis is covered by a thick cuticle (Kartashova, 1965; Metcalfe and Chalk, 1979).

2. **Epidermal Cells.** In the medial longitudinal section of the intrafloral nectary, epidermal cells were mostly elongated, and palisad-like in adaxial direction (Fig. 3.), although square-shaped cells were also found. According to Fahn (1979), the elongated cell shape is rather characteristic in extrafloral nectaries (e.g. *Amygdalus*). In some cultivars the epidermal cells were slightly papillate (Fig. 2.). The length/thickness quotient, which also characterises the shape of the epidermal cells, was always high (approaching 1) in ‘Bajai 6’, where cell shape was closest to isodiametric, whereas in ‘Jó szürke’ and ‘Nyári, Dunaföldvár’ this value was smaller, in accordance with the narrow, elongated shape of the epidermal cells.

3. **Nectary Stomata.** The position of the nectary stomata in relation to epidermal cells refers to the ecological type of the cultivar. In ‘Fillér’ and ‘Bőtermő Nyári Kálmán’ the guard cells were either in the same level as the epidermis (Fig. 4.), or sunken to half of the epidermal cells (Fig. 6.). These cultivars belong to the mesomorphic or slightly xeromorphic ecological type. In ‘Clapp’, ‘Mosoly’ and ‘Oszi vajkörte’ all the stomata were 1-3 cell rows deeper than the epidermis (Fig. 5.), indicating xeromorphy and better drought-resistance.

**Nectar Chambers**

Below the guard cells of stomata, among the cells of the glandular tissue, intercellular cavities of varying size were found. These chambers are capable of storing nectar before secreting it to the surface or following resorption. The size of the nectar chambers was very small (e.g. ‘Clapp’: < 200 µm²), small (e.g. ‘Viki’ and ‘Mosoly’: 200-300 µm², Fig. 5.), medium-size (e.g. ‘Fillér’: 300-600 µm², Fig. 4.) or large (e.g. ‘Bőtermő Nyári Kálmán’: > 600µm², Fig. 6.). The accumulated nectar can ensure favourable conditions to *Erwinia amylovora*, which infects the flowers through the nectary stomata.

**Glandular Tissue and Nectary Parenchyma**

1. **Histological Features.** The glandular tissue consisted of small, dark-staining cells of irregular shape, in contrast with other Rosaceae taxa (e.g. sweet and sour cherry), where the glandular cells are regular, mostly square-shaped, arranged in rows or columns
In some pears (e.g. Pyrus betulifolia) the glandular tissue could be well distinguished from the nectary parenchyma, which contained larger, lighter-staining cells with well-developed vacuoles (Fig. 7.). However, in most cultivars only a few subepidermal cell rows comprised a continuous glandular tissue, whereas in the deeper regions of the nectary glandular cells were mixed with parenchymatous cells (Fig. 8.). Such a mosaic structure can also be observed in other Maloideae taxa (Orosz-Kovács et al., 1995), e.g. in apple cultivars (Scheid-Nagy Tóth, 1991).

2. Thickness of the Glandular Tissue. The thickness of the glandular tissue usually amounted to the two fifth of the total nectary thickness. The average glandular tissue thickness was in the range 150-280 µm, the highest values measured in ‘Viki’ and ‘Jó szürke’.

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Literature Cited


**Figures**

![Image of the automorphic nectary apex of pear cv. Mosoly (M = 125x).](image-url)
Fig. 2. Nectary surface of cv. Szagos with sunken stomata (M = 600x).

Fig. 3. Elongated epidermal cells of cv. Nyári, Dunaföldvár (M = 400x).
Fig. 4. Mesomorphic stoma in the nectary epidermis of cv. Fillér (M = 400x).

Fig. 5. Xeromorphic stomata in the nectary epidermis of cv. Mosoly (M = 400x).
Fig. 6. Large nectar chambers in cv. Bőtermő Nyári Kálmán (M = 400x).

Fig. 7. Glandular tissue and nectary parenchyma can be well distinguished in *Pyrus betulifolia* (M = 400x).
Fig. 8. Mosaic structure: glandular cells and parenchyma cells mixed in the nectary of cv. Viki (M = 400x).