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The pericarpic structure of *Withania somnifera* (L.) Dunal

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Abstract. The small berry of *Withania somnifera* is enclosed in an inflated calyx. Its pericarp is histologically differentiated into a 5–6 layered compressed collenchymatous epicarp, a multilayered zone of parenchymatous mesocarp and a 3–4 layer thick endocarp. The anomocytic stomata surrounded by 4–6 epidermal cells occur only in the basal region of the fruit. The number of cells of the mesocarp does not increase much, but its cells become enlarged, vacuolated and separated at maturity. The endocarpic lobes adhere to the placental false septa and enclose the individual seeds in separate chambers.

Keywords. *Withania somnifera*; pericarp; placentae.

1. Introduction

Withania somnifera or "Ashwagandha" as it is called in Sanskrit, is mentioned as an important drug in ancient Ayurvedic literature. Being a medicinally important plant, it has attracted the attention of various workers in the field of medicinal botany. Its seedling and floral anatomy has been worked out by Deshpande and Singh (1967). The berry of *W. somnifera* is 5–9 mm in diameter and enclosed in much enlarged inflated and a somewhat 5 angled calyx (figure 1B). Khafagy and Sabri (1970) made a pharmocognostical study of *W. somnifera* but described very little about the anatomy of the fruit. Ram and Kamini (1964) studied the embryology and fruit development of this plant, but their account does not include the structural details of the fruit.

In this paper, a detailed structural analysis of the *W. somnifera* pericarp is made in continuation of the pericarpic studies in Solanaceous fruits (Dave *et al* 1979a, b, 1980a, b, c, 1981).

2. Material and methods

Ovaries and fruits in different developmental stages were collected and fixed in FAA for 24 hr, washed in 70% alcohol to proceed by the usual methods of dehydration and infiltration. The microtomed sections (8–10 μm) stained with safranin and fast green combination (Berlyn and Miksche 1976) were made permanent by the usual procedures. The diameteres of the ovaries and developing fruit stages are shown in table 1.

3. Observations

3.1 *Ovary (from flower bud and flowers)*

The ovary is 0·5 to 1·0 mm in diameter, broad at the base and slightly narrow towards the tip (figure 1A). As seen in cross-section it is lobed and 2–3 loculed with axile

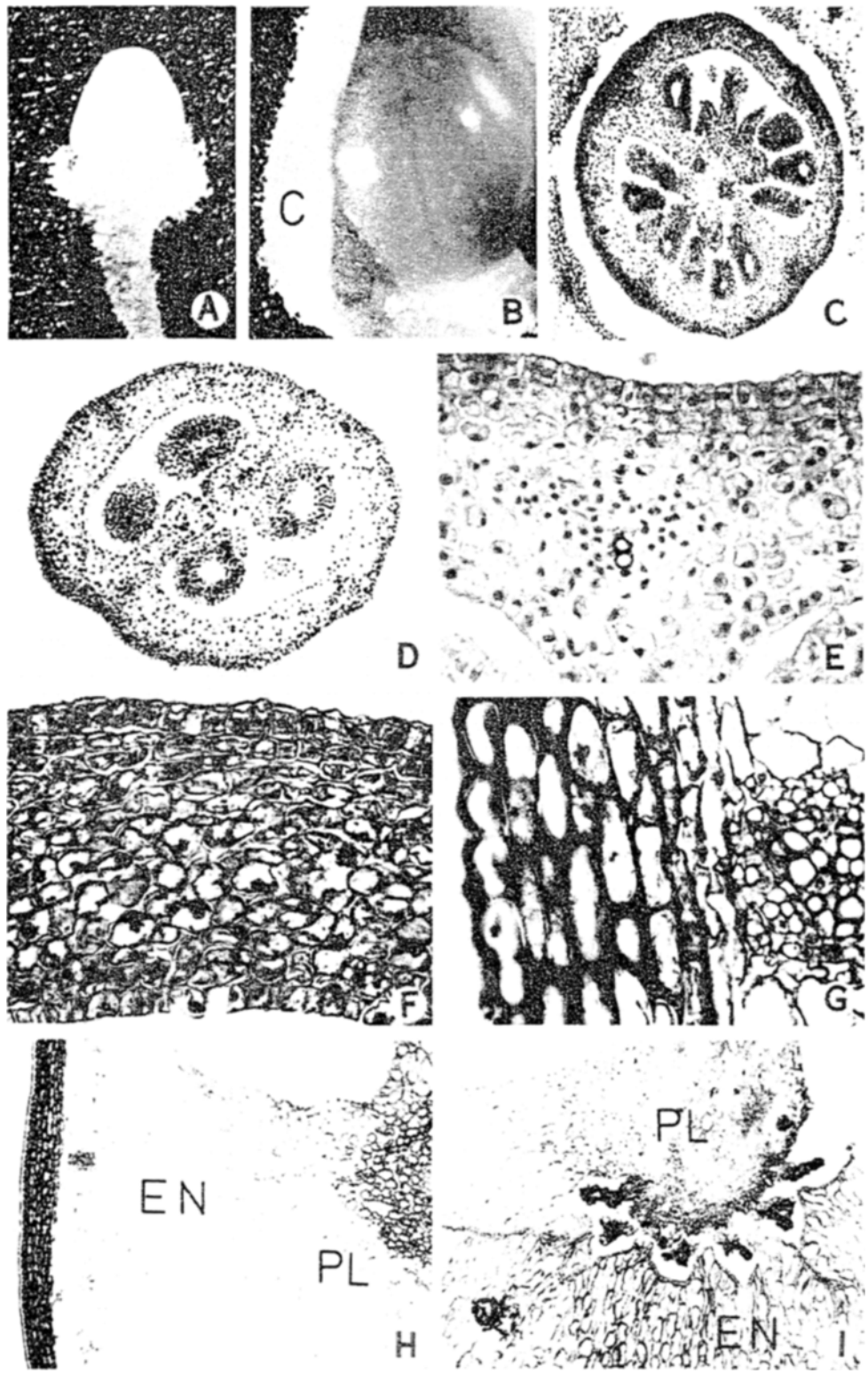
A
C
B
C
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Table 1. Measurements of the ovary and fruits studied at different developmental stages.

Stage	Diameter (mm)	Remarks
1	0·5–0·7	Ovary (from flower bud)
2	0·8–1	Ovary (from flower)
3	1·5–2	Developing fruit
4	3·0–5	(green in colour)
5	5·0–9	Mature fruit (red in colour)

placentation (figure 1C). The chambers are narrow in the terminal region. The basic vascular supply is made up of four strands which branch into 12–16 in the middle of the ovary. Again above the level of the chamber the ventral and placental strands seem to join and fade out, but only two dorsals are seen extending towards the style.

3.1a *Ovary wall*: The cells in the ovary wall are almost homogeneous with large spherical nuclei and small vacuoles. The ovary wall in the bud condition is 8–9 layers thick and in the open flower stage 10–12 layers thick (figure 1E). The outer epidermis has tubular cells with thin cuticle (figure 1E). Stomata are present only in the basal region of the ovary but trichomes are absent all over.

The 2–3 layers of outer hypodermal cells appear anticlinally and periclinally divided (figure 1E). The middle zone of the ovary wall is made up of thin-walled, large vacuolated parenchyma in which the young and developing vascular bundles are embedded. There are 2–3 inner hypodermal layers with periclinally divided cells. The inner epidermis has thinly cutinized tabular cells with spherical nuclei. Stomata and trichomes are absent in the inner epidermis.

3.1b *Placentae*: There are two (figure 1C) or three axile placentae in the ovary. In the terminal region of the ovary the placentae are not seen and the two septa appear free in the centre of the unilocular chamber (figure 1D).

3.2 *Developing pericarp*

The further growth of the fruit is due to cell divisions and enlargement of the pericarpic and placental tissue.

3.2a *Epicarp*: The outer epidermis and 4–6 outer hypodermal layers constitute the epicarp of the fruit which develops from the outer epidermis and 2–3 outer

Figure 1. **A.** Ovary from open flower (× 25·6). **B.** Berry with persistant calyx (× 25·6). **C.** TS of ovary at the middle region showing axile placentation (× 108). **D.** TS of ovary at terminal region showing free septa (× 160). **E.** Cellular details of ovary wall from ventral side (× 260). **F.** Cellular details of pericarp from lateral side (× 260). **G.** Cellular details of pericarp portion with vascular bundle (× 480). **H.** Cellular details of part of pericarp septum and placenta (× 48). **I.** Portion of endocarp and placenta with aborted ovules (× 40). (C, calyx; EN, endocarp; PL, placenta)

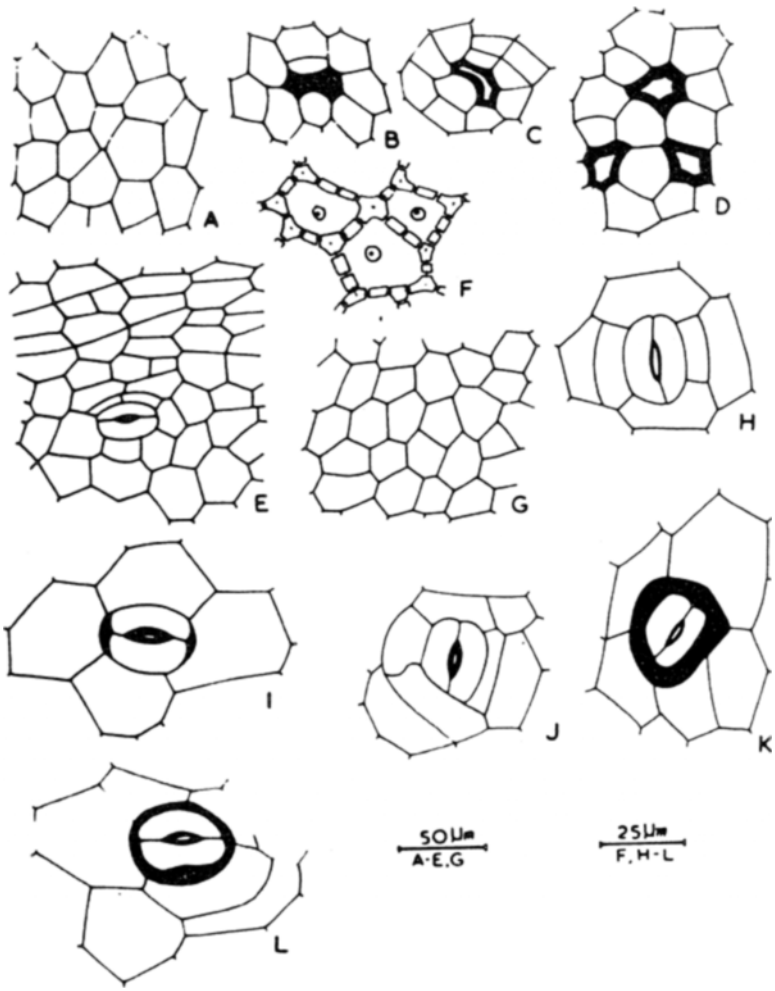

Figure 2. **A.** Outer epidermis in surface view. **B–D.** Wall thickening among the epicarpic cells. Note the formation of ventilating cleft in **C**. **E.** Outer epidermis from basal region showing the presence of stomata. **F, G.** Outer epidermal cells from the middle region of the fruit showing pitted walls. (F enlarged from G.) **H, J.** Anomocytic stomata surrounded by four epidermal cells. **I.** Thickening of polar walls of stomata. **K, L.** Thickening surrounding the stomata.

hypodermal layers of the ovary wall (figure 1G). The outer epidermis appears as polygonal parenchyma, with stomata and ventilating clefts (figures 2A, C, E, F, G, H–L). The anomocytic stomata are present only in the basal region of the fruit and are surrounded by 4–6 epidermal cells (figure 2E, H, J). Sometimes they show thickening on their polar walls or all around the guard cells (figure 2I, K, L). The epidermal cell walls in the mature stage of the fruit appear thickened and pitted, the cells enclosing cytoplasm and nuclei (figure 2F). Abnormal wall thickenings also occur in the outer epidermal cells of the developing pericarp (figure 2B, D). In transections the outer

tangential walls and the radial walls of the epidermis appear heavily cutinized (figure 1G). The 4–6 layers of outer hypodermal cells are transversely elongated or compressed and collenchymatous in nature. The whole epicarp of the mature fruit is easily peeled and separated from the inner thin walled cells of the mesocarp (figure 1G, H).

3.2b *Mesocarp*: It develops from the middle or mesodermal cells of the ovary wall. The cells do not increase much in number, but enlarge, become largely vacuolated and separated or form wide intercellular spaces towards the maturity of the epicarp (figure 1F, H, I). The mesocarpic vascular bundles are conjoint, collateral, bicollateral or concentric and embedded beneath the epicarp (figure 1G).

3.2c *Endocarp*: It develops mainly from 2–3 inner hypodermal layers and the inner epidermis of the ovary wall. During its further development, one, two or more inner hypodermal layers are produced by periclinal divisions of their walls which later undergo enlargement. They possess scanty cytoplasm and appear radially elongated and separated. The inner epidermal cells do not enlarge but elongate transversely or become compressed (figure 1I). Due to the uneven radial enlargement of the cells, the endocarpic lobes appear protruding towards the placenta in the fruit chamber (figure 1I). Some of these protruding lobes adhere with the placental septa to form individual chambers in which the seeds are enclosed.

3.3 *Placentae*

The peripheral tissue of the placentae in the early stages appear densely stained while the central cells are largely vacuolated. Later at some surface regions the placental tissue increases and enlarges to form the false placental septa which unite with the endocarpic lobes (figure 1I). The cells of the placental septa appear largely vacuolated and separated in the later stages of fruit development. The initial septa of the ovary which consists of almost isodiametric or polygonal cells with large spherical nuclei, later show elongated loosely arranged and more vacuolated cells with small elliptic or spindle shaped nuclei. The two concentric vascular bundles of the central placental axis are surrounded by largely vacuolated thin walled loosely arranged cells containing starch (figure 1H).

4. Discussion

Roth (1977) stated, "In berries which are surrounded by a protective calyx, however, the collenchyma fails to develop". But according to Klemt as quoted by Roth, the berries of Solanaceae generally develop a collenchymatous hypodermis. In contrast to Roth's statement but in accordance with Klemt's observation the pericarp of *Withania* berry consists of the epidermis and 4–6 collenchymatous hypodermal layers. Ontogenetically a single layer of the outer epidermis and 2–3 outer hypodermal layers of the ovary wall take part in its formation. The anomocytic stomata surrounded by 4–6 epidermal cells are present only in the basal region of the fruit as also found in *Physalis minima* by Patel and Dave (1976), and in *Lycium vulgare*, *Physalis alkekengi* and *Mandragora officinalis* (Roth 1977). The mesocarp of *Withania* is similar to that in *Nicandra physaloides* (Roth 1977).

The false placental septae are produced due to the limited meristematic activity and enlargement of the peripheral tissue of the placenta. The cells of the septa in mature fruit become elongated, vacuolated and separated. In some other berries like *Physalis alkekengi*, *Solanum citrullifolium*, *S. hendersoni*, and *S. nigrum* (Roth 1977), the locules are filled by proliferations of pericarp wall as well as of placentae. In *Solanum melongena* (Dave *et al* 1979b) and *S. indicum* (Dave *et al* 1980b) the multilocular condition is caused by the meristematic activity of the inner layers of the endocarp and the outgrowth from the peripheral cell layers of the placentae. No endocarpic outgrowths are found in *Solanum tuberosum* (Dave *et al* 1980c).

According to Deshpande and Singh (1967) in the lower region of the gynoecium the ovary is bilocular with axile placentation, but in the upper region the ovary becomes one-celled with apparently parietal placentation. As the locules separate from each other, the ventrals recede and the dorsals proceed to supply the style. This observation supports Puri's (1951) contention that anatomically parietal placentation is derived from axile type.

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