

---

# THE LEAF ANATOMY OF BALI SALAK CULTIVARS (*Salacca zalacca* var. *Amboinensis* (Becc.) Moge)

Ni Made Gari

Biology Department, Faculty of Mathematics and Natural Sciences,  
Udayana University, Bukit Jimbaran Campus – Bali;  
[nm.gari@gmail.com](mailto:nm.gari@gmail.com)

## Abstrak

Studi anatomi dilakukan untuk mengetahui karakteristik epidermis daun pada 13 kultivar salak Bali. Hasil penelitian ini menunjukkan bentuk sel pada bagian permukaan atas (adaksial) dan permukaan bawah (abaksial) daun salak Bali adalah persegi empat sampai jajaran genjang. Sedangkan dinding antiklinal sel epidermisnya berlekuk-lekuk dengan penebalan pada dinding tersebut. Semua kultivar yang diamati memperlihatkan tipe daun yang hipostomatik dimana stomata hanya dijumpai pada bagian abaksial daun. Walaupun demikian stomata terkadang dapat dijumpai pada bagian adaksial daun meski jumlahnya sangat sedikit. Tipe stomata pada daun salak Bali adalah parasitik dimana tiap sel penutup didampingi oleh satu atau lebih sel tetangga yang letaknya sejajar dengan stomata, dengan penebalan pada dinding sel penutupnya. Indeks stomata bervariasi antara 11.9% sampai 18.3% pada semua kultivar yang diamati.

**Kata kunci:** *Salacca zalacca* var. *Amboinensis*, anatomi, sel epidermis, stomata

## 1. Introduction

Bali salak (*Salacca zalacca* var. *amboinensis* (Becc.) Moge) is a member of the family Arecaceae, and of the genus *Salacca* (Moge, 1980 and Uhl and Dransfield, 1987). The cultivar commonly grows in Bali and is of considerable economic importance because of its edible fruits. The fruit is among other importance cultivars for the Indonesian market and has a prospective as an export commodity for the country (Oka, 1995). Thirteen cultivars are found in Sibetan Village, Karangasem Regency and the identification of these cultivars is based on common knowledge of fruits features (Oka, 1995 and Dinas Pariwisata Kabupaten Karangasem, 2000).

The anatomical structure of the leaf surfaces such as, epidermal cells and cuticles vary from species to species, or even among cultivars (Barford, 1988 and Solangi *et al.*, 2010). Although, a number of research studies have been conducted using anatomical features, there is no significant study that investigates all of the 13 Bali salak cultivars (Utami, 1989 and Darmadi, 2001). The stomatal index from the sample examined by Utami (1989) showed that the average stomatal index of Bali salak cultivars (the number of stomata per unit area divided by the total number of stomata and epidermal cells per unit

area) is 35.7%. This means that each unit area of the leaves contained average 35.7% stomata. Nevertheless, the study did not specifically mention which cultivars were investigated. More recent study by Darmadi (2001) established that the arrangement of epidermal cells of Bali salak cultivars was rectangular and the arrangement of their stomata was paracytic. However, this study also was not carried out on all cultivars.

Detailed studies on the cultivars based on additional leaf anatomical characters such as, pattern of anticlinal cell walls and thickening on guard cells have never been reported. Therefore, the present study aims to investigate the 13 *Salacca* cultivars based on additional leaf anatomical features, which may provide data that can be used as tools for a broad understanding of the existing *Salacca* cultivars.

## 2. Materials and Methods

Leaf samples were collected from the farmer fields at Sibetan Village, Karang Asem, Bali. Three leaf samples were collected from each of the 13 cultivars. Therefore, the total number of plants sampled was 39. Epidermal peels were made following the method of Artschwager (1930). Small segments



of lamina/dried leaflet (1 cm<sup>2</sup>) were cut. Tissue samples were placed in test tubes and 2 ml of concentrated nitric acid was added together with a few crystals of potassium chlorate (KClO<sub>2</sub>). The mixture was boiled and then poured slowly into distilled water to cool the mixture and to halt the maceration process. The sample was stained in a mixture of safranin and alcian blue (0.5% aqueous solution) for three hours, then rinsed in absolute ethyl alcohol for 30 minutes, followed by a second rinse for additional 30 minutes (Illic, 1985).

One slide was made for each of the 3 leaf samples and three representative fields of views were selected from each slide. All observations were made using a compound Olympus microscope at magnification X 400, with an eyepiece micrometer. Photographs were made using a microscope digital camera DP 12 system. The stomatal index (I) was

calculated according to the formula given by Salisbury (1927), where S = number of stomata per unit area and E = number of epidermal cells per unit area [ $I = S / (S + E) \times 100 \%$ ]

### 3. Results

Leaf anatomical surfaces of Bali salak cultivars as seen under Light Microscopy (LM) for both adaxial and abaxial leaf surfaces are presented in Figures 1. All 13 cultivars examined were hypostomatic which stomata were generally found on the abaxial surfaces (C and D), however, the stomata were rare on the adaxial surface or they were not seen in some fields of views (A and B). Adaxial epidermal cells were rectangular to rhomboid shaped. These occurred in all the 13 cultivars investigated (A and B). The adaxial cells of the surface were usually rectangular. Similar features were also shown by all cultivars with respect

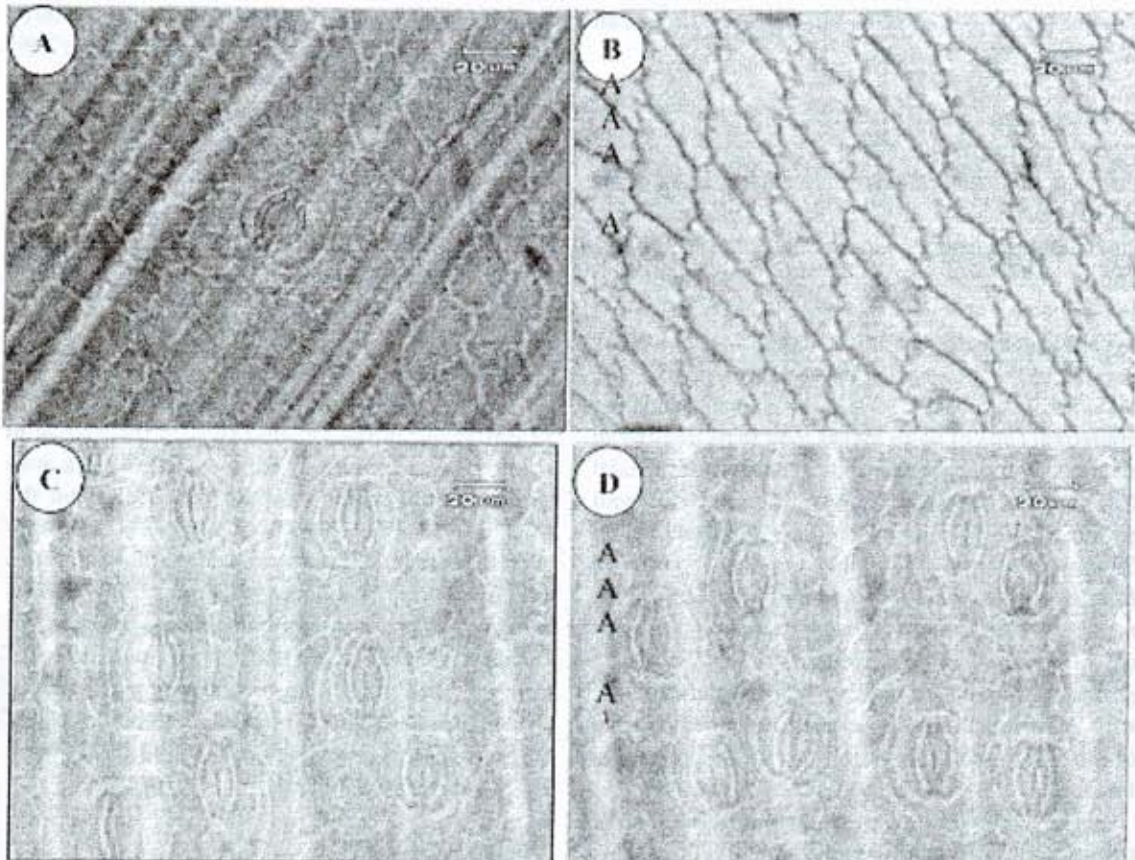


Figure 1. Light microscope (LM) images of leaf epidermal surfaces of Bali salak cultivars. The images show some field of views of adaxial leaf epidermal surface with one and without stomata (A-B). The abaxial leaf epidermal surface with numerous stomata (C-D). Magnification x 400.



to anticlinal cell walls. All cultivars examined showed undulation and ridged anticlinal cell wall patterns, with thickening on their anticlinal walls (A and B).

Stomata were abundant on the abaxial leaf surfaces and dispersed randomly over the whole area and aligned parallel to the veins. However, the occurrence of stomata per field of view on both surfaces of the leaves was somewhat different. Figure C and D illustrate that at the same magnification, stomata on the abaxial leaf epidermal surface were more frequent than those on the adaxial surfaces which only occasionally occurred (A and B). With respect to stomatal type, all cultivars examined displayed paracytic stomata, in which the stomata were enclosed by two subsidiary cells, which were adjacent to and parallel with the guard cells (C and D). All cultivars investigated also showed the thickening on the stomatal ledge or rims of the guard cells (C and D). The stomatal index values of the present study varied between 10.6% and 17.6% in all the 13 cultivars examined.

#### 4. Discussions

Results of the study show that the leaf anatomical features are constant among 13 cultivars investigated. Those features were cell shape, stomatal arrangements, pattern of anticlinal cell walls, and thickening on the guard cells. The epidermal leaf surfaces of the cultivars mainly show two types of cell shapes; rectangular to rhomboid, and elongate parallel to the mid-vein. This may be typical of the cultivars. Tomlinson (1990) reported that the adaxial epidermal cells of palm leaves tend to be irregular in shape. Anticlinal cell walls on both adaxial and abaxial leaf surfaces showed sinuous anticlinal cell wall patterns, with thickening on their anticlinal walls. Sinuous anticlinal cell walls were also reported in *Rhapis excelsa* and *Plectocomia muelleri*, other members of Arecaceae (Horn *et al.*, 2009). The degree of undulation of the epidermal cell walls is characteristic of each species. However, it can vary with environmental conditions (moisture, draught or shadow), and with phenological stage (Stace, 1965).

The paracytic type of stomata observed in the cultivars has been reported by Darmadi (2001). This stomatal shape was also reported in *Salacca affinis* and *Salacca wallichiana* (Tomlinson, 1961). Stomata

were found with the thickening on the stomatal ledge or rims of the guard cells of all cultivars examined. This may indicate the characteristics of the cultivars. Results from the present study also supported the previous leaf epidermal study of Bali salak cultivars, in terms of stomatal occurrence (Darmadi, 2001). Hypostomatic type of leaves was observed in all cultivars investigated. This means that stomata occurred only on abaxial leaf surfaces. However, it needs to be noted that stomata occasionally occurred on the adaxial leaf surfaces and were very rarely compared with the abaxial leaf surfaces. According to Tomlinson (1990), stomata were generally most abundant on the abaxial leaf surface of palm leaves, however in a number of genera with isobilateral leaves the stomata were equally numerous on both surfaces.

Stomatal index values ranged from 11.9% to 18.3%. This observation differs from studies of Bali salak cultivars by Utami (1989) and Darmadi (2001), in which stomatal index values were 35.7% and 17.6% - 37.9% respectively. However, some studies have shown that microclimate appears to influence the frequency distribution of stomata on leaf surfaces. This was observed in *Phlomis fruticosa* (Christodoulakis and Fasseas, 1991) and 31 species of Boraginaceae (Dasti *et al.*, 2003). The possible effects of microclimate on Bali salak cultivars remain to be investigated.

#### 5. Conclusions

This study revealed that leaf epidermal cells of 13 Bali salak cultivars examined were rectangular to rhomboid in shape. The type of leaves was hypostomatic, which stomata were dense on the abaxial leaf surfaces. However, stomata occasionally occurred rarely on the adaxial leaf surfaces. Sinuous anticlinal cell wall patterns, with thickening on their anticlinal cell walls were reported in the cultivars. All cultivars examined displayed paracytic type of stomata, with thickening on the stomatal ledge or rims of the guard cells. The stomatal index values of the present study varied from 11.9% to 18.3% in all the 13 cultivars examined.

#### Acknowledgement

I would like to thank AusAid for the financial support given to carry out this work.

## References

- Artschwager, E. 1930. "A comparative study of the stem epidermis of certain sugarcane Varieties". *Journal Agricultural Research*, 41. 853-865.
- Barford, A.S. 1988. "Leaf anatomy and its significance in Phytelephantoid Palms (Arecaceae)". *Nord. J. Bot.*, 8(4). 313-348.
- Clifford, H.T. and L. Watson. 1977. *Identifying grasses: data, methods and illustrations*. University of Queensland Press.
- Crishnamurthy, K.H. and B. Kannabiran. 1970. "Histomorphology of foliar epidermis and pharmacognosy in Asclepiadaceae". *J. Indian Bot. Soc.*, 40. 105-113.
- Christodoulakis, N.S. and C. Fasseas. 1991. "Seasonal dimorphism of *Phlomis fruticosa* under controlled environmental condition". *Acta Oecologica*, 12(3). 323-330.
- Darmadi, A.A. 2001. *Studi taksonomi pada cultivar salak Bali (Salacca zalacca var. amboinensis (Becc.) Moge)*. Thesis, Program Pascasarjana Institut Pertanian Bogor, Bogor.
- Dasti, A.A., T.Z. Bhokhari., S.A. Malik, and R. Akhtar. 2003. "Epidermal morphology in some members of family Boraginaceae in Baluchista". *Asian Journal of Plant Sciences*, 2(1). 42-47.
- Dilcher, W.C. 1968. "Approaches to the identification of angiosperm leaf remains". *Botanical Review*, 40(1). 1-157.
- Dinas Pariwisata Kabupaten Karang Asem. 2000. *Memperkenalkan Kebun Salak Sibetan Sebagai Agroturisme*. Kantor Pariwisata Kabupaten Karangasem, Amlapura, Bali-Indonesia.
- Horn, J.W., J.B. Fisher, P.B. Tomlinson, C.E. Lewis, and K. Laubengayer. 2009. "Evolution of lamina anatomy in the Palm Family (Arecaceae)". *American Journal of Botany* 96(8). 1462-1486.
- Ilic, J. 1985. The family key for hardwood identification. CSIRO, Division of Chemical and wood technology, Australia, Technical paper, no. 8.
- Moge, J.P. 1980. "The flabellate-leaved species of *Salacca* (Palmae)". *Reinwardtia*, 9(4). 56-63.
- Oka, I.B. 1995. *Studi pada beberapa kultivar salak Bali*. Laporan Penelitian. Fakultas Pertanian Universitas Udayana, Bali.
- Salisbury, E.J. 1927. "On the causes and ecological significance of stomatal frequency with special reference to the woodland flora". *Phil. Trans. Roy. Soc. Ser.*, 216. 1-65.
- Stace, C.A. 1965. "Cuticular studies as an aid to plant taxonomy". *Bull. Br. Mus. (Nat. Hist.) Bot.*, 4(1). 1-78.
- Tomlinson, P.B. 1961. *Palmae*. In "Anatomy of the Monocotyledons," Eds. (C.R.Metcalf). Oxford, The Clarendon Press.
- Tomlinson, P.B. 1990. *The structural biology of palms* (pp. 477). Oxford University Press,
- Uhl, N.W. and J. Dransfield. 1987. *Genera Palmarum. A classification of palms based on the work of Harold E. Moore, Jr.* (pp. 610). Allen Press, Inc., Lawrence, Kansas.
- Utami, N. 1989. *Anatomi daun dari Kecambah Salacca zalacca var. zalacca dan Salacca zalacca var. amboinensis*. Bogor: Herbarium Bogoriense. Balitbang botany, Puslitbang Biologi, LIPI. 4 hlm.