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Ultrastructure of the pericarp in the fruit of *Calophyllum inophyllum* Linné (Clusiaceae)

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ABSTRACT

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The family Clusiaceae is represented in the Tertiary flora of India by leaves, wood and a solitary fruit. The identification of the fruit with Clusiaceae is suspect. Therefore, the pericarp in the fruits of *Calophyllum inophyllum* Linné of the family Clusiaceae (= Guttiferae) has been examined under the scanning electron microscope to generate anatomical data that may help in identification of fossil clusiaceous fruits.

Key-words—fruit, pericarp, ultrastructure, *Calophyllum*.

सारांश

***केलोफिल्लम इनोफिल्लम* लिने (क्लुसिएसी) के फल में फलभित्ति की परासंरचना**

ऊषा बाजपेई

क्लुसिएसी कुल भारत के टर्शियरी वनस्पतिजात में पत्तियों, काष्ठ तथा एकल फल द्वारा निरूपित होता है। क्लुसिएसी कुल से फल का अभिनिर्धारण संशय में है। इसलिए क्लुसिएसी (=गुट्टीफेरी) कुल का *केलोफिल्लम इनोफिल्लम* लिने के फलों में फलभित्ति के शारिरीय आँकड़े उत्पन्न हेतु क्रमवीक्षण इलेक्ट्रॉन सूक्ष्मदर्शी के अन्तर्गत परीक्षण किया गया है जिससे कि क्लुसिएसस फलों के अभिनिर्धारण में मदद मिल सके।

संकेत शब्द—फल, फलभित्ति, परासंरचना, *केलोफिल्लम*।

INTRODUCTION

SEED morphology and anatomy have often been used for resolution of taxonomical problems. In contrast, fruit morphology and anatomy are not that frequently used as parameters for this purpose (Cutter, 1971). A study of some umbelliferous fruits under the scanning electron microscope (SEM) though has previously indicated that at this level of magnification some microscopic features of the surface may contain useful taxonomic traits (Heywood, 1968).

To further test this hypothesis, an investigation has been undertaken on the ultrastructure of fruits of certain dicotyledonous plants growing in southern India. The results of this investigation may provide additional parameters for the taxonomy of those fossil dicotyledonous fruits in which anatomical details are preserved. The characteristic feature of the fruit generally resides in the restriction of mechanical tissue to certain layers of the pericarp. The pericarp, which develops from the ovary wall, is divided in three different regions: an outer region, the epicarp; a middle region, the mesocarp and an inner region, the endocarp.

The present report is based on the investigation of ultrastructure of the pericarp in fruits of *Calophyllum inophyllum* Linné (Clusiaceae). Members of the family Clusiaceae are common in the tropical evergreen forests of Asia and South America; only a few species grow in tropical Africa. In India, the family is represented by species of the genera *Calophyllum*, *Garcinia* and *Mesua*, particularly in regions of eastern and southern India. However, fossil members of the family have also been reported from the Eocene of western India.

Lakhanpal and Bose (1951) reported fossil leaves and fruits referable to the family Clusiaceae from the Fuller's Earth bed at Kapurdi, western Rajasthan. Lakhanpal (1964) described and named these fossil leaves as *Mesua tertiara* and *Garcinia borooahii*. Chowdhury and Tandan (1949), Ramanujam (1960), Lakhanpal and Awasthi (1964, 1965), Prakash (1966) and Ghosh and Roy (1979) described fossil woods from Tertiary of Assam (*Kayeoxylon assamicum*), Miocene-Pliocene beds of Tamil Nadu (*Guttiferoxylon indicum*), Tertiary beds of Tamil Nadu (*Calophylloxylon indicum*, *C. cuddalorense*), Tertiary beds of Arunachal Pradesh (*Calophylloxylon eoinophyllum*) and the Miocene beds of Birbhum District, West Bengal (*Calophylloxylon bengalense*), respectively. The fruit *Indocarpa intertrappea* reported from the Tertiary Deccan Intertrappean beds of Madhya Pradesh has been compared with those of the Clusiaceae (Jain, 1964).

Some other fossil records of the Clusiaceae are: *Clusia fossilia* (Berry, 1925), from the Pleistocene of Trinidad, West Indies, *Clusia vera* (Hollick, 1924), *Rheedia miocenica* and *R. sylvargillacea* (Berry, 1925) from the Miocene of Trinidad, *Calophyllum calabaformis* (Berry, 1925, 1939) from the Miocene of Trinidad and Cuba, *Clusiaphyllum eocenicum* (Berry, 1930) from the Eocene of Arkansas in the USA, *Symphonioxylon stefaninii* and *S. scec-gureusis* (Chiarugi, 1933) from the Cretaceous of Somalia, *Guttiferoxylon fareghense* and *G. symphonioides* (Kräusel, 1939) from the Tertiary of Egypt, *G. platonioides* and *G. compactum* (Schönfeld, 1947) from the Tertiary of Colombia, *G. gracinoides* (Hofmann, 1944) and *G. prambachense* (Hofmann, 1952) from the Tertiary of Austria and *G. saharianum* (Boureau, 1952) from the Tertiary of Algeria.

MATERIAL AND METHOD

The genus *Calophyllum* consists of about 80 species (Willis, 1957), of which about 12 are indigenous to the Indian subcontinent, five species occurring in India. Mature fruits of *C. inophyllum* L. were collected from Palghat division of Karnataka forest and identification was confirmed by comparing them with the specimens in the herbarium of Botanical Survey of India, Kolkata. *C. inophyllum* L. is a moderate sized tree found along the coast above high watermark and in mangrove forests of Myanmar, along the Orissa coast, and down the western coast of India from Konkan southwards. It is also common in Tenasserim and in Andaman & Nicobar Islands (Pearson & Brown, 1932).

For light microscopy, the specimens were fixed in FAA and subsequently stored in 70 per cent ethanol. The specimens were processed in tertiary butyl alcohol series and embedded in paraffin wax. The paraffin embedded blocks were kept in 50 per cent glycerine after trimming to improve sectioning. The thickness of the sections ranged between 10 and 20 μm. The sections were stained in safranin-light green and safranin-fast green combinations, and mounted in 50 per cent glycerin. For SEM studies specimens were fixed in 4 per cent glutaraldehyde for 3-4 days. After careful washing with distilled water, sections were cut at thickness of 30-40 μm. The complete dehydration of sections was done in an ethanol series (at 30 minute intervals, by two changes) and finally for 10 minutes in acetone. The sections were attached to labelled stubs using double-sided adhesive tape, and coated with gold palladium (277 Å-413 Å thickness) in sputter coating unit. The specimens were investigated under Leo 430 SEM.

SALIENT FEATURES OF THE FRUITS

The fruits are globose, 6-9 cm in diameter. The pericarp is yellowish-green in colour. The epicarp is single-layered, composed of lignified cells covered with a highly cutinised layer followed by thin-walled, somewhat rounded and horizontally interspersed elongated cells with many secretory canals and vascular supply (Pl. 1.1). This zone is followed by the mesocarp, which is made up of typically elongated, highly lignified cells, perpendicular to the surface but variously curved inwards (Pl. 1.2). The cells have lignified walls and bear pits (Pl. 1.3). The innermost zone is thin-walled and aerenchymatous; most of the cells are filled with a dark gummy substance (Pl. 1.4). The endocarp is not clearly distinct, crushed, without lignified ground tissue.

PLATE 1 →

Calophyllum inophyllum Linné

1. Cross-section of the fruit showing epicarp consisting of a heavily cuticularised single-layered epidermis and a broad hypodermis with vascular bundles (v) and gum canals (g). Note: variously curved lignified cells of the mesocarp (m).
2. Cross-section of the fruit showing mesocarp (m) and a part of the endosperm (s). Note the crushed endocarp (e) in between the mesocarp and the endosperm.
3. A detailed view of the pitted surfaces of cells of the mesocarp.
4. Cells of the endosperm, some of which are filled with dark contents.

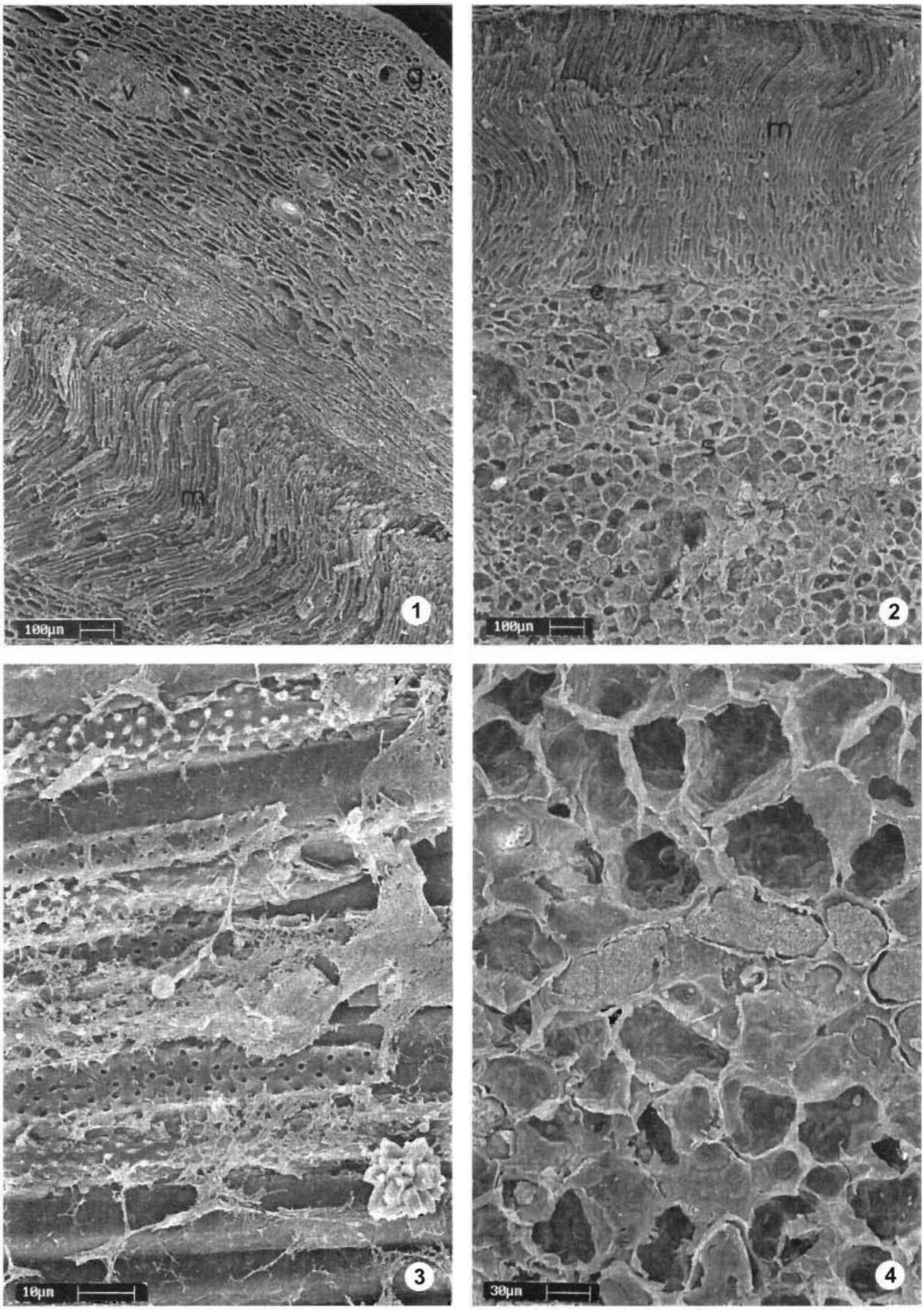

PLATE 1

RESULTS

In thin sections the three main divisions of the fruit wall, that is, the epicarp, mesocarp and endocarp are sharply marked. The epicarp is 2-layered, i.e., it comprises epidermis and hypodermis. The epidermal cells are commonly polygonal in transverse section. A thick cuticle covers the outer wall of the cells. The hypodermal cells are thin-walled, elongated but flattened and stretched towards the mesocarp. The cells of the epicarp are not homogeneous but interrupted by irregularly arranged vascular bundles of different sizes. Some of the cells are filled with a gummy substance. The cells of the mesocarp are characteristically perpendicularly elongated and arranged in rows, variously curved inwards. The highly lignified cells are very compactly arranged. In LM the walls of these cells show very small pits which are very clear under SEM. Thus, the mesocarp layer is made up of conspicuous cells. The cells of the endocarp are crushed at places, 1-2 layered, unlignified, unspecialised, polygonal, thin-walled, and parenchymatous. The endosperm is made up of thin-walled, polygonal cells of various sizes. In between the cells, scattered bands of cells filled with the dark content form a network throughout the region. The epidermis of the fruit surface sometimes shows stomata in irregular orientation.

DISCUSSION

A thick massive seed is present in each mature fruit of *Calophyllum inophyllum*. The seed completely occupies the locule. The testa is highly multiplicative and sclerotic. The thin and soft tissue of the endocarp was crushed probably by the enlargement of the seed because the cells of the endocarp are not lignified. The epicarp is made of multiple layers of thin-walled cells with irregularly arranged vascular bundles. The mesocarp of the fruit is strengthened by lignification. Perpendicularly elongated, variously curved, compactly arranged rows of pitted cells are characteristic of this species. This woody nature of the mesocarp is an important character of the pericarp, which was described as the endocarp by Corner (1976). The composition of these mechanical tissues and the pattern of distribution in the fruit wall are characters of taxonomic importance. SEM studies have shown that the delicate unspecialised cells of the endocarp get compressed in the mature fruit by the enlargement of the seed during its development. The latter observation needs to be verified from similar ultrastructural studies on the fruit pericarp of more species of the genus *Calophyllum*.

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