

**ANATOMICAL STUDIES OF THE AERIAL STEM, RHIZOME,  
LEAF SHEATH AND ROOT OF *ELETTARIA*  
*CARDAMOMUM* (MATON)**

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The highly aromatic seeds of *Elettaria cardamomum* have been an important spice for centuries (Hill, 1952). The cardamom plant is a native of Southern India, chiefly cultivated in India, Gautemala, Tanzania and Sri Lanka. According to the classification of Bentham and Hooker (1879) it belongs to sub-family *Zingiberaceae* of family *Scitamineae* while Rendle (1959) has given full family status to *Zingiberaceae*.

Cardamom is a perennial herb with rhizomatous root stock and leafy aerial shoots growing to a height of about 1.5 to 5m. The aerial stem is a typical clum surrounded by long sheathing leaf bases and divided into nodes and internodes. The stem is well developed when the plant is grown in plains. Tomlinson (3969) has worked out several aspects of the anatomy of cardomcm pertaining to the mid rib of leaf, lamina and leaf sheath. However no detailed work has so far been carried out to find out the exact nature of the aerial shoot of this plant and hence the present study was attempted.

**Materials and Methods**

The specimens used for this investigation were obtained from plants brought from the Cardamom Research Station, Pampadumpara and grown at Vellayani in pots. Hand sections of the stem, rhizome, leaf sheath and root were double stained with safranin and fast green for observations,

**Results and Discussion**

Cardamom has a branching rhizomatous region creeping horizontally under the soil from which arise the aerial stems. The rhizome is fleshy with the nodes and internodes crowded together. It bears scale leaves at the nodes, each with an axillary bud. In addition, the rhizome has terminal buds at the tips of the branches. These buds remain dormant underground and with the approach of the vegetative season, the terminal buds and sometimes also the axillary buds grow into aerial shoots which are often mistaken for pseudostems. These aerial shoots are unbranched and protected with sheathing leaf bases. The axillary buds of the leaves in the aerial stem are normally suppressed, It has been noted that in exceptional cases the terminal and axillary buds develop into racemose inflorescences. However inflorescences generally develop from the axillary buds in the rhizome.

*Aerial stem:* The stem has the typical monocot structure with numerous closed collateral endarch vascular bundles scattered in the ground parenchyma (Fig. 1a and 1b). The stem is solid. There is a thin subepidermal layer of sclerenchymatous cells separating the inner vascular bundles from the outer ones. Such a peripheral fibrous cylinder separating the aerial stem into cortex and central cylinder is a typical feature of family *Zingiberaceae* (Tomlinson 1969). Each vascular bundle is surrounded by a prominent bundle sheath of sclerenchyma cells. There are two or three large metaxylem vessels and a few protoxylem vessels. A protoxylem lacuna is present in some bundles. In the parenchyma cells, rhomboidal crystals of calcium oxalate are found occasionally. Tomlinson (1969) has also observed the presence of prismatic, rhombohedral or tubular crystals of calcium oxalate in the assimilating and ground tissue cells among many members of *Zingiberaceae*.

*Rhizome:* The rhizome is sharply differentiated into an outer cortex and a central core by a plexus of irregular congested vascular bundles. Root traces are inserted in this plexus. In the peripheral cortex there are only a few vascular bundles while numerous vascular bundles are seen in the sub-cortical and central core regions. Vascular bundles are irregularly distributed in the cortex and core. They are closed collateral and endarch as in the aerial stem. In each bundle there are several protoxylem and metaxylem vessels. The bundles are supported with sclerenchymatous bundle caps. The outer most cell layers of the cortex are developed into a kind of periderm which is a common feature in the underground rhizomes of *Zingiberaceae* (Tomlinson, 1969).

*Leaf sheath:* The sheathing base of the leaf has single layered upper and lower epidermis. Patches of hypodermal sclerenchyma are seen associated to both upper and lower epidermal regions but the sclerenchyma patches are more prominent below the upper epidermis. Vascular bundles are seen in a single row alternating with large schizogenous air spaces (Fig. 4a and 4b). Each bundle has a bundle sheath of sclerenchyma, a large patch of phloem and xylem below the phloem.

*Root:* The epidermis is single-layered with a large number of epidermal hairs. Cortex and pith regions are large and parenchymatous. The endodermis shows well developed casparian strips (Fig. 3a and 3b). Vascular elements are radial and exarch. There are about 30 to 40 xylem and phloem groups. The vascular tissues are surrounded by sclerenchyma in mature roots. Such islands of vascular tissues are generally seen in *Zingiberaceae* roots according to Tomlinson (1969).

There are similarities and differences between the anatomy of the rhizome and that of the aerial stem. The vascular bundles are similar in their nature and development in both. The aerial stem shows a typical monocot structure with numerous endarch, closed collateral and scattered vascular bundles.

They have prominent bundle sheaths. In the rhizome there is a demarcation into a cortex-like area and an inner central core by the presence of a plexus of congested vascular bundles and root traces. In the peripheral cortex there are very few vasucular bundles indicating that it is mainly a storage tissue. In the aerial stem such a non-vascular region is absent. The inner part of the cortex and central core of the rhizome show numerous vascular bundles with bundle caps rather than bundle sheaths. The vascular traces to the adventitious roots found in the rhizome are absent in the aerial stem. So the adventitious roots originate only from the rhizomatous part of the stem.

In the leaf sheath the inner epidermis directly surrounding the stem shows a lesser development of sclerenchyma because that region is well protected and does not need much mechanical support. Also as the aerial stem is always surrounded by sheathing bases of the leaves development of chlorenchyma in the stem is very limited.

**Summary**

The detailed anatomy of the aerial stem, rhizome, leaf sheath and root of cardamom is studied in the present investigation. The aerial shoot has a typical monocotyledonous stem known as 'culm' with nodes and inter-nodes protected by long sheathing leaf bases. In the rhizome the nodes and inter-nodes are crowded together. It can be differentiated from the aerial stem due to the presence of scale leaves and adventitious roots. The aerial stem, rhizome, leaf sheath and root have typical monocotyledonous anatomy.

**സംഗ്രഹം**

ഏലത്തിന്റെ വായവതണ്ടും, ഭ്രുകോണ്ഡം, ഇലപ്പോള, വേരും എന്നിവയുടെ ആന്തരിക സംഘടന വിശദമായ ഒരു പഠനം നടത്തി. ഏകബീജപത്രികളായ സസ്യങ്ങളിൽ പ്രാൗഢികമായി കാണപ്പെടുന്ന 'കം' എന്നറിയപ്പെടുന്ന തണ്ടിന്റെ ഘടന തന്നെയാണു ഇതിലെ വായവതണ്ടിനും ഉള്ളതെന്നു കണ്ടു. ഭ്രുകോണ്ഡത്തിൽ പർവങ്ങളും പർവസന്ധികളും വളരെ ഇടതിങ്ങിയാണു കാണുന്നതു്. വായവതണ്ടിൽനിന്നും ഇതിനുള്ള വ്യത്യസ്തം ശല്ക്കപത്രങ്ങളുടെയും അവസ്ഥാനിക മൂലകങ്ങളുടേയും സാന്നിധ്യമത്രെ. ഏലത്തിന്റെ തണ്ടും, ഭ്രുകോണ്ഡം, ഇലപ്പോള, വേരും എന്നിവയ്ക്കു ഏകബീജപത്രീ സസ്യങ്ങളുടെ പ്രാൗഢികഘടന തന്നെയാണുള്ളതെന്നു കണ്ടു.

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(M. S. received 18-1-77)