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# Structure and Development of Stomata in the Leaves of Some Zingiberaceae

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## ABSTRACT

The epidermal structure and development of stomata in four taxa of Zingiberaceae viz: *Aframomum melegueta* K. Schum, *Aframomum sceptrum* K. Schum, *Curcuma longa* L. and *Zingiber officinale* Rosc. have been investigated. Unicellular, eglandular trichomes are observed on the epidermis of *A. sceptrum* and *Z. officienal*. Anomocytic stomata with agenous ontogeny, paracitic stomata with eumesogenous ontogeny and tetracytic stomata with mesoperigenous ontogency are recorded in *Z. officinale, Aframomum* species and *C. longa* respectively. Stomata of *Z. officinale* are the smallest in size ($20.6 \times 14.3 \times 10.5\ \mu m$) while those of *C. longa* are the largest ($42.5 \times 31.5 \times 20.2\ \mu m$). These two taxa also recorded the highest ($43.7/mm^2$) and lowest ($28.6/mm^2$) stomatal frequency respectively which suggests a linear regression of frequency on size.

## INTRODUCTION

Despite the morphological and physiological importance of the stomatal apparatus (Carpenter and Smith, 1975) information on stomatal structure, development, distribution and frequency is lacking or incomplete for many monocotyledonous plants. A perusal of the available literature reveals that cuticular studies of monocotyledonous plants have been undertaken by Barthelat (1893), Campbell (1881), Ekundayo (1972), El-Cazzar and Hamza (1975), Flint and Moreland (1946), Inamdar (1968), Nyawuame and Gill (1988, 1990), Pant and Kidwai (1966), Shah and Gopal (1970), Stebbins and Jain (1960), Stebbins and Khush (1961), Stebbins and Shan (1960) and Tomlinson (1956, 1961, 1965a, 1965b, 1969, 1974).

However, apart from Ekundayo (1972) who reported stomatal morphology in *Dioscorea* and *Elaeis guineensis* there is no evidence that monocotyledonous crop plants have been studied phytodermologically. Furthermore, only growth and genetic parameters are currently considered in crop plant breeding programmes. Virtually no infromation is available on the role of foliar epidermal features in the breeding of cropplants.

The present authors, however, believe that such information could be incorporated in any future crop breeding programmes as the net yield of crops depends on the physiology of the stomatal apparatus.

The family Zingiberaceae is economically important in tropical Africa as a source of spices, perfumes and condiments and condiments and many species are used in herbal medicine and dyes. The present study which is a part of an ongoing project "Phytodermology of crop plants of Nigeria" undertaken by the junior author reports the epidermal structure and stomatogenesis of four spices species of this family. Two of the presently investigated species i.e. *Curcuma longa* L. and *Zingiber officinale* Rosc. are cultivated on commercial basis in Northern Nigeria while *Aframomum melegueta* K. Schum and *Aframomum sceptrum* K. Schum are grown as garden plants in Southern Nigeria.

## MATERIALS AND METHODS

Foliar materials of *A. melegueta, A. sceptrum C. longa* and *Z. officinale* were collected fresh from plants growing in local gardens in Benin City (Lat. 6.5°N.,

**Table 1.** A summary of the taxa studied along with their epidermal structure and stomatal particulars

| Taxon | Leaf surface | Wall | Distribution of mature stomato on the leaf surface | Morphological type of mature stomata | Ontogenetic type of stomatal development | Stomata measurements Length (μm) | Breadth (μm) | Pore size (μm) | Frequency (No./mm²) |
|---|---|---|---|---|---|---|---|---|---|
| *Aframomum melegueta* K. Schum | U | Straight | Hypostomatic | Paracytic | Eumesogenous | 23.8 | 16.4 | 11.7 | 33.6 |
| | L | Straight | | | | | | | |
| *Aframomum sceptrum* K. Schum | U | Straight | Hypostomatic | Paracytic | Eumesogenous | 32.2 | 20.4 | 16.1 | 31.4 |
| | L | Straight | | | | | | | |
| *Curcuma longa* L. | U | Straight | Hypostomatic (very few stomata observed on the upper surface) | Tetracytic | Mesoperigunous | 42.4 | 31.5 | 20.2 | 28.6 |
| | L | Straight | | | | | | | |
| *Zingiber officinale* Rosc. | U | Straight | Hypostomatic | Anomocytic | Agenous | 20.6 | 14.3 | 10.5 | 43.7 |
| | L | Straight | | | | | | | |

U = Upper L = Lower

Long. 6.0°W), in Bendel State, Nigeria. Both young and mature leaves were fixed in formalin-acetic acid-alcohol for 24 hours and then subsequently stored in 70% athanol. Samples of epidermal peels in all the taxa were obtained using the method described by Gill and Karatela (1983). The peels were stained with 1% safranin solution in 50% aqueous ethanol and temporarily mounted in 50% glycerol. The stomatal frequency figures presented in this paper are based on averages of 10 foliar materials for each taxon. Size measurements of stomata have been obtained from averages of 50 observations taken from the 10 foliar materials. The line drawings were made at a uniform magnification of x260 using 'Abbe' drawing apparatus. Terminology used in this paper is that of Metcalfe (1961) and Rasmussen (1981).

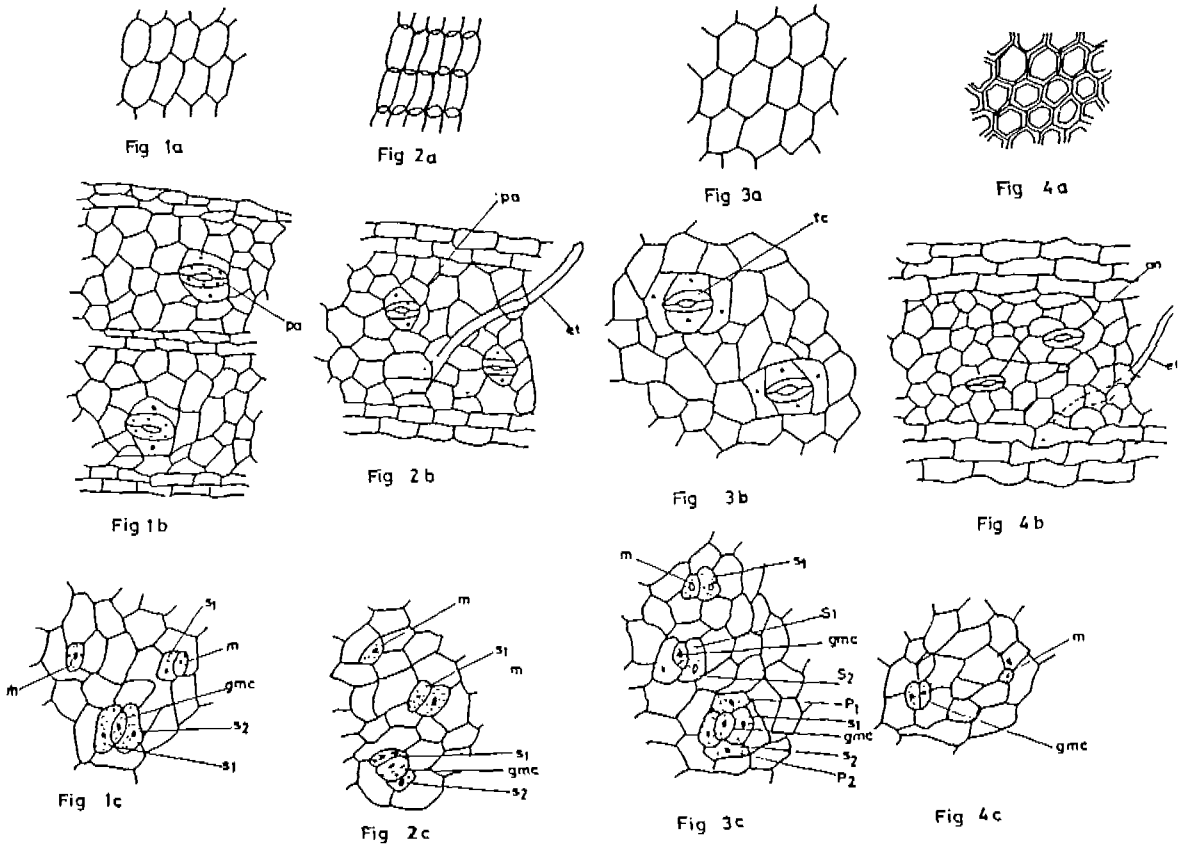
## RESULTS

The taxa studied along with their stomatal features viz: distribution, morphological type, ontogenetical type, size and frequency have been summarized in Table 1. *Aframomum melegueta* K. Schum.

Both the upper and lower epidermides of mature leaves are composed of regular cells with straight anticlinal and periclinal walls. The intercoastal regions of the upper epidermis consists of more or less rectangular cells which are much longer than broad (Fig. 1a). The cells of the lower epidermis on the other hand are polygonal (Fig. 1b). Mature stomata are restricted to the abaxial surface of the leaf. Each stoma has two lateral subsidiary cells (Fig. 1b), mature stomata being paracytic. Epidermal peel from the abaxial surface of a young leaf (Fig. 1c) reveals that the ontogeny of the paracytic stomata is cumesogenous.

***Aframomum sceptrum* K. Schum.** The cells of the upper epidermis are in cylindrical rows with the ends of one row overlapping with those of the next row (Fig. 2a). The cells of the lower epidermis are straight-walled and penta-to hexagonal in shape (Fig. 2b). Unicellular, eglandular trichomes have been recorded on the lower epidermis. The leaves are hypostomatous, mature stomata having been observed on the abaxial surface only. Mature stomata are paracytic with the two lateral subsidiary cells of each stoma much smaller than the intercoastal cells. The ontogeny of the paracytic stomata is eumesogenous, the two subsidiary cells having been derived from the same initial as the stoma (Fig. 2c).

***Curcuma longa.* L.** The upper epidermis is composed of hexagonal cells with straight walls (Fig. 3a). The cells of the lower epidermis which are also straight-walled are not as regular as those of the upper epidermis (Fig. 3b). The leaves are hypostomatic but a few stomata have been observed on the upper epidermis. Mature stomata are tetracytic; each stoma being surrounded by two lateral and two terminal subsidiary cells of which the former are much smaller than the lat-




**Figs. 1a-4a.** Structure of mature epidermis (adaxial of *Aframomum melegueta, Aframomum sceptrum, Curcuma longa* and *Zingiber officinale* respectively.

**Figs. 1b-4b.** Structure of mature epidermis (abaxial) of *A. melegueta, A. sceptrum, C. longa* and *Z. officinale* respectively. Note: an = anomocytic stoma; et = eglandular trichome; pa = paracytic stoma; tc = tetracytic stoma.

**Figs. 1c-2c.** Devellpmental stages of paracytic stomata in *A. melegueta* and *A. sceptrum* respectively.

**Fig. 3c.** Developmental stages of a tetracytic atoma in *C. longa.*

**Figs. 4c.** Stages in the organizaton of anomocytic stoma in *Z. officinale.*
Note: gmc = guard cell mother cell; m = meristemoid; $p_1$ = first periogene subsidiary cell; $p_2$ = second perigene subsidiary cell; $s_1$ = first mesogene subsidiary cell; $s_2$ = second mesogene subsidiary cell.

ter (Fig. 3b). The developmental sequence of the tetracytic stomata is mesoperigenous. During the organization of a tertracytic stoma, a meristemoid cuts off a small cell on either side which gradually becomes a lateral subsidiary. The perigenes at the terminal ends of the meristemoid gradually transform into polar subsidiary cells (Fig. 3c). A meristemoid organizes into a guard cell mother cell which eventually divides by a vertical wall to form two equal guard cells (Fig. 3c).

***Zingiber officinale* Rosc.** The epidermal cells of both the upper and lower surface are hexagonal. The cells are more or less isodiametric with thickened walls (Fig. 4a). The trichomes observed on the epidermal surface are simple, unicellular and eglandular. The leaves are hypostomatic with anomocytic stomata restricted to the lower surface (Fig. 4b). In the formation of an anomocytic stoma, no changes in the shape of neighbouring epidermal cells take place as a meristemoid develops directly into a stoma (Fig. 4c).

## DISCUSSION

Earlier contributions to phytodermology of the family Zingiberaceae are by Barthelat (1893), Tomlin-

son (1956, 1969). Except Tomlinson (1969), these studies did not report stomatal development in the family. Both the upper and lower epidermides of the presently investigated taxa are composed of polygonal cells which may be isodiametric. Simple, unicellular and eglandular trichomes have been observed in *A. sceptrum* and *Z. officinale*. The nature of epidermal cells and trichomes reported here confirms the earlier report of Tomlinson (1969).

Stebbins and Khush (1961) recognized four types of stomata i.e. hexacytic, tetracytic, paracytic and anomocytic stomata in the monocotyledons. El-Gazzar and Hamza (1975) reported the prevalence of tetracytic and hexacytic stomata in monocotyledons. Earlier, Tomlinson (1969) reported the occurrence of paracytic and tetracytic stomata in the family Zingiberaceae. During the present study anomocytic stomata have been observed in *Z. officinale* whereas mature stomata in the two species of the genus *Aframomum* and *C. longa* are paracytic and tetracytic respectively. The leaves of the four taxa are hypostomatic, mature stomata being restricted to the abaxial surface. This observation is in lins with the earlier report of hypostomatic leaves in Zingiberaceae (Tomlinson 1969).

The developmental pattern of anomocytic, paracytic and tetracytic stomata is agenous, eumesogenous and mesoperigenous respectively. The sequence of stomatal development in *A. melegueta*, *A. sceptrum*, *C. longa* and *Z. officinale* is reported here for the frist time.

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