

Cultivated Ginger of Peninsular Malaysia: Utilization, Profiles and Micropropagation

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Abstract

There are approximately 160 species of Zingiberaceae belonging to 18 genera in Peninsular Malaysia. Roughly 16-20% are traditionally utilized by the indigenous folks as spices, condiments, vegetables, food flavours and medicines. The resurgence of interest in herbs and the potential lucrative anticipated revenues from the herbal industry have spurred renewed interest in exploiting traditional knowledge and practices into scientific realities. Current research priorities offer promising development of natural resources into nutraceuticals, cosmeceuticals and biopharmaceuticals. Hence the need to profile or fingerprint species for quality control and consistency of the species utilized. It is also important to establish protocols for micropropagation as a means of providing consistent supply of stable and elite materials for mass propagation and commercialization. Selected examples of indigenous uses, species profiles and successful micropropagation of cultivated ginger are discussed.

Introduction

Besides Thailand, Malaysia represents one of the richest region in terms of Zingiberaceous species in South East Asia. Approximately 60 % of the total land area of Malaysia is reportedly covered by tropical rainforests and an estimate of 15,000 species of flowering plants has been recorded. Of these, there are more than 320 species of Zingiberaceae (excluding many undescribed taxa) representing 21 genera. In Peninsular Malaysia, there are roughly 160 species of Zingiberaceae belonging to 18 genera (Larsen *et al.*, 1999). Worldwide there are more than 1,200 species of Zingiberaceae belonging to more than 50 genera. Hence the total count for Malaysia

account for at least 20 % of the world taxa and 40 % of the world genera. The Zingiberaceae species have been utilized for various purposes worldwide and have been a part of the Asian culture since time immemorial. In Malaysia Zingiberaceae species are used as spice, condiment, food flavour, vegetable, beverage, medicine, ornamental as well as in rituals associated with beliefs, customs and traditions. Of late some cultivated gingers are exploited for the cosmetic, nutraceutical and pharmaceutical industry. Between 16-20 % of the Peninsular Malaysian gingers are edible and these are consumed fresh, cooked, pickled or boiled. The plant parts consumed are mainly rhizomes but the inflorescences, fruits, seeds, young shoots and rarely leaves are also utilized.

Utilization

The growth rate in global herbal industry is estimated at 7 % annually with an estimated value of USD \$183 billion in 2005. Blessed with a rich biodiversity, Malaysia has identified the herbal industry as another source of economic engine of growth and as such has provided the relevant national policies for the development of this important industry. In the Malaysian scenario, ginger has been identified as one of the 10 most popular local herbs that have great commercial potential (data from Malaysian Herbal Corporation). In maximising the economic potential of our rich bio-resources, ethnic knowledge and practices need to be exploited and developed into scientific realities. One of the significant contribution of such knowledge is the practices of traditional complementary medicine (TCM). Global market surveys have revealed that TCM plays a major role in the healthcare market both in developing and industrialized nations, most prominent being China (100%), followed by Africa (70-80%) and India (70%) (data from Malaysian Herbal Corporation). Our ethnobotanical surveys of selected states in Peninsular Malaysia representing East, West and South West region of Peninsular Malaysia revealed some interesting findings with regards to TCM.

In general, the practices of TCM in the villages surveyed are influenced by the following factors:

- socio – economic status;
- availability of modern medicine;
- remoteness of the village;
- availability of the herbs used in TCM;
- the age of the population;
- the traditional knowledge of the population.

The results of our ethnobotanical surveys also indicated that Zingiberaceae species are among the most frequently used herbs in folk-medicine. For instance, many medicinal ginger are utilized for women-related ailments or healthcare, such as post-partum medicine, post-natal care treatment in the form of tonic, herbal extracts, decoctions, ointment, aromatic herbal bath, etc. These ginger are also reported to be carminative. Various species are used either as single plant or in herbal mixtures with several Zingiberaceae species or other herbs for treatment of arthritis, skin infections, inflammation, stomach-ache, muscle pains and strains etc. Selected examples of indigenous uses are presented as follows:

1. Post partum medicine and Post-natal health care

- rhizomes of *Boesenbergiarotunda* (L.) Mansf. eaten raw or pickled.
- rhizome juice of *Curcuma longa* L. and *Zingiber ottensii* Valetton drunk.
- leaves of various combinations of Zingiberaceae species, such as *Alpinia galanga* (L.) Willd., *Curcuma longa*, *Amomum compactum* Sol. ex Maton, *Etilingera elatior* (Jack) R.M. Sm., *Zingiber montanum* (J. König) A. Dietr., *Curcuma mangga* Valetton & Zijp in combination with other aromatic herbs such as *Pandanus amaryllifolius* Roxb., *Cymbopogon nardus* (L.) Rendle etc. are boiled and used as an aromatic herbal bath for ladies in confinement. This is practised for 2 weeks or throughout the confinement period (42 days).

2. Dysmenorrhea

- rhizome juice of *Alpinia conchigera* Griff. mixed with water and drunk.

3. Treatment for skin fungal infection (*panau*)

- ground rhizomes of *Alpinia conchigera* mixed with vinegar or kerosene and rubbed on infected parts.

4. Treatment for jaundice

- *Zingiber officinale* Roscoe boiled with *Alpinia galanga*, *Vigna radiata* (L.) R. Wilczek (mung bean), garlic and vinegar and the decoction drunk.

5. To relief flatulence/stomachache/colic

- rhizome juice of *Zingiber officinale* drunk.
- rhizome juice of *Curcuma zedoaria* (Christm.) Roscoe drunk.
- rhizome of *Curcuma mangga* eaten raw with rice.
- rhizome juice of *Alpinia galanga* mixed with other herbs and drunk.

6. Treatment for muscle pains & strains
 - decoction of whole plant of *Curcuma aeruginosa* Roxb. drunk.
 - oil of *Alpinia conchigera* applied topically.
7. Treatment for sprain
 - poultice rhizome of *Kaempferia galanga* L. with rice, applied topically.
 - poultice leaves of *Zingiber zerumbet* (L.) Sm., applied topically.
8. Health drink/treatment for lethargy
 - rhizome juice of *Alpinia conchigera* and fresh milk drunk in the morning.
9. Treatment for aching joints (e.g., knee joints)
 - rhizome juice of *Zingiber officinale* Roscoe var. *rubrum* Theilade and vinegar, applied topically.
 - rhizome juice of *Zingiber officinale* drunk.
10. Treatment for hypertension
 - rhizome of *Kaempferia galanga* eaten raw.
 - rhizome of *Zingiber zerumbet* eaten raw.
11. Flavour
 - leaves of *Elettariopsis curtisii* Baker for flavouring fish dish.
 - leaves of *Curcuma longa* for flavouring vegetable, fish and meat dishes.
 - rhizomes of *Alpinia galanga*, *Curcuma longa*, *Zingiber officinale* for flavouring various dishes.
12. Cosmetic powder
 - rhizome of *Curcuma zedoaria* ground finely with glutinous rice and 100 types of flowers and soaked in water.
 - leaves of *Kaempferia galanga* mixed with rice and several aromatic plant parts, ground and soaked in water; residue used as cosmetic powder.

Utilization: nutritional value of edible gingers

Realizing the diverse utilization of the cultivated gingers, studies have been carried out to investigate the nutritional composition of these species. Generally our result showed that the moisture content of the rhizomes is high exceeding 70% and low in crude fibre content. The low crude fibre content renders these species suitable as spices. The fat and carbohydrate content are relatively low in the species studied (Table 1). Table 2 shows the

data on thiamine, riboflavin and vitamin C of 5 cultivated gingers. Vitamin C content is generally low except for peeled rhizome of *Zingiber officinale* (11mg/100g) and young rhizome of *Curcuma mangga* (15.46 mg / 100g). This may justify the consumption of the young rhizome *Curcuma mangga* as a fresh vegetable in Peninsular Malaysia. Our studies on some mineral content of *Alpinia galanga*, *Curcuma longa*, *Kaempferia galanga* and *Etilingera elatior* (Table 3), indicated that ferum content is quite high in the roots of *K. galanga* (78.30mg /100g) and in rhizomes of *E. elatior* (67.10mg/100g). This result supports the development of *K. galanga* as a health drink as the rhizomes and the roots are usually taken as a whole when consumed. The screening on the anti-nutritional content showed that no cynogenic glycosides were detected in the twelve cultivated gingers studied (Rahim *et al.*, 1991; Ibrahim *et al.*, 1994).

Table 1. Proximate composition of some common Zingiberaceae species (per 100 g) [Hashim *et al.*, 1988; *Tee *et al.*, 1988; **English and Lewis, 1991; ***Zanariah *et al.*, 1997]

Species	Part	Energy kcal	Moisture (g)	Protien (g)	Fat (g)	Carbohydrate (g)	Fibre (g)	Ash (g)
<i>Z. officinale</i>	Young rhizome	-	88.5	-	-	2.1	-	-
<i>Z. officinale</i> *	Young rhizome	52	86.1	2.1	1.0	8.6	1.7	0.5
<i>Z. officinale</i> **	Peeled rhizome	26	90.4	0.8	0.4	4.8	-	-
<i>Z. officinale</i> ***	Mature rhizome	43	87.9	0.7	0.9	8.1	1.7	0.7
<i>C. domestica</i>	Fresh rhizome	-	83.9	-	-	6.0	-	-
<i>C. domestica</i> *	Dried rhizome	335	14.2	2.3	5.0	70.1	3.2	5.2
<i>C. domestica</i> ***	Rhizome	35	89.3	0.9	0.5	6.9	1.7	0.8
<i>Z. zerumbet</i>	Young rhizome	-	89.1	-	-	2.8	-	-
<i>Z. zerumbet</i> ***	Rhizome	45	88.5	0.4	0.7	8.9	1.3	0.3
<i>A. galanga</i> *	Rhizome	72	89.9	0.9	0.7	6.5	1.6	0.4
<i>A. galangal</i> ***	Rhizome	71	81.5	0.8	0.7	13.0	1.6	1.4
<i>C. mangga</i>	Young rhizome	-	81.1	-	-	3.8	-	-
<i>C. mangga</i> ***	Rhizome	47	88.1	0.4	1.2	8.6	1.1	0.5

Table 2. Vitamin composition of some Zingiberaceae species (mg/100g weight) [Hashim *et al.*, 1988; *Tee *et al.*, 1988; **English and Lewis, 1991; ***Zanariah *et al.*, 1997]

Species	Part	Thiamine	Ribo flavin	Ascorbic acid
<i>Z. officinale</i>	Young rhizome	-	-	2.83
<i>Z. officinale</i> *	Young rhizome	0.04	0.04	5.30
<i>Z. officinale</i> **	Peeled rhizome	0.09	0.06	11.00
<i>Z. officinale</i> ***	Mature rhizome	0.04	0.06	5.78
<i>C. domestica</i>	Fresh rhizome	-	-	1.83
<i>C. domestica</i> *	Dried rhizome	0.03	0.12	0.00
<i>Z. zerumbet</i>	Young rhizome	-	-	6.38
<i>Z. zerumbet</i> ***	Rhizome	0.02	0.02	1.65
<i>A. galanga</i> *	Fresh rhizome	0.02	0.40	0.00
<i>A. galanga</i> ***	Rhizome	0.03	0.01	0.93
<i>C. mangga</i>	Young rhizome	-	-	15.46
<i>C. mangga</i> ***	Rhizome	0.03	0.04	1.95

Ginger products

The popularity of herbal products has increased greatly in recent years due to the consumer's preference for natural ingredients in their medicine, food and personal care products. Several cultivated gingers in particular, *Zingiber officinale*, have been developed commercially (globally and locally) into various herbal products. Selected examples are given below:

1. Medicine

- Arthritis (e.g., Zinaxin).
- Nausea –tablets.
- Anti-inflammatory products.
- Flatulence and indigestion (e.g., Eno).
- Post partum medicine including the Indonesian *jamu* (capsules, tablets, tonic, powder, poultice).
- Medicinal oils / ointment.
- Balm.

2. Health products

- Ginger and ginseng capsules.
- Ginger and garlic capsules.
- Dietary supplement (vitamin C supplement).

Table 3. The levels^a of K, Na, Ca, Mg, Fe and Zn in the rhizomes, roots, leaves and inflorescence of *A. galanga*, *C. domestica*, *K. galanga* and *E. elatior* (Ibrahim and Rahim, 1988)

Part of the Plant	Zingiberaceae species	(g/100g) ^b						(mg/100g) ^b	
		K	Na	Ca	Mg	Fe	Zn		
Rhizomes	<i>A. galanga</i>	1.53 ± 0.15	0.013 ± 0.001	0.09 ± 0.004	0.25 ± 0.02	0.28 ± 0.03	0.06 ± 0.06		
	<i>C. domestica</i>	0.94 ± 0.08	0.023 ± 0.002	0.13 ± 0.003	0.16 ± 0.01	4.11 ± 0.30	13.90 ± 1.80		
	<i>K. galanga</i>	0.50 ± 0.02	0.697 ± 0.010	0.26 ± 0.01	0.37 ± 0.02	4.20 ± 1.20	8.50 ± 0.76		
	<i>E. elatior</i>	1.59 ± 0.17	0.135 ± 0.006	0.35 ± 0.003	0.15 ± 0.001	67.10 ± 15.30	0.09 ± 0.01		
Roots	<i>A. galanga</i>	1.95 ± 0.74	0.06 ± 0.004	0.47 ± 0.01	0.30 ± 0.004	0.38 ± 0.09	0.10 ± 0.03		
	<i>C. domestica</i>	4.89 ± 0.90	0.032 ± 0.008	0.15 ± 0.03	0.05 ± 0.01	N.D.	N.D.		
	<i>K. galanga</i>	1.88 ± 0.43	1.130 ± 1.010	0.41 ± 0.01	0.62 ± 0.02	78.30 ± 9.80	5.90 ± 0.75		
	<i>E. elatior</i>	2.58 ± 0.19	0.046 ± 0.002	0.26 ± 0.01	0.16 ± 0.007	0.12 ± 0.01	0.05 ± 0.01		
Leaves	<i>A. galanga</i>	1.80 ± 0.20	0.015 ± 0.001	1.14 ± 0.07	0.43 ± 0.03	0.28 ± 0.02	0.19 ± 0.01		
	<i>C. domestica</i>	2.88 ± 0.18	0.064 ± 0.004	0.84 ± 0.02	0.22 ± 0.02	10.70 ± 1.40	3.90 ± 0.21		
	<i>K. galanga</i>	1.53 ± 0.10	0.067 ± 0.004	0.96 ± 0.02	1.20 ± 0.06	1.87 ± 1.00	14.30 ± 2.50		
	<i>E. elatior</i>	3.20 ± 0.20	0.014 ± 0.001	0.16 ± 0.02	0.15 ± 0.01	0.19 ± 0.01	0.07 ± 0.001		
Inflorescence	<i>A. galanga</i>	3.11 ± 0.32	0.005 ± 0.003	0.42 ± 0.01	0.25 ± 0.01	0.15 ± 0.001	0.09 ± 0.001		
	<i>E. elatior</i>	1.12 ± 0.01	0.020 ± 0.001	0.17 ± 0.01	0.16 ± 0.01	N.D.	2.62 ± 0.37		

a = as is dry weight basis, b = mean ± standard deviation, n = 3, N.D. = non-detectable

- Herbal teas.
 - Functional beverages.
3. Personal care
- Aromatic soaps.
 - Aromatherapy products (e.g. massage oils, scrubs, bath oils, etc.).
 - Perfumes.
 - Shampoo and conditioner.
 - Various cosmetics.
4. Skin care
- Moisturizers and toner.
 - Skin lightening/whitening cream.
 - Anti-aging/anti-wrinkle cream.
 - Anti-acne cream.
 - Anti-eczema cream (e.g., *Psoriasis*).
5. Food, confectionery and sweets
- Biscuits / cookies/cakes.
 - Ice cream.
 - Chocolates and sweet preserves.
 - Jam, chutney.

Profiles

In developing plant based products, research and quality control measures on the potential natural resources need to be intensified and established. In this respect, species profiling is considered as a useful tool in maintaining quality, especially when there are problems of presence of adulterants. Several techniques of species profiling are usually used such as chemical profiling, DNA fingerprinting and other botanical techniques. Our studies have revealed that DNA fingerprinting technology is useful in authentication of not only species but also varieties and variants (Plate 1 and Plate 2). For instance, based on RAPD primer OPA 4 as shown in Plate 1, *Zingiber zerumbet* and its three variants could be differentiated quite easily. In another study (Plate 2), local varieties of *Zingiber officinale*, namely *Zingiber officinale* var. *rubrum* (*halia padi*) and *Zingiber officinale* var. *rubrum* (*halia bara*), were shown to differ very slightly in their DNA profiles based on RAPD primers OPA 1, OPA 8 and OPA 20.

Some botanical methods are also useful in identifying species, such as anatomy of leaves and petioles and SEM studies on reproductive structures of plants. These botanical techniques are useful as ancillary tools

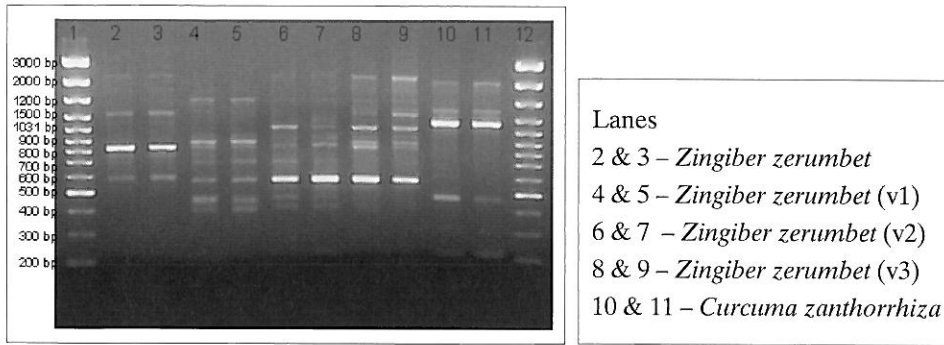


Plate 1. DNA Profile of variants of *Zingiber zerumbet* and *Curcuma zanthorrhiza* (RAPD primer OPA4).

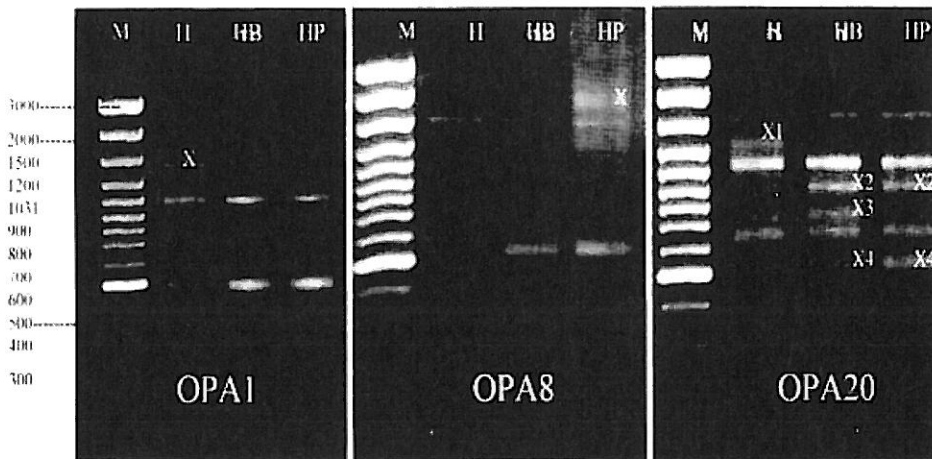
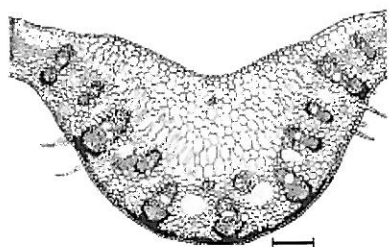
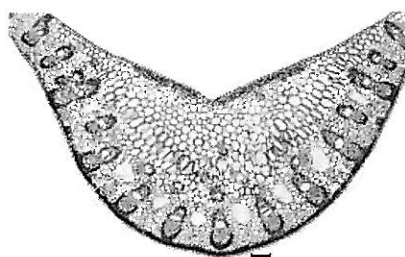
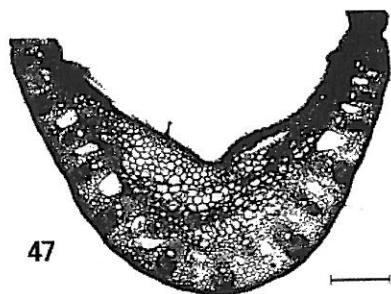
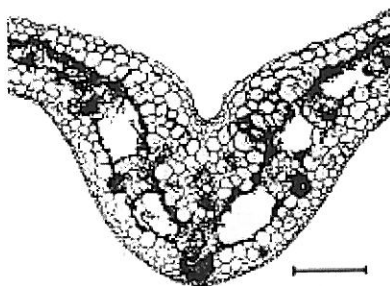
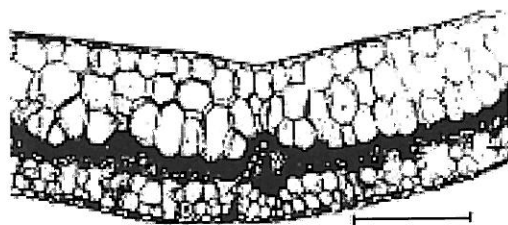
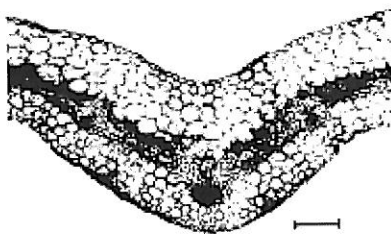
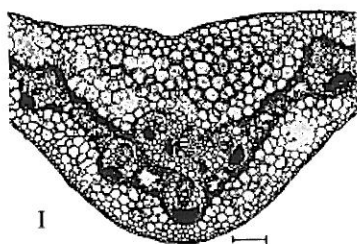
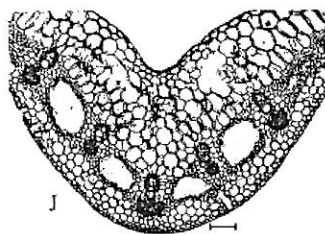


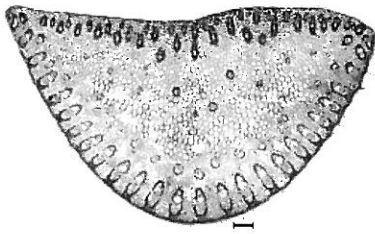
Plate 2. DNA profiles of *Zingiber officinale* and its varieties (RAPD primers OPA1, OPA8 & OPA20). 'X' shows the polymorphic banding patterns distinguishing all varieties studied; (OPA1: X=1500bp, OPA8: X=2000bp, OPA20: X1=1350bp, X2=900bp, X3=800bp, X4=550bp) H = *Z. officinale* Rosc var. *officinale* (halia), HB = *Z. officinale* var. *rubrum* (halia bara), HP = *Z. officinale* var. *rubrum* (halia padi), M= Marker 100bp Ladder Plus.

in authentication of species used in product development. Plates 3, 4 and 5 exhibit clearly the differences between selected gingers in their transverse sections of leaf midribs, petioles and margins respectively. Although SEM features of pollen, stigma and labellum of some gingers may not be as distinct, in most cases these data are also useful in species identification as shown in Plate 6.

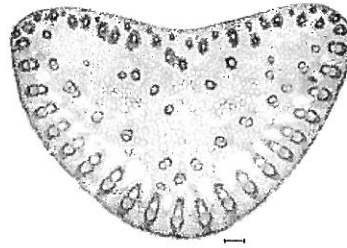
A) *Alpinia conchigera*B) *A. galanga*C) *A. galanga* - ChinaD) *Boesenbergia rotunda*E) *Kaempferia galanga*F) *K. parviflora*I) *K. pulchra*J) *K. rotunda*

Scale bars = 500 μm (A,B,C)
 Scale bars = 200 μm (D,E,F,G,H)

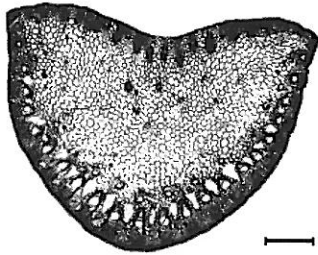
Plate 3. Transverse sections of leaf midribs.



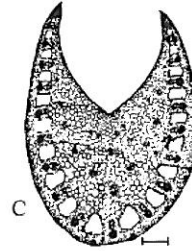
A. galanga



A. conchigera



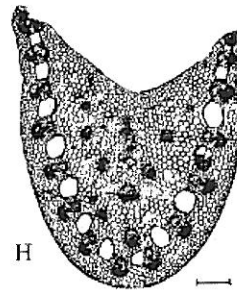
A. galanga – China



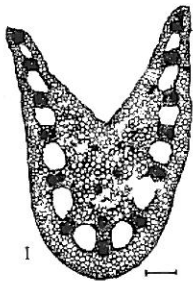
Boesenbergia rotunda



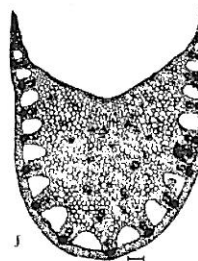
Kaempferia galanga



K. parviflora



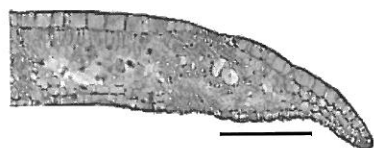
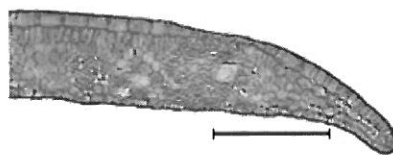
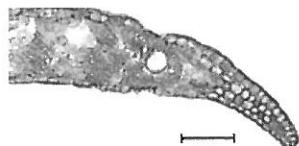
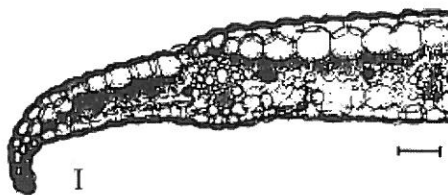
K. pulchra



K. rotunda

Scale bars = 500 μ m

Plate 4. Transverse sections of petioles.

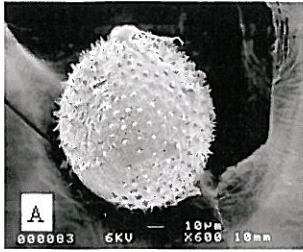
A) *Alpinia conchigera* – leftB) *A. conchigera* – rightC) *A. galanga* – leftD) *A. galanga*- rightE) *A. galanga* – ChinaF) *Boesenbergia rotunda*G) *Kaempferia galanga*H) *K. parviflora*I) *K. pulchra*J) *K. rotunda*

Scale bars = 200 μ m (A,B,C,D,E)

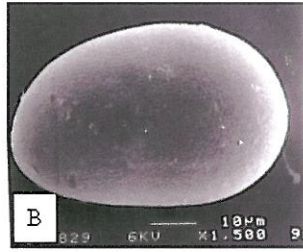
Scale bars = 50 μ m (F,G,H,I,J)

Plate 5. Transverse sections of leaf margins.

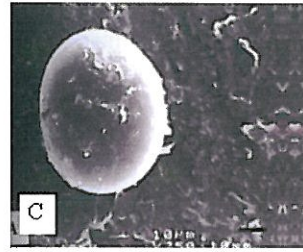
Pollen



Boesenbergia plicata

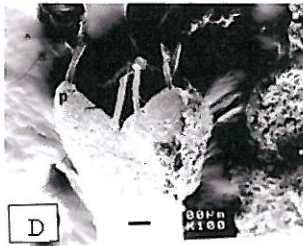


Scaphochlamys kunstleri

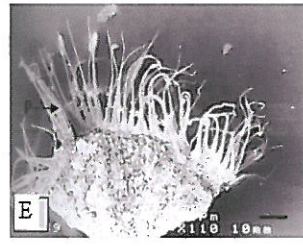


Hedychium coronarium

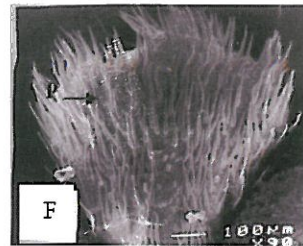
Stigma



Boesenbergia rotunda



Kaempferia galanga

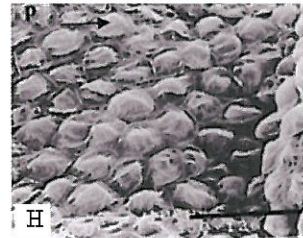


Scaphochlamys klosii

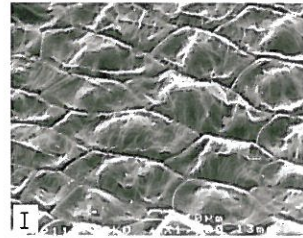
Labellum



Boesenbergia plicata
(Middle labellum)



Boesenbergia rotunda
(Middle labellum)



Hedychium coronarium
(Lower labellum)

A, B, C (x 10μm)
D, E, F (x 100μm)
G, H, I (x 100μm)

Plate 6. SEM studies of flower parts.

Table 4. Field performance of micropropagated and control plants for five quantitative traits (Muda *et al.* 2004)

Parameter Study	<i>Z. officinale</i> (Halia)		<i>Z. officinale</i> var. <i>rubrum</i> (Halia bara)		<i>Z. officinale</i> var. <i>rubrum</i> (Halia padi)	
	<i>in vitro</i>	control	<i>in vitro</i>	control	<i>in vitro</i>	control
No. of tillers	6.0 ± 1.0	4.6 ± 0.9	4.8 ± 0.8	3.4 ± 0.6	6.6 ± 0.6	4.4 ± 1.1
Plant height (cm)	56.3 ± 5.2	57.2 ± 9.6	26.3 ± 2.3	24.5 ± 3.9	24.3 ± 6.1	24.8 ± 4.7
No. of leaves	64.8 ± 16.3	54.8 ± 7.4	35.0 ± 6.4	31.4 ± 3.1	52.0 ± 15.8	33.0 ± 4.7
Leaf area (cm ²)	27.6 ± 1.2	25.9 ± 1.4	20.5 ± 0.4	18.2 ± 0.6	17.4 ± 0.7	17.2 ± 0.3
Fresh weight of rhizome (g)	50.7 ± 23.3	38.4 ± 20.0	19.3 ± 3.2	12.0 ± 5.0	21.8 ± 4.5	11.3 ± 4.9

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