
ORIGINAL ARTICLE

Floral and fruit morphology of some species in *Garcinia* spp.

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Abstract

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Morphological studies of reproductive parts of some species in *Garcinia* revealed some differences and similarities. Flowers of these species are composed of both male and female flowers. Female flowers are solitary and occur in single or occasionally in clusters (2-10 flowers) developed at the terminal buds of young branches in case of mangosteen, but both terminal buds and axillary buds were found in the other species. Primary parts of the flowers in this genus comprised four sepals and four petals which were different in size and color. Many stamens, both filamentous and sessile anthers, are observed in both male and female flowers in different location. The number of anthers varied among the species ranging from 20 to 40 sets in phawa and approximately 135 sets in somkhag. The colors of fruits are species specific ranging from yellow (somkhag and ma-phut) to red (phawa) or deep purple (mangosteen) and different in size, shape, rind characters and flavor. Three of six species produce no seed to few seeds (1-2). Viability of pollens ranges from 100% (cha-muang, phawa and ma-dun) to 0% (mapood).

Key words : *Garcinia*, floral morphology, mangosteen, somkhag, phawa

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บทคัดย่อ

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ลักษณะทางสัณฐานของดอกและผลในพืชสกุล *Garcinia* บางชนิด
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การศึกษาลักษณะทางสัณฐานของดอกและผลในสกุล *Garcinia* บางชนิด พบทั้งที่มีความคล้ายคลึงกันและแตกต่างกัน ดอกของพืชชนิดดังกล่าวอาจเป็นเพศผู้หรือเพศเมีย ดอกตัวเมียมีลักษณะเป็นดอกเดี่ยวๆ หรือเป็นช่อ (2-10 ดอก) เกิดตรงปลายยอดสุด (ในมังคุด) หรือเกิดทั้งปลายยอดสุด และตามข้างของกิ่ง (ในชนิดอื่นที่เหลือ) ดอกประกอบด้วยกลีบเลี้ยง 4 กลีบ และกลีบดอก 4 กลีบ มีสีสูรและขนาดแตกต่างกัน เกสรในดอกทั้งสองประเภทมีทั้งที่มีและไม่มีก้านชู มีตำแหน่งที่ตั้งแตกต่างกัน มีเกสรตัวผู้จำนวนมากทั้งที่มีและไม่มีก้านชู ซึ่งจำนวนนั้นผันแปรตามสปีชีส์ ตั้งแต่ 20-40 ชุด ในพะวาถึง 135 ชุด ในส้มแขก สีของผลแตกต่างแต่สีเหลือง (ในส้มแขก มะพูด) ถึงแดง (พะวา) หรือม่วงเข้ม (มังคุด) ขั้นกับชนิด ขนาด รูปร่างลักษณะผิวผล และรากติดของผลแตกต่างกัน ในจำนวน 6 ชนิดที่ศึกษา พบว่ามี 3 ชนิดที่ไม่สร้างเมล็ดหรือสร้างแต่น้อยมาก (1-2 เมล็ด) ความมีชีวิตของเรซูตั้งแต่ 0% (มะพูด) ถึง 100% (มะพูด พะวาและมะตัน)

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Garcinia belongs to the family Guttiferae or Clusiaceae. The genus arose in southeast Asia, ranging from the southern part of Thailand and peninsular Malaysia to Indonesia and to some parts of the Philippines (Richards, 1990c). However, the exact origin of the genus is still debated. According to Whitmore (1973), the genus is listed as having 39 species with another ten unidentified or unnamed in this region. Among these species, only a few are known and used in daily life in Thailand, namely *G. mangostana* L. (now being grown as an orchard fruit tree) *G. atroviridis* Griff, *G. speciosa* Wall., *G. cowa* Roxb. and *G. dulcis* Kurz (Lim et al., 1983). The latter four species possess both medicinal and horticultural properties. *G. atroviridis* Griff, *G. dulcis* Kurz and *G. cowa* Roxb contain a high concentration of hydroxy citric acid (HCA), especially in the fruit and leaf. This chemical regulates some enzymes in the hydrolysis pathway in order to efficiently convert fat or fatty acid into energy (Te-chato, 1997). *G. speciosa* Wall. can grow well under drought conditions. So it is used as a rootstock for mass propagation of mangosteen.

Richards (1990b) reported using morphological characters for identification among the three

species of *Garcinia*, *G. mangostana*, *G. malaccensis* and *G. hombroniana*. He showed that four characters; latex and petal color, sessile stigma and fruit color of *G. mangostana* resembled those of *G. malaccensis*. Another three characters of *G. mangostana*, stigma, stamen/staminode lobe, and fruit resembled those of *G. hombroniana*. Based on these similarities he stated that *G. mangostana* is a hybrid between *G. hombroniana* and *G. malaccensis*. However, there have been no research reports which confirm this phenomenon.

The purpose of this study is to reveal floral and fruit morphology and pollen viability in some important species of *Garcinia* which have been found in southern Thailand for further improvement of those species by conventional and biotechnological methods.

Materials and methods

Plant materials

In this investigation, six species of *Garcinia* namely *G. mangostana* L. (mangosteen), *G. speciosa* Wall. (phawa), *G. atroviridis* Griff. (somkhag), *G. dulcis* Kurz. (ma-phut), *G. cowa* Roxb. (cha-muang) and *G. schomburgkiana* Pierre

(ma-dun) were collected from the Plant Science Research Station, Prince of Songkla University, Hat Yai campus and private orchards in the Narathiwat province. Reproductive parts (flowers and fruits) were collected for investigation.

Comparative study on floral and fruit morphology of *Garcinia* spp.

Reproductive parts of each species were morphologically compared. Within this group, the six species are differentiated by 13 characters as shown in Table 1.

Pollen viability analysis

For testing viability of pollen, anthers from each species of *Garcinia* were excised and placed in a drop of 0.5% acetocarmine on a glass slide. The anthers were gently squeezed to release the inner pollen. The slide was covered with a cover glass and excess staining solution blotted. The slide loaded with a mixture of pollen and staining solution was heat by alcohol flame. Morphology and viability of pollen from each species were observed and counted under inverted microscopy. Viable pollens were scored and interpreted as the

number of stained pollens divided by total number of pollen in the same field multiplied by 100.

Results

Floral and fruit morphology of *Garcinia* spp.

Morphological studies of reproductive parts of various species in *Garcinia* revealed some differences and similarities (Table 1, Figure 1). Most wild species and male plants or male flowers have a long period of flowering and flower more than one time a year, whereas cultivated species, (e.g. mangosteen) bear fruit only once a year. In the case of cultural management, off-season flowering can be induced. Among these species, mangosteen contains a concentrate yellow latex affecting the quality of its fruits.

Floral parts

Flower

Flowers of these species are either male or female or both which occur separately on different plants or appear together on the same plant. Female flowers are solitary and occur singly or occasionally in clusters (2-3) as found in mangosteen,

Table 1. Floral and fruit morphological characters of some species in *Garcinia*.

Characters	<i>G. cowa</i> Cha-muang	<i>G. speciosa</i> Phawa	<i>G. atroviridis</i> Somkhag	<i>G. mangostana</i> Mangosteen	<i>G. dulcis</i> Ma-phut	<i>G. schomburgkiana</i> Ma-dun
Flowering	July-Sept.	June-Sept., Jan-Mar	July-Sept.	Mar-April, July-Sept.	July-Sept.	Jan-Mar(-June), July-Sept.
Latex	Yellow	White	Yellow	Yellow	White	Yellow
Petal color	Light yellow	Cream- Light yellow	Purple	Red	Light green	Pink
Stigma	-	Stipitate	Sessile	Sessile	Stipitate	-
Stigma Surface	-	Smooth	Corrugated	Corrugated	Corrugated	-
Stigma lobe	-	20% diameter	80% diameter	20% diameter	20% diameter	-
Stamen mass	Clustered	Lobed	Round	Isolated	Lobed	Clustered
Female Flower	-	No staminodes	Staminodes	Staminodes	Staminodes	-
Pollen Viability	96-100%	93-100%	3-5%	0.1-1%	0%	95-100%
Fruit shape	-	Oval	Globose	Globose	Globose	-
Fruit color	-	Red	Green	Purple	Yellow	-
Fruit surface	-	Smooth	Wrinkle	Smooth	Lobed	-
Fruit flavor	-	Astringent	Sour	Sweet/sour	Sour	-

- No character found in these species



Figure 1. Floral morphology of Garcinia in some species (bar = 1 cm)

A: *G. mangostana*
B: *G. atroviridis*
C: *G. schomburgkiana*
D: *G. cowa*
E: *G. dulcis*
F: *G. speciosa*

[Color figure can be viewed in the electronic version]

phawa, somkhag, ma-dun and cha-muang but clusters of 6-10 flowers are usually found in ma-phut. In mangosteen, the flowers develop at the terminal buds of young branches in case of mangosteen; whereas in the other species, the flowers develop at both terminal and axillary buds.

Petals and sepals

Primary parts or construction of the flowers in this genus are very similar. They are composed of four sepals and four petals. Sepals of some species are separated into two whorls; outer and inner ones. Petal sizes and colors of these species differ. Subjective evaluation indicated that mangosteen has the biggest size, followed by

somkhag and ma-phut. Ma-dun and cha-muang produce flowers of nearly the same size. In case of color, both somkhag and ma-dun have red to dark red color while mangosteen has a pinkish red one. The other species have petal color ranging from light green to yellow (Table 1, Figure 1).

Stamens and pistil

Many stamens, both filamentous and sessile anthers, are observed in the flower. Generally, the stamens develop in both male and female flowers. In female flowers of mangosteen, ma-phut and somkhag, they are located on the petal around the ovary at the lower position than stigma. The first two species produce filamentous anthers while the

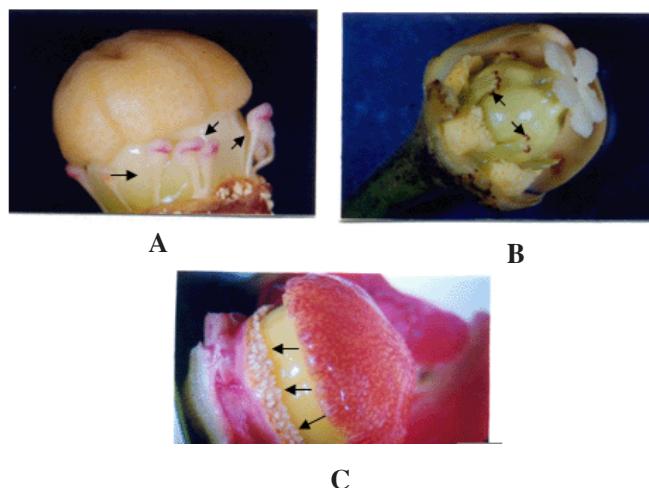


Figure 2. Characteristics of stamen (arrows) containing in female flowers of *Garcinia* spp.
A: *G. mangostana* B: *G. dulcis*
C: *G. atroviridis*

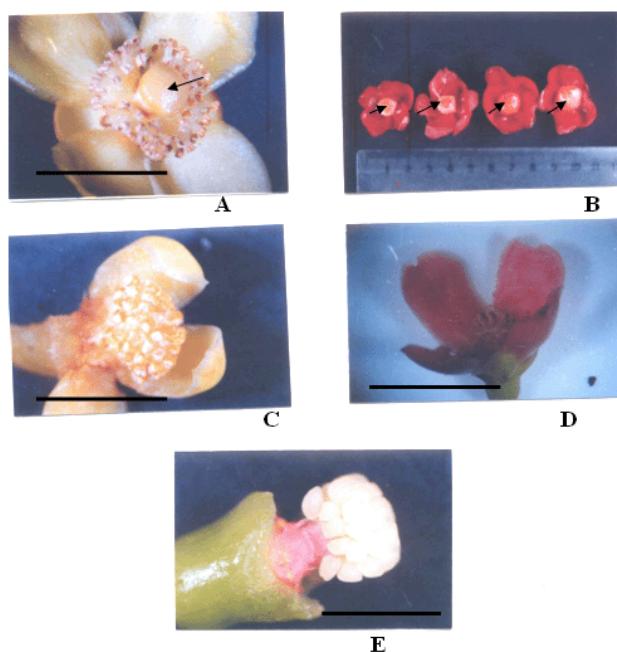


Figure 3. Male flowers with (A,B arrows) and without (C,D,E) rudimentary ovary
(bar = 1 cm)
A: *G. speciosa* B: *G. atroviridis* C: *G. cowa*
D: *G. schomburgkiana* E: *G. dulcis*
[Color figure can be viewed in the electronic version]

latter species produces sessile ones (Figure 2a,b,c). In the case of male flowers in phawa and somkhag, stamens develop as a tube or fused together and

extend over the entire ovary (Figure 3a,b). Male flowers of the two species also produce a small non-functional or rudimentary ovary. For cha-

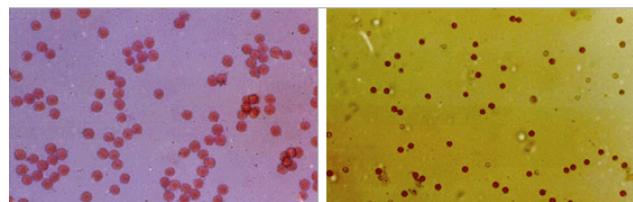


Figure 4. Viable pollen contained in anther of male flower staining with 0.5% carmine.
A: *G. speciosa* **B: *G. cowa***

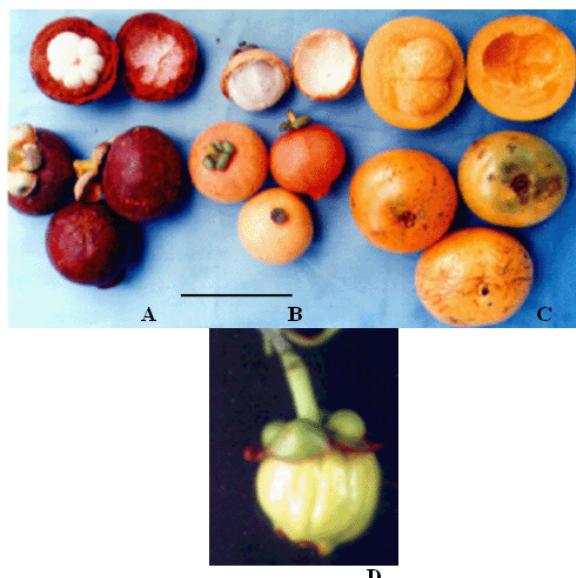


Figure 5. Fruit morphology of some *Garcinia* species (bar = 5 cm)
A: *Garcinia mangostana* **B: *G. speciosa***
C: *G. dulcis* **D: *G. atroviridis***
[Color figure can be viewed in the electronic version]

muang, ma-dun and ma-phut, the male flowers have only a cluster of sessile anther without a rudimentary ovary but with viable pollens (Figure 3c,d,e). The number of anthers varied among the species ranging from 20 to 40 sets in phawa and about 135 sets in somkhag.

Fruit and seed

Fruits of these species were reported to develop without pollination and fertilization (Richards, 1990a). After blooming for at least 24-hour period, petals wither and drop within a few

minutes. The unfertilized ovary develop to mature fruit within 4 to 6 months depending upon the species. The colors of fruits are specific to each species, ranging from green in somkhag, yellow in ma-phut, to pinkish red in phawa and purple in mangosteen (Figure 5). Moreover, size, shape, rind characters and flavor differ as shown in Table 1 and Figure 5. Nucellar tissue in ovary also develops to be apomictic seed through agamospermy (Richards, 1990a). Number, shape, and size of the seeds varied. Among the four species which set fruit, phawa has the highest number of seeds

(6-8 per fruit), while the other three species produce few seeds (1-2) to no seed. However, all of the seeds are recalcitrant which leads to a limited distribution of the species.

Pollen viability analysis

Inside the anther, a high number of 93-100% viable pollens were found in male flowers of chamuang, phawa and ma-dun, whereas there was no viable pollen in ma-phut (Figure 4). Very low viable pollens were observed in mangosteen (0.1-1%) and somkhag (3-5%). For female or pistillated flowers of all species, only 0-1% viable pollen was found. According to this phenomenon these stamens are so called staminode.

Discussion

The nature of plants in *Garcinia* differ from species to species. Some can grow under shade while the others survive under arid conditions or full sunlight. Among these species, mangosteen is very sensitive to unsuitable environments, especially under drought, as mangosteen is a very slow growing tree and seed germination is very poor. Studies on the morphology of these species are very rare. It is reported that most or all *Garcinia* spp. are apomictic and the fruit develops without fertilization (Richards, 1990a). Moreover, pollination has not been reported by any researchers except in *G. hombroniana* (Richards, 1990b). From this investigation, morphological characteristics are of great importance for helping us to know the way for pollination. The data of pollen viability reveal the possibility of crossing among the species, especially between phawa and mangosteen, in order to transfer drought resistance. In the future, commercial planting of mangosteen will reduce the cost of agricultural practices. In the past, grafting mangosteen on the rootstock of related species was applied for that purpose; however, grafting success both *in vitro* and *ex vitro* was quite low (Te-chato *et al.*, 1992; 1995). Recent work indicates that self-grafting (grafting of mangosteen on self-rootstock) also provides a good result (Sdoodee *et al.*, 1992). On the other hand, root

supporting technique promotes early growth of mangosteen (Sdoodee *et al.*, 1992). The species that is suitable for root supporting is phawa. This species is best in combating problems compared with the other species. DNA works also revealed that phawa is very close to mangosteen (Te-chato *et al.*, 2000). Accordingly, pollination of the two species is promising.

Conclusion

Only few species of *Garcinia* have been listed in daily life of southern Thailand. At least of four species are used as fresh fruit and medicinal purpose. Each species has different floral morphology and pollen viability. Some have both male and female flowers while other have only male or female flowers. Data from this morphological observation and pollen viability investigation might be of great importance in crossing some species which are very close e.g. mangosteen and phawa. In future, new characters of mangosteen, especially drought tolerance, obtained from these crossings is possible.

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