The Floral Morphology and Anatomy of Kenanga (Cananga odorata (Lam.) Hook.f. & Thomson)

F O Nurhayani¹, A S Wulandari¹*, T K Suharsi²

¹ Department of Silviculture, Faculty of Forestry, IPB University (Bogor Agricultural University), Bogor, Indonesia
² Department of Agronomy and Horticulture, Faculty of Agriculture, IPB University (Bogor Agricultural University), Bogor, Indonesia

*Corresponding author e-mail: rr_arum@yahoo.com

Abstract. Cananga odorata (Lam.) Hook.f. & Thomson is one of the essential oils producing plants that have many benefits for humans. However, there is little information about the floral morphology and anatomy of C. odorata. The aim of this study is examining the floral morphology and anatomy of C. odorata. The flower morphology (color, shape, and size of the flower) were observed at fresh mature flowers. While, the flower anatomy (pistil, stamen, and ovary) were observed at flower histological samples. The flower was fixed, dehydrated, alcoholized, embedding in paraffin, and stained with safranin-fast green. The results of this study showed that flowers of C. odorata are complete flowers that had 3 green sepals (0.5 – 0.9 cm), 6 – 12 yellowish-green petals (2.5 – 7.2 cm), 8 – 15 dark green pistils (5 – 8 mm), and numerous stamens. The shape of pistils is oval and contains one ovary which has 8 – 12 ovules. The shape of the stamens is elongated oval and contains pollens. The information about the floral morphology and anatomy of C. odorata might enhance the understanding of future studies regarding natural reproduction and cultivation programs.

1. Introduction

Cananga odorata (Lam.) Hook.f. & Thomson is the members of the Annonaceae family. C. odorata consists of two varieties. They are C. odorata var. fruticosa and C. odorata var. odorata. C. odorata var. fruticosa is a shrub that has a height of 1 – 1.5 m. C. odorata var. odorata consists of two forms. They are forma macrophylla and forma genuine. C. odorata var. odorata forma macrophylla is known as java cananga because it comes from Java, while C. odorata var odorata forma genuine is known as ylang-ylang from the Philippines. Both are trees that have a height of up to 30 m [1, 2]. This study used C. odorata var. odorata forma genuine.

C. odorata is fast-growing species that grown in the tropical lowland with altitude 1 – 1800 mdpl, mean mean annual temperature is 20 – 27 °C, mean annual rainfall is 650 – 4,000 mm, and soil with pH 4.5 – 8. The native distribution of C. odorata is Cambodia, Indonesia, Laos, Malaysia, Myanmar, Papua New Guinea, Philippines, Solomon Islands, Thailand, Vietnam. Then these plants are distributed to other countries such as Cameroon, China, Comoros, Ivory Coast, India, Jamaica, Madagascar, Reunion, Seychelles, Sri Lanka [3].

C. odorata has great benefits for humans. The woods used for construction materials. The seeds may be used to treat fever. In Indonesia, the flowers used against malaria and leaves are rubbed on the skin to treat itchiness. Dried flowers and bark are also used medicinally [4]. The flowers are used for religious ceremonies such as the “Oke Sou” ceremony to welcome the maturity of girl in Lako Akediri.
Village, West Halmahera, Indonesia [4]; “Balimau Tradition” ceremony in Pariaman, West Sumatera, Indonesia [5]; and “Sura Month Welcoming” ceremony in Nganjuk, East Java, Indonesia [6]. The flowers can be extracted to yield an important essential oil containing 1 – 2% volatile oil widely used in the manufacture of beauty products such as perfumes, soap, shampoos and hair oils [7]. Cananga oil used as antimicrobial, antibiofilm, antifertility, anti-inflammatory, and antimelanogenesis activities [8]; natural antibacterial because it contains flavonoids and saponins [9]; antidepressants for humans [10]; and lotion and perfume manufacture that are more effective in repelling insects because cananga oil contain benzyl benzoate, caryophyllene, linalool and eugenol [11].

Several essential oil studies conducted in C. odorata. The floral morphology and anatomy of C. odorata has never been undertaken. The information about floral morphology and anatomy of the species is vital for developing knowledge and science. It could enhance the understanding of the reproductive biology in the species, which is under human threat and has a very low regeneration and germination rates. The aim of this study is understanding floral morphology and anatomy of C. odorata.

2. Method

2.1. Materials
The buds and mature flowers collected in February 2019 at IPB University (6°33’23.0” S - 106°43’55.0” E). Other materials used in this study were HNO₃ (nitric acid), aquades, FAA (formaldehyde acetic acid alcohol), alcohol concentration of 70%, alcohol concentration 0f 96%, absolute alcohol, xylol, paraffin, haupt adhesive, safranin (2%), fast green (1%), and entellan.

2.2. Anatomy
The method used in the preparation of histological samples followed [12] with modifications. The buds and mature flowers were cut longitudinally with a scalpel and soaked in aquades. Next, they soaked in HNO₃ (3:1) for 24 hours. Samples were put into vacuum, fixed in FAA for 24 hours, dehydrated through alcohol series (alcohol concentration of 70%, alcohol concentration of 96%, and absolute alcohol) for 24 hours each, and followed by xylol-alcohol combinations (1:3, 1:1, 3:1, 1:0, and 1:0) for 24 hours each. Then samples were infiltrated and embedded in paraffin wax. Samples were cut longitudinally with a microtome (thick = 20 μm), placed on object glass that has given haupt adhesive, dropped with aquades, and stored on the hot plate (temperature = 40 °C) for ± 2 days. Sections stained with safranine and fast green. Finally, sections on object-glass were dropped with entellan and covered it with a cover glass.

2.3. Observation
The observation consisted of morphological and anatomical of cananga flowers. Observation of flower morphology consists of the color and shape of the sepals, petals, pistils, and stamens. Then, flowers counted the number of sepals, petals, and pistils in flower. They were cut longitudinally to observe the position of the pistil and stamens with lup. They were measured in overall length and width, the length of sepals, petals, pistil, and stamens with the ruler. Histological samples were observed with a microscope to see the anatomical structure of flowers such as pistils, stamens, and ovaries.

3. Result and discussion
The flowers of C. odorata is highly fragrant. Their flowers arranged in groups and each group has ± 3 flowers. Each bunch of flowers is arranged axillary in each branch. This is consistent with a statement from Parotta [13] that C. odorata has inflorescences arranged in bunches or clustered arranged axillary on older branches at the base of leaves or branches behind the leaves. The flowers are green-yellow and fragrant.

The flowers are included in a complete flower because all parts of the flower, such as adornments (sepals and petals) and reproductive organs (pistils and stamens) are in one flower (Figure 1).
Complete flowers or perfect flowers (flos complete) are flowers that have sepals, petals, pistils, and stamens [14]. Some plants that are members of the Annonaceae family are bisexual so that they can self-pollinate [15]. Flowers of C. odorata belongs to the hermaphrodite plant because, in one individual plant, there are male and female reproductive organs [16].

The adornments flower consists of sepals that serve to protect the flower when the buds and petals that function as ornaments and attract insects [17]. Sepals are one part of the flower that is usually green. The sepals have a protective function when the flower is still a bud, play an essential role in photosynthesis, and contribute to fruit dispersion. The petal has a variety of colors and shapes, has a fine texture, and contains a lot of pigment [18].

The sepals are green and have a round shape. Petals are green when young, then turn yellow when mature, yellowish-brown when they wilt and drooping. The flower stalk is green, elongated, and slightly hairy. The stamens are numerous and arranged around the pistil, which located in the middle of the flower. The stamens crowded into a triangular mass along with pistils and whose stigmas also crowded together. It caused the stamens, and pistils cannot be seen in full from the outside. The stamens are light green, while the pistils are dark green (Figure 1c, d).

The size of the flowers is various. Table 1 shows that the length of flowers can reach 7.5 cm, while the diameter can reach 11.5 cm. The flower stalk has 1 – 3 cm long. There are 3 strands of sepals that have 0.5 – 0.9 cm long. The number of petals in one flower can reach 12 strands, and the size of each strand is different. There are 8 – 15 pistils in each flower. They are oval and small (5 – 8 mm long).

The results are accordance with the literature, and there are only a few differences. The flower of C. odorata is ± 7.5 cm long, while the flower stalk is 1 – 2.5 cm long. There are 3 sepals which have a round shape, yellow-green, hairy, and 0.6 cm long. The number of petals is 6 which is banded and rolled, wavy or straight, 4 – 6 cm long (sometimes up to 8 cm). The petals are green when young, yellowish, yellowish-brown, and finally droops when withered. The flowers have numerous stamens.
less than 3 mm long that are pointed and becoming reddish tinged at the apex and 8 – 15 green pistils that are ≤ 6 mm long [2, 13].

Table 1. The measurement results of the flowers Cananga odorata (Lam.) Hook.f. & Thomson.

| No  | Variation              | Unit  | Result       |
|-----|------------------------|-------|--------------|
| 1.  | Length of flower       | cm    | 3.5 – 7.5    |
| 2.  | Diameter of flower     | cm    | 6.5 – 11.5   |
| 3.  | Length of the flower   | cm    | 1 – 3        |
|     | stalk                  |       |              |
| 4.  | Number of sepals       | -     | 3            |
| 5.  | Length of sepal        | cm    | 0.5 – 0.9    |
| 6.  | Number of petals       | -     | 6 – 12       |
| 7.  | Length of petal        | cm    | 2.5 – 7.2    |
| 8.  | Width of petal         | cm    | 0.7 – 1.5    |
| 9.  | Number of pistils      | -     | 8 – 15       |
| 10. | Length of pistil       | mm    | 5 – 8        |

The observation of flower anatomy from C. odorata showed that the flower buds have smaller and fewer pistils and stamens than the mature flowers. In mature flowers, the pistils and the stamens fully developed following the typical flower pattern of C. odorata. The pistils had an oval shape, while the stamens elongated in shape (Figure 2 a,b).

Each pistil contains one large ovary. The ovary was in the middle of the pistil, style oblong, and slender (Figure 2c). In one ovary, there were 8 – 12 ovules (Figure 2d). The ovule is a structure of seed plants that protects the ovum. The ovary wall is the outermost layer of the ovule. The integument is composed of epidermal tissue which is quite tight. The nucellus is a network in the middle of the ovule that surrounded by an integument. A micropyle is a hole in the ovule (Figure 2e). Stamens are small, have pointed tips, and contain pollen (Figure 2f).

The outer and inner epidermis forms the ovarian walls. The outer epidermis consists of cube-shaped cells that are larger than the inner epidermis. The seed comes from anatropous, bitegmic, crassinucellate ovules. Inter integument ovules are called pluriseriates which have a larger cell layer. The integument is composed of outer and inner epidermal tissue in a cube shape with relatively dense cytoplasm and a large nucleus. Nucellus will develop with thin-walled polyhedral cells. The development of nucellus cells into subepidermal and apical cells indicates periclinal division. Cell division at the tip of the nucellus micropyle causes cell proliferation to exceed the micropyle. Cells that limit the embryo sac then extend tangentially [19].
Figure 2. Light micrographs of the flower of Cananga odorata (Lam.) Hook.f. & Thomson: a. longitudinal section of the buds showing pistils and stamens, b. Longitudinal section of the mature flower showing pistil and stamen, c. Pistil with several ovaries, d. Ovary with 8 – 12 ovules, e. ovule with detail of its part, f. stamen showing pollen. in- integument, mi- micropyle, nu- nucellus, ov- ovule, ow- ovary wall, oy- ovary, pi- pistil, po- pollen, sg- stigma, st- stamen.

4. Conclusion
The flowers of C. odorata are complete or perfect flowers because they have petals, sepals, pistils, and stamens. The sepals are green with a length of 0.5 – 0.9 cm, the petals are yellowish-green with a length of 2.5 – 7.2 cm and a width of 0.7 - 1.5 cm, the pistils are dark green, and 5 – 8 mm long, and the stamens are light green. The pistils are oval, and there is one ovary that contained 8 – 12 ovules. Stamens have oblong-elongated shapes and contain pollen.

Incorporating these morpho-anatomical findings in future studies can provide a better understanding of the evolution of this species. The general use of broader morpho-anatomical characters is recommended.

Acknowledgments
We thank the IPB University, Silviculture Laboratory, Plant Morphology, Anatomy, and Cytology Laboratory LIPI (Lembaga Ilmu Pengetahuan Indonesia) for the use of facilities and support for this investigation.

References
[1] Turner I, Veldkamp J 2009 Gardens’ Bulletin Singapore 61, 189–204.
[2] Rugayah. 2014 Jurnal Biologi Indonesia 10, 67–76.
[3] Orwa C, Mutua A, Kindt R, Jamnadass R, Anthony S 2009 Cananga odorata. Agroforestry
Database (Nairobi: World agroforestry)

[4] Wakhidah A, Silalahi M, Pradana D H 2017 Biodiversitas 18, 65-72.
[5] Hulyati R, Syamsuardi, Ardinis A. 2014 J Biologi Universitas Andalas 3, 14-19.
[6] Ayuningtyas P, Hakim L 2014 Biotropika 2, 31-39
[7] Brokl M, Faucconnier M L, Benini C, Lognay G, du Jardin P, Focant J F 2013 Molecules 18, 1783-1797.
[8] Tan L T H, Lee L H, Yin W F, Chan C K, Kadir H A, Chan K G, Goh B H 2015 Traditional Uses, Phytochemistry, and Bioactivities of Cananga odorata (Ylang-Ylang). Evidence-Based Complementary and Alternative Medicine. doi: http://dx.doi.org/10.1155/2015/896314.
[9] Dutsuria N, Hikamah SR, Sudiarti D. 2016. Bioshell. 5, 324-332.
[10] Zhang N, Zhang L, Feng L, Yao L 2016 Phytomedicine 23, 1727-1734.
[11] Budi J J S, Damayanti N L Y, Dhani Y R, Dewi N P A 2018 Jurnal Kimia 12, 19-24
[12] Xu F, Craene L R D 2010 Annals of Botany 106, 591-605.
[13] Sass J E. 1951. Botanical Microtechnique. (Iowa: The Iowa State College Press)
[14] Parotta 2009 Cananga odorata (Lam) Hook.f. & Thoms., 1855. Enzyklopadie Der Holzgewachse 54:1–8.
[15] Tjitrosoepomo G 2005 Plant Morphology [Morfologi Tumbuhan] (Yogyakarta: Gadjah Mada University Press)
[16] Sari K Y 2017 Jurnal Media Sains 1, 71-76.
[17] Rustam E, Pramono A A. 2018. Pros Sem Nas Masy Biodiv Indon 4, 13-19.
[18] Souza L A, Moscheta I S 2011 Tropical Biology and Conservation Management 1, 1-14.
[19] Silva A C, Souza L A 2009 Acta Scientiarum Biological Sciences 31, 425-432.