

Plant Structure Morphology and Utilization of AI to Visualize Chemical Content in *Artocarpus integer* (Cempedak)

Baiq Nabila Saufika Zainuri^{1*}, Galuh Elisa Roliana Fatimah^{1,2}, Wahyu Indah Widya Astuti¹, Aliefman Hakim¹

¹Master of Science Education, University of Mataram, Indonesia.

²State Junior High School 3 Labuapi, Indonesia.

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Corresponding Author:

Baiq Nabila Saufika Zainuri

baiqnabilasaufika@gmail.com

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Abstract: This study aims to understand the morphology, chemical content, and potential uses of *Artocarpus integer* (Cempedak) using Artificial Intelligence (AI) technology. This research is motivated by the lack of comprehensive scientific information regarding cempedak, especially regarding its chemical content and potential uses. The research method used is qualitative, including direct observation in East and West Lombok, in-depth interviews with local communities, and a comprehensive literature study. The results of the study successfully identified the typical morphological characteristics of cempedak, such as a semi-circular tree canopy, wide, elongated leaves with fine hairs, and large, oblong, and thorny fruit. In addition, this study also successfully identified various flavonoid compounds contained in cempedak. The use of AI technology, in this case ChemSketch, allows for accurate and efficient visualization of the chemical structures of these compounds. This research makes a significant contribution to enriching knowledge about cempedak, especially in terms of its morphology and chemical content.

Keywords: *Artocarpus Integer*; Cempedak; Plant Morphology; Chemical Content; Artificial Intelligence.

Introduction

Artocarpus integer (Cempedak) is a tropical fruit plant native to Southeast Asia, belonging to the Moraceae family, a close relative of jackfruit and breadfruit (Zakaria, 2019). This plant is believed to have originated in the Malay Peninsula and spread to surrounding regions such as Indonesia, Thailand, and the Philippines. Cempedak thrives in areas with humid tropical climates, with high rainfall and warm temperatures throughout the year (Lestari, 2020).

Cempedak is a large, shady tree that can reach a height of 20 meters. Its leaves are oval with fine hairs on the backs, dark green and glossy. The flesh is yellow to orange, has a strong, distinctive aroma, and is soft and slightly fibrous. (Zakaria et al., 2019).

A thorough understanding of plant morphology, namely the shape and structure of its organs, is the first step in identifying the distinctive characteristics of cempedak and exploring its potential for optimal use (Lestari, 2021). Plant morphology can also provide clues to the chemical constituents of various plant parts, such as the fruit, leaves, stems, and roots (Putri, 2020).

The development of artificial intelligence (AI) technology has opened up new opportunities in various fields, including plant research. One interesting use of AI is in visualizing the chemical composition of plants, including cempedak. Using the AI algorithm, ChemsSketch, it is possible to identify and depict the molecular structure of chemical compounds found in cempedak more accurately and efficiently (Wibowo, 2021).

This study aims to describe the morphology of the structure of the cempedak plant, analyze its chemical content, and utilize AI to describe its chemical compounds.

Method

This research was conducted from March to May 2024 using a qualitative approach. The research locations were East Lombok (Figure 1) and West Lombok (Figures 2 and 3).

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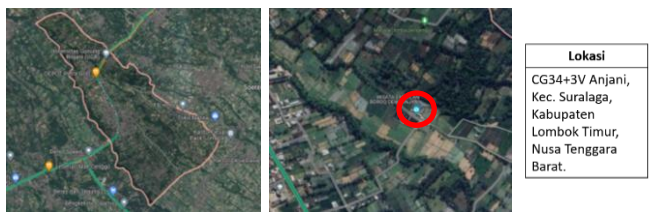


Figure 1. Growing location 1

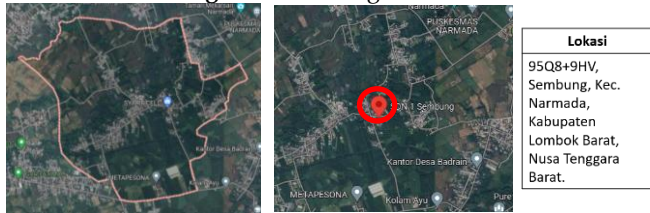


Figure 2. Growing location 2

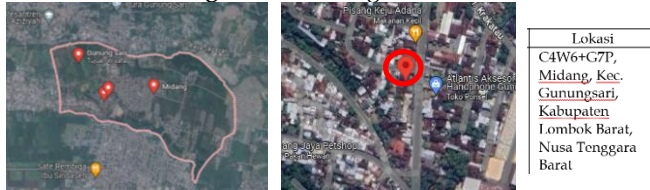


Figure 3. Growing location 3

This research was conducted in several stages, beginning with direct observation of cempedak morphology in East and West Lombok, followed by in-depth interviews to explore local knowledge about cempedak. A literature review was conducted to gather scientific information related to cempedak morphology, chemical composition, and uses. Data from the observations, interviews, and literature review were analyzed qualitatively to identify patterns and relationships. Next, the chemical compounds identified from the literature review were visualized using ChemSketch.

ChemSketch plays a crucial role in visualizing the chemical composition of plants, including cempedak (*Artocarpus integer*). With its ability to draw 2D and 3D chemical structures, ChemSketch enables researchers to depict compounds identified from plant extracts, such as flavonoids, phenolics, and fatty acids found in cempedak (Wibowo, 2021).

Results and Discussion

The *Artocarpus integer*, or cempedak (Figure 4), belongs to the Moraceae family. The Moraceae family is found in tropical and subtropical regions, including Lombok, West Nusa Tenggara. However, several sources we spoke with stated that cempedak is a rare and infrequent plant. Cempedak plants do not grow wild; instead, they are cultivated independently by local residents in their yards. Cempedak plants are similar to jackfruit, but the main differences lie in their morphology, including the shape of the tree canopy, the

characteristics of the leaves and trunk, and the size and shape of the fruit.



Figure 4. *Artocarpus integer* tree

Morphology of Cempedak Plants

Cempedak fruit has a wide, pyramidal, rounded, oval, semi-circular, protruding, and irregular canopy. Cempedak generally has a semi-circular canopy shape. Some grow in open areas, unprotected by surrounding plants (Figure 5).



Figure 5. Cempedak tree canopy

Cempedak leaves vary in the shape of the leaf blade, leaf tip, and leaf base. The shape of the cempedak leaf blade found is broadly elliptical with a leaf size that

is larger, wider, and glossier than jackfruit leaves with fine hairs on the underside and leaf veins (Figure 6) and trunk (Figure 7) of the cempedak tree.



Figure 6. cempedak leaves



Figure 7. Cempedak tree trunk

Cempedak fruit is large, oblong, and spiky (Figure 8). Its skin is green when young and turns greenish-yellow when ripe. The flesh is bright yellow, soft, and has a distinctive, fragrant aroma. It can be eaten fresh or processed into various foods and drinks. Besides the fruit, cempedak seeds can also be consumed after being boiled or fried. The wood is of good quality for construction and furniture.



Figure 8. cempedak fruit

Cempedak plants are known to produce primary and secondary metabolites. Primary metabolites are directly involved in the growth, development, and reproduction of plant organisms and support basic life

processes such as respiration, photosynthesis, and protein synthesis. Examples include carbohydrates, proteins, and lipids. Secondary metabolites, on the other hand, are compounds produced from the biosynthesis of primary metabolites and are not directly involved in growth, development, or reproduction. However, they can aid in plant reproduction and protection. These compounds possess pharmacological activity or may treat various diseases, but they can also be harmful. Compounds included in secondary metabolites include flavonoids, phenolics, alkaloids, saponins, tannins, steroids, terpenoids, and others (Kusbiantoro, 2018; Annisa, 2021).

Plant Taxonomy of *A. integer* (Cempedak)

Table 1. Taxonomy of *Artocarpus Integer*

Kingdom	:	<i>Plantae</i>
Subkingdom	:	<i>Tracheobionta-cascular plants</i>
Division	:	<i>Magnoliophyta</i>
Subdivision	:	<i>Magnoliophyta</i>
Class	:	<i>Magnoliopsida – Dicotyledons</i>
Subclass	:	<i>Hammamelidae</i>
Order	:	<i>Urticals</i>
Family	:	<i>Moraceae</i>
Genus	:	<i>Artocarpus</i>
Species	:	<i>Artocarpus integer</i> (Thunb) Merr.

(Zakaria, 2019)

Chemical Content (Flavonoids) in Cempedak

Flavonoids are phenolic compounds found abundantly in the genus *Artocarpus*, characterized by the presence of prenyl groups. Flavonoids can be found in plant tissues such as leaves, bark and stem wood, root bark and wood, and flowers. The structural diversity of flavonoids is determined by the number and position of oxygen functional groups, the presence of O-methylation and C-methylation, the inclusion of C-terprenyl (isoprenyl, geranyl, and farnesyl groups), and O-glycosylation (Zakaria, 2019). Flavonoid compounds from *Artocarpus Integer* (Cempedak) can be seen in Table 2.

Table 2. Flavonoid Compounds from *Artocarpus Integer*

Species	Plant Parts and Origin	Framework Types	Library
<i>Artocarpus Integer</i>	Root bark, stem bark (Indonesia)	Flavanones, oxepinoflavones, pyranoflavones	Ahmad, 1996; Judge, 1999 and 2005;
	trunk wood (Indonesia)	3-prenylflavone, Tetrahydroxanthone, furanodihydrobenzoxanthone	Nomura, 1998
	Wood stem (India)	3-Prenylflavone, oxepinoflavone	Pendse, 1976

Chemical Compound Skeleton Image

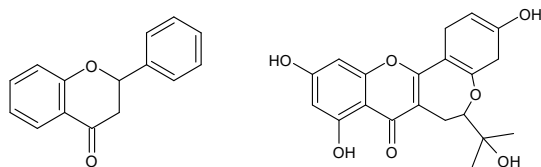


Figure 9. Flavanone **Figure 10.** Oxepinoflavone

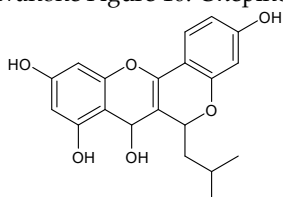


Figure 11. Pyranoflavones

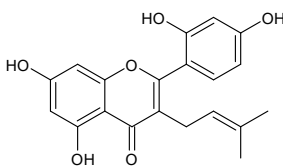


Figure 11. 3-Prenylflavone

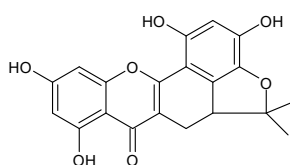


Figure 12. Furanodihydrobenzoxanthone

Material Relevant to Science Learning in Phase D of Junior High School Level

Learning Outcomes in Phase D say Participants can measure the physical aspects they encounter and utilize a variety of motion and force, understand the relationship between the concepts of work and energy, measure the temperature magnitude caused by the heat energy provided, and can also distinguish between insulators and heat conductors. Grade VII, Material: Chapter 1. Scientific method, namely Measurement of basic and derived quantities to measure the length, width, outside and shape of leaves, stems and others. Students are able to classify living things and objects based on observed characteristics, identify the properties and characteristics of substances, distinguish physical and chemical changes and separate simple mixtures. Grade VII, Material: Chapter 5. Classification of Living Things, Chapter 6. Ecology, and Biodiversity of Indonesia. Students can describe atoms and compounds as the smallest units of matter and cells as the smallest units of living things, identify the organizational system of life and conduct analysis to find the relationship between organ systems and their functions and abnormalities or disorders that appear in certain organ systems (digestive system, circulatory system, respiratory system and reproductive system)

(Inabuy et al. 2021). Grade VIII, Material: Chapter 1 Introduction to cells, Chapter 5. Elements, Compounds, and Mixtures (Maryana et al. 2021). Grade IX (Sutia, C., et al. (2022)., Material: Chapter 1. Growth and development, Chapter 5. Chemical reactions and their dynamics, and Chapter 6. Inheritance of traits and biotechnology (Decree of the Head of the Agency for Standards, Curriculum and Assessment of Education, Ministry of Education, Culture, Research, and Technology, 2022).

Material relevant to learning physics, chemistry, and biology in Phases E and F at high school level

Grade X Phase E, Physics material: Quantities and derivatives in the sub-material Measurement of basic and derived quantities (length, mass, time, area and volume). Such as measuring the length and mass of leaves, measuring the height of stems and diameter of seeds, etc. Grade XII Phase F, Chemistry material: Functional groups in carbon compounds, namely organic compound material and carbon chains, functional groups as active centers in chemical compounds, nomenclature of organic compounds and so on. Discussion of chemical structures in *Artocarpus Integer* plants. Grade XI Phase F, Biology material: Regulatory processes in plants, about tissues, organs and organ systems in plants consisting of roots, stems, leaves, fruit, seeds, etc. (Decree of the Head of the Agency for Standards, Curriculum and Assessment of Education, Ministry of Education, Culture, Research, and Technology, 2022).

Conclusion

This research has successfully revealed the distinctive morphological characteristics of *Artocarpus integer* (Cempedak), such as a semi-circular canopy, broad, hairy leaves, and large, round, and spiny fruit. Furthermore, this research has successfully identified various flavonoid compounds contained in cempedak, which have potential health benefits. The use of AI technology, specifically ChemSketch, allows for accurate and efficient visualization of the chemical structures of these compounds, opening up further opportunities for cempedak research and utilization in various fields.

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Author Contributions

In this study, Baiq Nabila Saufika Zainuri was responsible for writing the introduction, discussion of points 3 and 4, research methodology, and review and editing the article. Galuh Elisa Roliana Fatimah contributed to writing the abstract, discussion of points 5 and 6, article review, and acknowledgements. Wahyu Indah Widya Astuti compiled the discussion of points 1 and 2, article review, and wrote the conclusion of this study.

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Conflicts of interest

The authorities declare no conflict of interest

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