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Exploration of characteristics of trichomes, chlorophyl content, and lead content in Fabaceae leaves in the Malabar Urban Forest, Malang

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ABSTRACT

This research aimed to analyze the characteristics of trichomes, chlorophyll and lead content of various leaves in the Fabaceae family in the Malabar Urban Forest, Malang. The research was carried out using direct exploration methods (for sampling the leaves of each plant), and laboratory observations. The research will start from July 2023 to May 2024. The research was carried out in the Malabar Urban Forest, Malang, and the Biology Laboratory of UMM. Observation of anatomical structures using a binocular microscope, leaf chlorophyll content using a spectrophotometer, and lead content using the AAS method. The results of the research show that [1] there are variations in the characteristics of leaf trichomes in terms of type and other characteristics and there are variations in the number or average of trichomes; [2] Chlorophyll content in various types of leaves of the Fabaceae family in the Malabar Urban Forest. The highest chlorophyll a and b content is found in the *Samanea saman* plant and the lowest in *Erythrina crista-galli*; and [3] leaf lead content shows variation. The highest lead content is in the leaves of the *Samanea saman* plant and the lowest is *Gliricidia sepium* and *Senna siamea*. This research provides implications as baseline data for monitoring changes in trichome characteristics, chlorophyll content and lead in the leaves of Fabaceae family plants in the Malabar Urban Forest in the future as indicators of environmental dynamics. Information regarding variations in Fabaceae leaf characteristics can be used to develop bioindicators of environmental pollution, especially related to heavy metal pollution, as well as provide input for the management and conservation of urban forests.

Keywords: Chlorophyll content, lead, trichome characteristics, urban forest

INTRODUCTION

Malabar Urban Forest is one of the green open spaces in Malang City, East Java, Indonesia. This forest is located in the middle of Malang city center. Government Regulation Number 63 of 2002 concerning Urban Forests outlines city forests as the center of an ecosystem that is shaped like a natural habitat and contains biological natural resources that are dominated by trees and blend with the surrounding environment. Urban forest refers to vegetation community in the form of trees and their associations that grow on city land or around the city, in the form of stripes, spread out, or in clusters, with a structure resembling/imitating a natural forest, forming a habitat that allows life for animals and creates a healthy, comfortable and aesthetic environment (Dharma & Zakaria, 2022; Kim, 2016).

Urban forest has a function as a protected forest and conservation of several plants. The existence of green open space in urban areas has a very important function for the sustainability of a city from an ecological perspective (Aulia et al., 2023; Hirokawa, 2011; Paudel & States, 2023; Saninah et al., 2023). Intrinsic (main) functions are very diverse, including as an oxygen producer. The existence of urban forests must be maintained. Efforts that can be made are to preserve and maintain various kinds of trees and plants (Angraini et al., 2023; Sari et al., 2022).

The dominant plant species are trees that grow towering and large. The plants and trees found in the Malabar Urban Forest have different types, tree diameter, plant height and age, carbon uptake, and various families. The group and type of plant can influence the structure and size of plant anatomy, one of which is the leaf organs. Leaves are plant organs that have morphological and anatomical characteristics with very high variations. Another factor that causes anatomical structures to change is environmental conditions. The diversity that exists in plants, which includes different families, will also determine their anatomical characteristics, chlorophyll content, and ability to absorb pollutants. One of the families that can be studied and researched is the Fabaceae family.

The Fabaceae is a group of plants that are used as road protectors (Adhia et al., 2022; Purwasih et al., 2013). Most of the plants protecting city roads are dominated by the Fabaceae group, based on their ability to absorb heavy metal pollutants such as lead. Several plants in the Fabaceae that have the effective ability to absorb lead (Aisyah & Putri, 2024; Gawronski & Gawronska, 2007; Susilowati et al., 2021). The ability of Fabaceae plants to absorb pollutants affects the characteristics of their trichomes and the anatomical structure of their leaves. Apart from that, it is also related to the chlorophyll content of the leaves, this is because chlorophyll functions to strengthen cells, and chemically neutralize pollutants because chlorophyll is rich in nutrients and contributes oxygen which can neutralize and thwart the activity of chlorophyll free radicals so it is very useful for supporting healthy air. The presence of chlorophyll can improve health conditions by increasing the function and physiological processes of plants, which are influenced by external and internal factors (Gostin, 2009; Kuswandi et al., 2023; Latifa et al., 2019; Salsabila et al., 2022).

External and internal factors greatly influence the morphology and physiology of a plant in its survival in an environment. External factors are soil, humidity, light, nutrients and water. Internal factors include genes, hormones, anatomical structure and morphology (Seleiman et al., 2021; Sudirman et al., 2021; Yang et al., 2021). Based on the description above, there is a very close relationship between the anatomical structure of leaves, the ability to absorb lead and other pollutants, the chlorophyll content of leaves, and the air conditions in an environment. The Fabaceae can absorb impurities. However studies on the anatomy, chlorophyll content, and lead/ Plumbum (Pb) of plant leaves in the Malabar Urban Forest have not been widely reported, so research on the characteristics of the Fabaceae family leaves in the Malabar City Forest is very important to do.

Initial research regarding plant crowns, the number of plants that make up the Malabar Urban Forest, epidermis density, tree diameter and carbon uptake, characteristics of the leaf stomata of the Sapindaceae family, characteristics of the trichomes of the Fabaceae (Latifa et al., 2021; Latifa & Fatmawati, 2018; Madapuri, 2020; Riadi, 2024). However, research on the anatomical structure, chlorophyll content and lead content in Fabaceae leaves is still limited and has not yet been studied in detail. The diversity of families and types of each plant has specific and unique characteristics in terms of morphology and anatomy. Plant leaves also contain chlorophyll and different abilities in the process of absorbing pollutants such as lead (dos Santos et al., 2022; Latifa et al., 2019; Yavas et al., 2024).

This research aimed to analyze the anatomical characteristics, chlorophyll and lead content of various leaves of the Fabaceae family in the Malabar Urban Forest, Malang City. This research is focused on exploring anatomical characteristics (trichomes) so as to obtain observational data on the type, type, size, shape, number and density, leaf chlorophyll content, and leaf lead of Fabaceae family plants in the Malabar Urban Forest. This research has the potential to become the basis for policy in the conservation and management of Malabar Urban Forest and various urban forests in Indonesia. Scientific information about the anatomy and characteristics of stomata and trichomes, leaf chlorophyll and lead content of various Fabaceae family plants in the Malabar Urban Forest is closely related to plant physiology and the ability to protect plants, the ability to absorb heavy metals and the health of the air in the environment. In an academic context, this research can support Biology Education research in the Field of Environmental Biology and university research strategic plans in leading areas of health and the environment. Data collection information on the number of Fabaceae plants can be used as an indicator for choosing the right trees to overcome air pollution in the future with an environmental health orientation.

METHOD

Type and time of research

This type of research is quantitative descriptive. The research was carried out from July 2023 to May 2024. The research was carried out in the Malabar Urban Forest, Malang City dan Biology Laboratory of Universitas Muhammadiyah Malang (UMM) to carry out observations of anatomical structures using a binocular microscope and leaf chlorophyll content using a spectrophotometer, observing lead content using the AAS method.

Research implementation

The research implementation process was carried out as follows: (a) Data collection on Fabaceae family plants, the species name has been identified from previous research, (Latifa et al., 2019; Latifa et al., 2021), Identification is carried out by referring to various sources of books and articles, and taxonomists, namely lecturers from Biology education; (b) Sampling; (c) Observation of anatomical structures using the section method referring to Hafiz and Rahayu (2013), namely preparation of tools and materials; each leaf was cleaned, fixed using FAA and fixed with xylol: paraffin, blocking with paraffin, slicing followed by staining, graded alcohol dehydration and alcohol: xylol, and observation continued with mounting and labeling; (d) Observation and calculation of chlorophyll content using the method referred to in Latifa et al. (2019) using 85% acetone as a solvent and measuring the absorbance value of the chlorophyll solution at wavelengths (λ) = 663 and 645 nm. Anatomical observation replication was carried out 3 times, chlorophyll and lead content measurements were carried out once; (e) measurement of lead (Pb) content referring to Rindyastuti and Hapsari (2017). In this study, the leaves used were leaves from the 5th leaf blade from the leaf tip which were used for observing anatomy, chlorophyll and lead content.

Data collection technique

Data from the research were obtained from: (1) observing the cells and tissues that make up the anatomical structure of the leaves, (2) the chlorophyll content of the leaves which was obtained from calculating the determination formula by entering the absorbance value from observations using a spectrophotometer, and (3) the lead content in the leaves.

Data analysis

Data analysis uses descriptive statistics based on research findings and articles that are descriptive of relevant research results.

RESULTS AND DISCUSSION

Data collection activities have been carried out and the results obtained are (1) Complete inventory data of Fabaceae plants with the number of trees in the Malabar Urban Forest; (2) Photo observations of trichomes from each plant leaf; (3) Determining the type and type of trichomes of each plant; (4) Chlorophyll content in leaves; and (5) Data on lead content in leaves. Complete Fabaceae plant inventory data with the number of trees in the Malabar Urban Forest of Malang city is presented in Table 1.

Table 1. Data from Fabaceae identification results

No	Local name	Latin name	Amount
1	Gamal	*Gliricidia sepium*	46
2	Sono Kembang	*Pterocarpus indicus*	20
3	Flamboyan	*Delonix regia*	19
4	Ketepeng	*Senna alata*	18
5	Trembesi	*Samanea saman*	11
6	Asam jawa	*Tamarindus indica*	10
7	Dadap Merah	*Erythrina crista-galli*	6
8	Sengon	*Enterolobium cyclocarpum*	6
9	Johar	*Senna siamea*	1

Table 1 shows that there are 9 types of plants in the Malabar City Forest. The five dominant plants are *Gliricidiasepium, Pterocarpus indicus, Delonix regia, Cassia alata,* and *Samanea saman*. Meanwhile, other types of plants are *Tamarindus indica, Erythrina crista-galli, Enterolobium cyclocarpum,* and *Senna siamea*. Several types of Fabaceae plants such seem to dominate in the Malabar Urban Forest. This is likely due to the advantages of these plants in reducing urban pollution. For example, the leaves of Fabaceae plants generally have a good ability to accumulate heavy metals such as lead, which is one of the main pollutants in urban areas (Bierza, 2022; Deepalakshmi et al., 2014; Mahar et al., 2016; Mahmud et al., 2020; Martínez et al., 2003; Sabreena et al., 2022; Sumalan et al., 2023; Yan et al., 2020). Apart from that, the varying characteristics of the trichomes and leaf chlorophyll content of these types are also thought to play a role in absorbing and neutralizing various types of air pollutants (Bui et al., 2022; Giri et al., 2013; Wei et al., 2017). These superior physiological and morphological characteristics enable Fabaceae plants in the Malabar Urban Forest to grow well and dominate, and effectively contribute to absorbing and minimizing the impact of pollution in the urban environment.

The results of observations of trichome types are presented in Table 2, where in general there are two types of trichomes, namely glandular and non-glandular trichomes. Based on the characteristics of leaf trichomes, it is known that there are variations in type and other characteristics. On one type of plant, there are only one type of trichome and there is also more than one type of trichome attached, as presented in Figure 1, Figure 2, Figure 3, Figure 4, Figure 5, Figure 6, Figure 7, Figure and Figure 9.

Table 2. Types of leaf trichomes of Fabaceae plants

No	Plants	Types of trichomes
1	*Tamarindus indica*	Non Glandular
2	*Erythrina crista-galli*	Non Glandular & Glandular
3	*Delonix regia*	Non Glandular
4	*Gliricidia sepium*	Glandular
5	*Senna siamea*	Non Glandular
6	*Cassia alata*	Glandular
7	*Enterolobium cyclocarpum*	Non Glandular
8	*Pterocarpus indicus*	Glandular
9	*Samanea saman*	Non Glandular

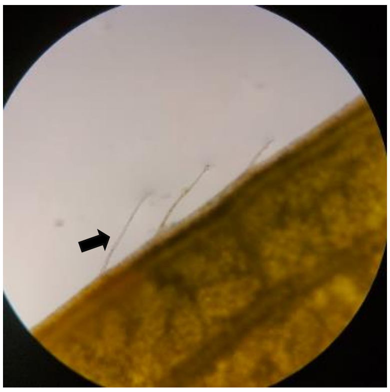
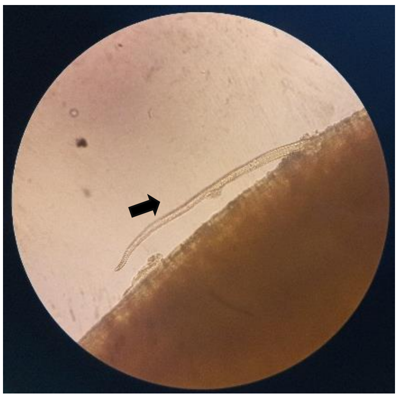

Figure 1. *Tamarindus indica* trichomes
Magnification: 40x10

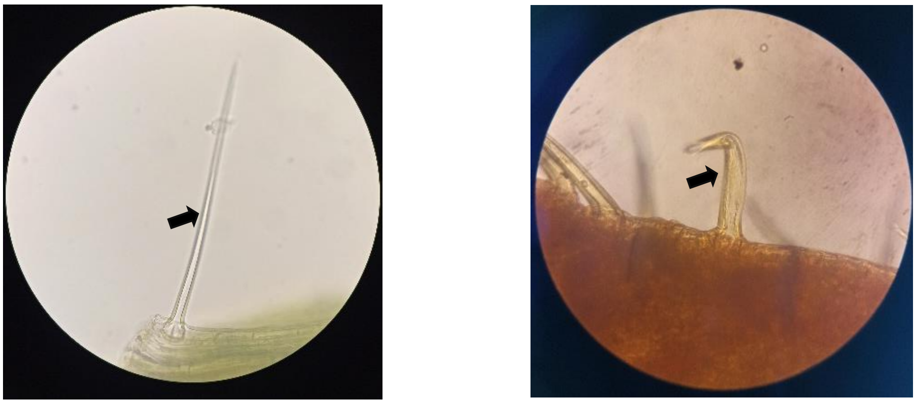

Figure 2. *Erythrina crista galli* trichomes
Magnification: 40x10

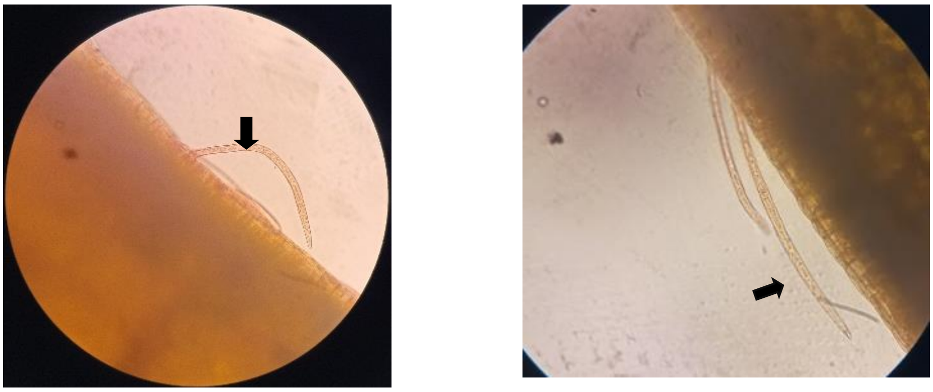

Figure 3. *Delonix regia* trichomes
Magnification: 40x10

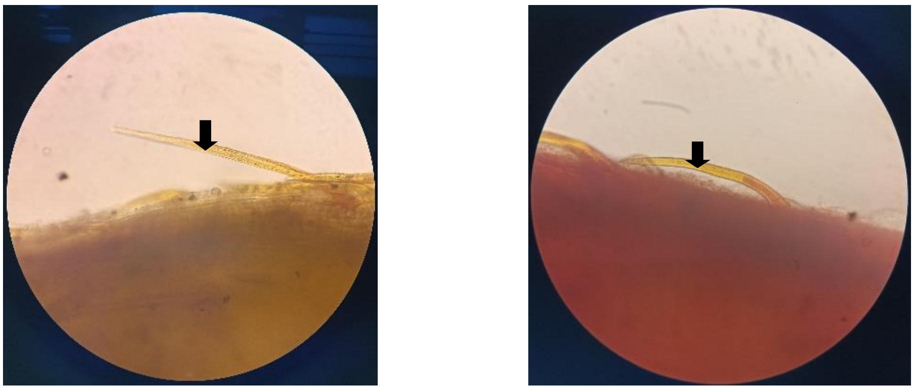

Figure 4. *Gliricidia sepium* trichomes
Magnification: 40x10

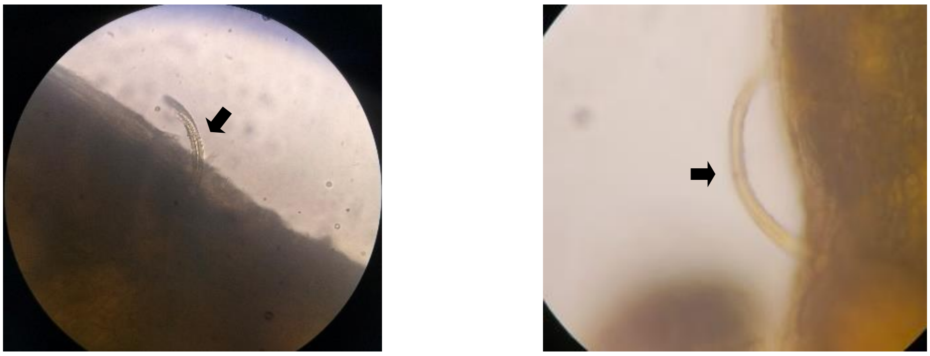

Figure 5. *Senna siamea* trichomes
Magnification: 40x10

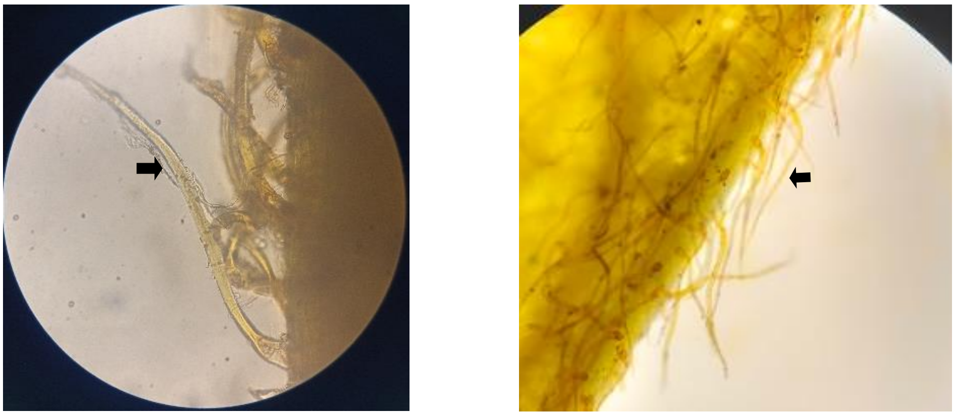

Figure 6. *Senna alata* trichomes
Magnification: 40x10

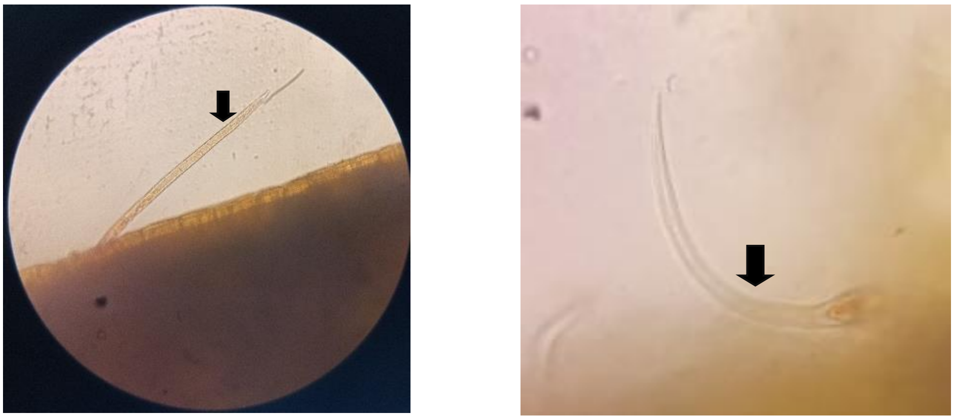

Figure 7. *Enterolobium cyclocarpum* trichomes
Magnification: 40x10

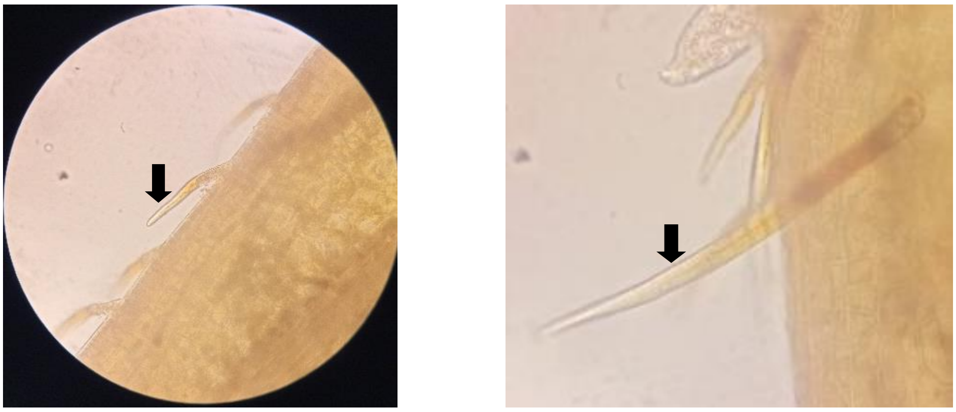

Figure 8. *Pterocarpus indicus* trichomes
Magnification: 40x10

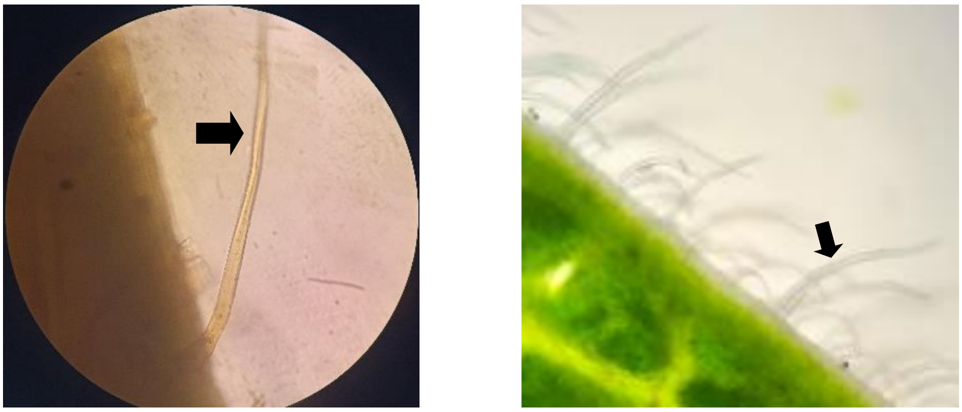

Figure 9. *Samanea saman* trichomes
Magnification: 40x10

The results of observing the characteristics of leaf trichomes showed variations in type and other characteristics. Broadly speaking, there are two types of trichomes, namely glandular and non-glandular trichomes. On one type of plant, there are only one type of trichome and there are also more than one type of trichome attached. The structure and morphology of trichomes are diverse and can be used as a key for identifying genera, species, subspecies and varieties from the various families studied (Harisha & Jani, 2013). Trichomes have various structural variations in large and smaller plant groups, but also sometimes have uniform characteristics within one taxon, can be used for taxonomic purposes, and identifying plant types and understanding relationships between species (Dasti et al., 2002). Studies on trichomes in plants from one family have a type of non-glandular trichome with a shape each star has 2-4 arms, while Glandular trichomes are only single-celled (Agustin, 2021; Nurohmah, 2021; Udlwi'ah, 2015).

Other research was conducted on the Cucurbitaceae family on the plant species *Citrus lanatus, Citrullus colocynthis*, *Cucumis melo*, *Cucumis sativus, Cucumis edulis, Cucumeropsis manii*, and *Cucurbita moschata*. The results of the research showed that in each plant, non-glandular trichomes were found in the form of simple multicellular trichomes and glandular trichomes in the pelt form (Ajuru et al., 2018).

The trichomes on the roots are non-glandular trichomes which do not have secretions and also do not have a secretory function. This is in accordance with the characteristics of non-glandular trichomes, namely having a multicellular hair shape that can be star-shaped and has a sharp tip (Gostin, 2023; Huchelmann et al., 2017; Watts & Kariyat, 2021).

Trichomes are epidermal protrusions that point outward and act as additional tools in the plant. Trichomes have various types and shapes of non-glandular trichomes, glandular trichomes, scales, papillae and root hairs which can be used for absorption (Han et al., 2022; Hülskamp, 2004; Watts & Kariyat, 2023). This is in accordance with the characteristics of glandular trichomes, namely trichomes that can produce thick and sticky secretions (Jia et al., 2012; Wagner, 1991). The leaves have the form of secretory trichomes which are one celled or in the form of scales, having large secretory cells at the narrow end of the stalk. Leaf trichomes have the function of absorbing water and nutrients, reducing disturbances caused by plant defenses against herbivores (Traw & Dawson, 2002). The number of trichomes in plants exposed to drought stress is self-protection against tissue damage, as a form of plant adaptation mechanism to fulfill CO_2 assimilation for photosynthesis, and suppress excessive transpiration processes (Ma et al., 2020; Yang et al., 2021).

The diversity of types and shapes of trichomes found is related to the function of trichomes which are derivatives of the epidermis as protectors of leaf organs (Watts & Kariyat, 2021). Each trichome has a different function, non-glandular trichomes function, among other things, as a barrier to the entry of pathogens through the stomata, while glandular trichomes function to secrete secondary metabolites. Trichomes often have unicellular or multicellular heads consisting of cells that produce secretions and are borne on stalks of non-glandular cells (Gostin, 2023). In other research, it was stated that the head of the trichome contained brown pigment, but in this study it was not known whether it actually contained pigment or not because this study only looked at the trichome from the outside (Harisha & Jani, 2013).

Meanwhile, in terms of type and shape, it is known that in general what is found is the unicellular trichome type and the subulate form. Specifically, *Erythrina crista-galli* has two types of trichomes, namely unicellular and multicellular and trichome shapes, namely subulate and globular. This is as shown in Table 3.

Table 3. Types and shapes of trichomes on Fabaceae leaves

No	Plant name	Types	Shapes
1	*Tamarindus indica*	Unicellular	Subulate
2	*Erythrina crista-galli*	Unicellular	Subulate and Globular
3	*Delonix regia*	Unicellular	Subulate
4	*Gliricidia sepium*	Unicellular	Subulate
5	*Senna siamea*	Unicellular	Subulate
6	*Cassia alata*	Unicellular	Subulate
7	*Enterolobium cyclocarpum*	Unicellular	Subulate
8	*Pterocarpus indicus*	Unicellular	Subulate
9	*Samanea saman*	Unicellular	Subulate

As a result of observing the characteristics of leaf trichomes, there are variations in the type and shape of trichomes, in general there are two types, namely unicellular and multicellular. There are three types of trichome shape characteristics, namely subulate and globular. On one type of plant, there are only one form of trichome and there are alsomore than one form of accompanying trichome.

Trichomes are often found on the top surface, only the bottom, or both. The number of trichomes of each plant found on the leaves varies for each type (Nurrohman et al., 2022). The large number of trichomes on leaves can be assumed to be a form of plant adaptation to the surrounding environment. Trichomes are often found in plants that have chlorophyll, this is also related to the use of trichomes as a protector of the leaf mesophyll against heat loss, can remove mineral salts from leaf tissue which are needed plant (C. Li et al., 2021; Lusa et al., 2015; Wang et al., 2021). Plant organs such as leaves adapt to polluted environments, with their morphological or anatomical structure. Changes occur in the thickness of epidermal cells, shape, size, number and density of trichomes (Yuliany et al., 2021).

The shape, size and density of the shape and type of trichomes also influence the function of the trichomes in protecting the leaf organs of a plant. The number of cells that make up trichomes is influenced by the number of trichomes and the length of the trichomes. The number of trichomes influences the number of cells that make up the trichome because the more the number of trichomes in one field of view, the more cells that make up the trichome. The number of cells that make up trichomes will follow the pattern of the number of trichomes when under drought stress conditions (Hernandez & Park, 2022; Wang et al., 2021).

It is said that trichomes in epidermal tissue have special properties as a defense force against insects, determined by the presence of glands (glandula) or not (non-secretory), density, length, shape and straightness of the trichomes (Oksanen, 2018; Wagner, 1991). Trichomes on Erythrina crista-galli L were simple unicellular with an average length of 0.41mm (Cahyono et al., 2022). Trichomes generally measure between micro to several centimeters with various shapes that are specific between species. Trichomes have a secretory cell cavity with a diameter of 10-30µm to 40-60µm (Sari et al., 2021; Punja et al., 2023; Tanney et al., 2021).

Observation results of leaf chlorophyll content

The results of observations related to leaf chlorophyll content are visualized in Figure 10. Figure 10 shows that the plant that has chlorophyll content (both a and b) is *Samanea saman*, while the lowest is *Erythrina crista-galli*.

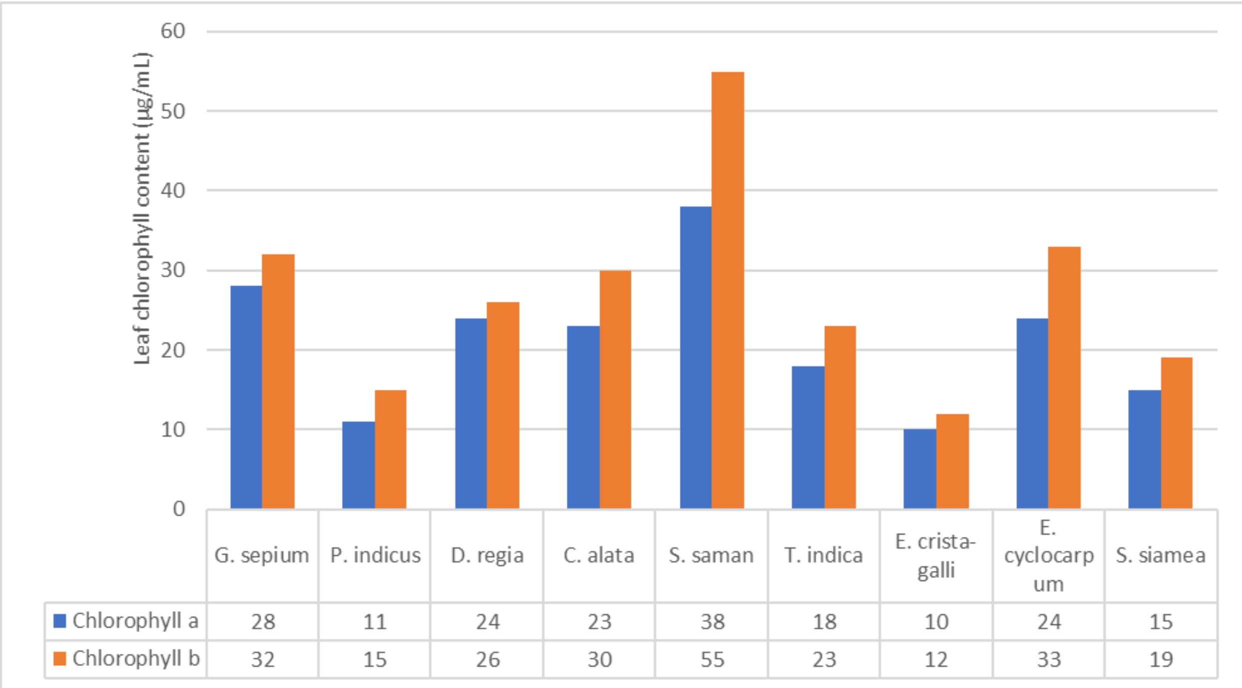

Figure 10. Diagram of calculation results of leaf chlorophyll content

The results of calculations and observations obtained data on the chlorophyll content in various types of leaves of the Fabaceae family in the Malabar City Forest. The *Samanea saman* plant has the highest chlorophyll a and b contents, namely 38 µg/ml and 55 µg/ml. The smallest chlorophyll a and b contents in *Erythrina crista-galli* were 10 µg/ml and 12 µg/ml. The different chlorophyll content is due to the formation of pigments including chlorophyll which is influenced by various factors. Kusumastuty (2018) states that the influencing factors are internal and external. There are internal and external factors that influence such as genetics, light, temperature, soil pH and nutrients. Sumenda et al (2011) states that if there is interference with one of the factors, chlorophyll biosynthesis will be disrupted.

Physical and chemical factors influence chlorophyll content. Budiono et al (2016) in their research proved that the higher the light intensity, the chlorophyll will increase. Apart from light, temperature also affects chlorophyll levels. Temperature is an environmental parameter that plays a role in enzymatic reactions. Plants have different optimum temperatures. Temperature is caused by light intensity together with humidity, the higher the light intensity, the higher the temperature.

Several factors that influence the formation of leaf chlorophyll are light factors and water factors. Light quality is closely related to photosynthesis in plants which in turn is related to plant biomass. Chlorophyll in bright places is higher than in dark places because light affects chlorophyll for photosynthesis in spinach plants (Y. Li et al., 2018).

Leaf development and leaf area play a role in photosynthesis. The photosynthesis results of a plant unit are determined by the leaf area. The wider leaf area allows for more efficient light capture. Leaf angle and leaf area index are one of the most important things that influence light interception and canopy photosynthesis (Liu et al., 2021). Leaves are the main organ of plants because the process of plant photosynthesis takes place in the leaves. A plant's ability to carry out photosynthesis is largely determined by the area of its leaves because the larger the leaf area, the greater the light that the plant can capture. Leaf area describes the ongoing photosynthesis process. The greater the leaf area, the higher the photosynthesis process that takes place in the leaves so that the photosynthate produced in the leaves will be greater, which is reflected in the dry weight of the plant (Wulandari et al., 2024).

The acidity level or pH is also one of the physical parameters that supports plant life. The pH states the activity of hydrogen ions which can be classified into acids and bases. The pH of each plant has a different optimum range. In general, soil pH is 5.5-7.5. Soil pH is acidic which can cause Al, Fe and Mn poisoning. The high content of these nutrients will inhibit root growth and the translocation of P and Ca to plants. In addition, the availability of nutrients will decrease. Under soil pH conditions of 4, the amount of nutrients available is only small. Therefore, pH is responsible for the availability of nutrients. The influence of soil pH on N availability is more indirect, namely on the activity of microorganisms involved in N availability. Acid soil conditions can also inhibit microbial activity, including mineralization of organic matter and nitrification. The elements K, Ca and Mg are generally not available to plants on acidic soil because some of the minerals are weathered. Of the three, the Mg element is the most affected by pH because it is more easily leached by H, Al and Fe ions than the other two elements. The Mg element functions as a component of the chlorophyll molecule and an enzyme activator in the phosphorylation process (Arifin et al., 2022).

Water is a primary need for all living creatures such as plants. Plants that lack water can disrupt their life processes. The water contained in the soil acts as a solvent and binder between soil particles, which then affects the stability of soil structures/aggregates, soil strength and geological materials. Chemically, water acts as a transport medium for dissolved substances and particles that help form and decompose soil. Water below the ground surface has a broad impact on chemical and physical processes in natural soil, and the survival of life in it depends on the availability of this water. Biological production in the soil, from forest products to agricultural crops, is highly dependent on the availability of groundwater, which is influenced by the properties of the soil and the moisture in it (Hasyyati et al., 2023). One of the impacts of water on plants is on plant physiology, one of which is on chlorophyll. Sufficient amounts of water make chlorophyll synthesis optimal, but if plants experience drought stress (lack of water) and water stress (excess water) in the rainy season, chlorophyll synthesis will be disrupted. According to Nurrudin et al (2020) lack of water affects plant metabolic processes. When there is a lack of water, some of the leaf stomata close, preventing the entry of CO_2 and inhibiting the photosynthesis process. In addition, lack of water inhibits protein synthesis. Plants that experience water shortages are generally smaller in size compared to plants that grow normally.

Results of observation of leaf plumbum content

The results of observations of leaf lead content show variations, as in Table 4.

Table 4. Observation results of lead content in leaves

No	Plant leaves	Lead content [ppm]
1	*Tamarindus indica*	0.0657
2	*Erythrina crista-galli*	0.0562
3	*Delonix regia*	0.0631
4	*Gliricidia sepium*	0.0462
5	*Senna siamea*	0.0462
6	*Cassia alata*	0.1032
7	*Enterolobium cyclocarpum*	0.1662
8	*Pterocarpus indicus*	0.1307
9	*Samanea saman*	0.2106

The highest lead content is in the leaves of the Samanea saman plant at 0.2106 ppm and the lowest is *Gliricidia sepium* and *Senna siamea*, each at 0.0462 ppm. The ability to absorb lead (Pb) by plants is not always influenced by internal factors, but can also be influenced by environmental factors where the plants grow. Differences in plants in accumulating Pb pollutants in the air can be influenced by several environmental factors, including vehicle intensity and climatic factors including humidity and air temperature, season, and wind speed. Climatic factors have a big influence on the ability of leaves to absorb pollutants from the air.

Temperature has an important role in the distribution of lead in leaves. This research was conducted in the dry season so the humidity value was low. The low humidity value is caused by the intensity of light in the dry season so that the water content in the air is low. The high and low humidity of the air can affect the size of the pollutant content in both closed and open spaces due to the presence of pollutant solvents which cause pollution (Baldauf et al., 2021; Chowdhury et al., 2021; DaMatta & Cochicho Ramalho, 2006; Yang et al., 2020). Increasing the temperature to the plant's tolerance limit will increase the respiration rate so that it can influence the process of opening stomata to absorb gas from the environment (Hou et al., 2024; Moore et al., 2021; Xu et al., 2016). According to Winardi (2014), a higher temperature increase will affect lead (Pb) levels to decrease in an area. It is known that very high temperatures cause the air in an area to expand easily which can affect the condition of lead (Pb), causing it to become thinner (dilution).

It is hoped that the findings from this research will provide information for academics, practitioners and observers who devote themselves to the environment. The characteristics of the trichomes found in Fabaceae family plants in the Malabar forest can be used as a recommendation for selecting plants to be planted, in this case they are related to the characteristics of the existing trichomes including the shape, type, number and ability of each trichome on the plant to absorption of pollutants and for the purpose of beautifying a city, apart from that, it is also important as basic information in planning a healthy city environment and supporting the general goals of city development. There are two general goals of city development, namely to obtain efficient environmental support, one of which is a place that is clean, pleasant, comfortable, safe and attractive (Latifa et al., 2021).

The results of this research can be used to develop bioindicators of environmental pollution, especially related to heavy metal pollution. Variations in leaf characteristics of Fabaceae family plants, such as trichomes, chlorophyll content, and heavy metal accumulation, show potential as indicators of environmental conditions. This information can be used to build a biomonitoring model that can monitor and identify levels of heavy metal pollution in the Malabar Urban Forest. Furthermore, this bioindicator data can be a valuable input for efforts to manage and conserve urban forests.

On the other hand, data on the characteristics of Fabaceae plant leaves can also be used for management and conservation purposes of the Malabar Urban Forest. Information regarding variations in the morphological and physiological characteristics of leaves can help understand the dynamics of urban forest ecosystems, as well as be a basis for planning more appropriate management strategies. Thus, the results of this research have dual implications, both for the development of pollution bioindicators and for the management and conservation of urban forests.

CONCLUSION

Based on research findings, it can be concluded that there are variations in trichome characteristics, chlorophyll content, and lead content in various types of leaves of the Fabaceae family in the Malabar City Forest. The characteristics of leaf trichomes vary in type and other characteristics. Broadly speaking, there are two types of trichomes, namely glandular and non-glandular trichomes. On one type of plant, there are only one type of trichome and there are also more than one type of trichome attached. Various types of leaves from the Fabaceae family in the Malabar City Forest have various chlorophyll contents. The *Samanea saman* plant has the highest chlorophyll a and b contents, namely 38 µg/ml and 55 µg/ml. The smallest chlorophyll a and b contents in *Erythrina crista-galli* were 10 µg/ml and 12 µg/ml. Leaf lead content showed variations. The highest lead content is in the leaves of the *Samanea saman* plant at 0.2106 ppm and the lowest is *Gliricidia sepium* and *Senna siamea*, each at 0.0462.

Based on the conclusions of this study, we can provide two recommendations for future research. Future researchers can carry out further research to examine the relationship between trichome characteristics, chlorophyll content, and the accumulation of the heavy metal lead in the leaves of Fabaceae plants. Correlation and regression analysis can be used to see the relationship between these parameters and their potential as indicators of heavy metal pollution. Future researchers can also develop a biomonitoring model for heavy metal pollution in City Forests based on the leaf characteristics of Fabaceae plants. This can be done by expanding the range of plant types studied, considering other environmental factors, and validating models developed through field studies in other locations with different environmental characteristics.

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