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Designing Miniature Pot Gardens Using Indonesian Medicinal Plants: An Architectural and Floristic Perspective

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ABSTRACT

Purpose of the study: This study aims to analyze the architectural and floristic characteristics of medicinal plants in the Purwodadi Botanical Gardens collection, assess the aesthetic potential of plants as components of miniature gardens in pots of various sizes, and evaluate the level of public appreciation for miniature garden designs based on local Indonesian medicinal plants.

Methodology: The research employed descriptive and experimental methods at the Purwodadi Botanical Gardens. Data were obtained through field observations, an inventory of medicinal plant collections, analysis of morphological and floristic characteristics, design of miniature garden models in large, medium, and small pots, and a questionnaire survey of 170 respondents. The tools used included a camera, clay and rubber pots, organic planting media, observation sheets, and an aesthetic evaluation instrument.

Main Findings: Eleven types of medicinal plants have high aesthetic value based on their branches, leaves, flowers, and fruit. The medium-sized miniature garden pot model received the highest public appreciation and the most stable aesthetic value. The large-pot model showed increased appreciation after further evaluation, while the small-pot model experienced a decline due to changes in plant conditions. The beauty of the garden is influenced by the appropriateness of plant size, visual combinations, color variations, and optimal use of space.

Novelty/Originality of this study: The novelty of this research lies in the integration of medicinal plant architecture analysis, floristic composition, pot-based miniature garden design, and community perception evaluation in a single integrated approach.

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1. INTRODUCTION

Indonesia is known as a mega-biodiversity country with a rich flora, including various types of medicinal plants that have been used for generations by local communities [1], [2]. Medicinal plants not only have functional value as traditional medicines but also possess aesthetic potential that can be utilized in landscape architecture and garden design [3], [4]. The variety of crown shapes, stem structures, leaf textures, colors, and growth patterns of medicinal plants provides unique and attractive visual characteristics that can be developed as decorative elements in limited spaces. In the modern context, utilizing medicinal plants as aesthetic

elements is a relevant approach to supporting sustainable greening and improving the quality of residential environments [5], [6].

The evolving urban lifestyle, which tends to favor practical and aesthetic green spaces, has driven a growing interest in miniature potted gardens [7], [8]. The miniature garden concept is considered capable of bringing elements of beauty, coolness, and educational value to limited areas, such as yards, terraces, balconies, and small public spaces. Furthermore, miniature gardens also have ecological and psychological value because they can enhance visual comfort and provide a relaxing effect for the community [9], [10]. The use of medicinal plants in miniature gardens is an attractive alternative because in addition to beautifying the environment, these plants can also be used as functional plants that support family health [11], [12].

One source of medicinal plant germplasm with significant potential for development as a component of miniature gardens is the plant collection at the Purwodadi Botanical Gardens. This botanical garden houses a diverse collection of Indonesian medicinal plants with diverse morphological and architectural characteristics. Each plant species has a distinct branching pattern, canopy shape, plant height, and leaf arrangement, creating its own unique aesthetic value. This diversity provides an opportunity to explore garden design based on plant architectural characteristics, particularly in arranging plants in pots of varying sizes [13], [14]. Studying plant architectural characteristics is crucial because it can determine the suitability of plant types for the aesthetic function and spatial proportions of miniature gardens [15], [16].

Plant architecture is a crucial aspect of botany and landscape science, studying the growth patterns and morphological structure of plants as a whole [17], [18]. The architectural characteristics of plants can influence the visual quality of a garden, including compositional balance, harmony of form, and spatial dynamics. In addition to architectural aspects, floristic composition is also a crucial factor in creating the beauty of miniature gardens, as it relates to the combination of plant types, color diversity, and texture of vegetation. Therefore, analyzing the architectural and floristic characteristics of medicinal plants is necessary so that plant selection in miniature gardens considers not only their medicinal function but also their aesthetic value and suitability to the landscape design [5], [11].

Although extensive research has been conducted on medicinal plants and their uses, most studies focus on their phytochemical content, pharmacological benefits, and cultivation techniques [19], [20]. Research specifically examining the architectural aesthetic value of medicinal plants as components of miniature potted gardens is still relatively limited. Furthermore, previous studies generally have not integrated analysis of plant architectural characteristics with evaluation of public preference or appreciation of the resulting garden designs [17], [21]. This situation indicates a research gap in the development of medicinal plants as aesthetic elements based on miniature landscapes that adapt to the needs of modern spaces.

The novelty of this research lies in its integrative approach, which combines analysis of plant architectural characteristics, floristic composition, miniature garden designs in various pot sizes, and evaluation of public appreciation of the resulting garden designs. This research not only views medicinal plants from a functional perspective but also as aesthetic elements with visual value and commercial potential in landscape design. The urgency of this research is increasing as the public demand for efficient, educational, aesthetic, and environmentally friendly garden concepts amidst limited urban space. The results of this study are expected to serve as a reference in the development of garden designs based on local Indonesian plants while also supporting medicinal plant conservation through a creative landscape approach.

Based on the description, this study aims to determine the architectural and floristic characteristics of several medicinal plants in the Purwodadi Botanical Gardens collection, to determine their potential as components of miniature gardens in large, medium, and small pots, and to design and evaluate public appreciation of the resulting miniature gardens.

2. RESEARCH METHOD

2.1. Description of the Study Area

The Purwodadi Botanical Gardens are located in Purwodadi District, Pasuruan Regency, East Java, at 7°47' South Latitude and 112°41' East Longitude, approximately 300 meters above sea level. The botanical garden covers an area of approximately 85 hectares, with varying topography, ranging from flat to undulating. Average annual rainfall is 2,372 mm, with the wettest months occurring between November and March. Temperatures in the area range from 22°C to 32°C.

2.2. Preliminary Study

The Purwodadi Botanical Gardens' garden area is divided into 25 plots, spread across two main areas, separated by a main road as the boundary. This botanical garden serves as a conservation area for various plant species, particularly those native to dry habitats. During the dry season, the area can experience a period of approximately four to five months without rain, from June to October. This condition is characterized by a dry environment and numerous leaf droplets. A preliminary study was conducted to determine the types of medicinal

plants with potential for use as components of a miniature potted garden [22], [23]. In the initial phase, the entire medicinal plant collection was inventoried and then categorized into endemic and exotic plants. Next, the endemic plants were selected based on several criteria, including high aesthetic value, herbaceous habit, primary use of the crown or aboveground plant parts, perennial or annual use, ease of cultivation and care, abundant availability, and usefulness in daily life.

The selected medicinal plants were then re-evaluated through a first-stage questionnaire distributed to 20 respondents, staff members of the Purwodadi Botanical Gardens. The assessment was conducted on four aesthetic aspects: branching, leaf shape, flower shape, and fruit shape. Respondents gave a score of 3 for the good category, a score of 2 for the fair category, and a score of 1 for the poor category. The assessment was conducted subjectively according to each respondent's perception. The aesthetic value of the plant was calculated using an average score formula based on the number of respondents in each assessment category. In this calculation, a value of A indicates the aesthetic value of the plant, while a, b, and c represent the number of respondents who gave a score of 1, 2, and 3, respectively. Plants that received a score of more than 2 on at least two aesthetic criteria were selected for use in the next research stage. In addition, plants that only scored high on one criterion could still be considered if their main aesthetic aspect lies in the leaves with a high assessment value.

2.3. Determination of Architectural and Floristic Characteristics of Medicinal Plants

The architectural characteristics of medicinal plants were determined by observing their branching patterns, while their floristic characteristics were analyzed based on the shape, color, type, and position of flowers and fruits on the plants. Observations of plant life forms were conducted through the growth direction of the main stem, which included upright, lying, creeping, and climbing types. Furthermore, the branching types observed included monopodial, sympodial, and dichotomous or forked branching. Leaf characteristics analyzed included leaf blade shape, leaf color, surface texture, leaf vein pattern, and leaf arrangement on branches and stems [24], [25]. Meanwhile, observations were made on the fruit development, color, and morphology of the fruit produced by each medicinal plant. All architectural and floristic characteristics of the plants were observed directly in the field through observations of the morphological conditions of the plants. To strengthen the observations, this study was also supported by a study of relevant literature related to the architectural and floristic characteristics of medicinal plants.

2.4. Making a Mini Garden Model in a Pot

The medicinal plants selected through the first phase of the questionnaire were then designed into miniature potted gardens. The design phase began with the creation of a drawing or sketch of the garden design as a reference for plant arrangement. The composition of the miniature gardens took into account several aspects, including similar growing environment requirements such as soil moisture and shade levels, variations in leaf shape and color, plant size or height, and the diameter of the pots used. This study used three pot sizes: 54 cm, 27 cm, and 22 cm in diameter. The large pots were made of rubber, while the medium and small pots were made of clay. The planting medium used was a mixture of soil and manure in a 1:1 ratio. Each miniature garden design for each pot size was replicated three times.

The medicinal plants were then planted according to the design and maintained for approximately five months. After this growth period, the shape and composition of the resulting miniature gardens were evaluated. This was done by pruning dry leaves and branches or excessive growth that obscured other plants. Furthermore, replanting or replacing damaged or dead plants was carried out to maintain the garden's composition. This evaluation phase aims to achieve a miniature garden that is proportional, harmonious, and has optimal aesthetic value. After the evaluation process is complete, the plants are maintained for approximately one month to ensure the miniature garden remains stable and grows well before the next assessment phase.

2.5. Determining Community Appreciation

The final results of the medicinal plant planting, arranged in the form of miniature gardens, were then exhibited to the public to determine their level of appreciation for the garden designs. Public assessment was conducted through a second phase of questionnaires. Respondents included 100 adults, including visitors and staff of the Purwodadi Botanical Gardens, lecturers, staff, and students at Brawijaya University. Several aspects assessed in the questionnaire included the appropriateness of pot size to plant size, the harmonious combination of medicinal plants in each garden model, the utilization of space in the pots, and the overall aesthetics of the garden models [26], [27]. Respondents rated the designs using a score of 3 for excellent, 2 for fair, and 1 for poor.

The assessment data for each miniature garden model was then averaged to obtain a final score using a predetermined scoring formula. These scores were used to determine the level of public appreciation for each miniature garden design in pots. A third phase of evaluation was conducted two months after the second evaluation to clarify the public's appreciation of the miniature garden models obtained previously. At this stage,

the number of respondents involved was 50 people using the same assessment techniques and evaluation criteria as in the second stage.

2.6. Research Design

The study of the architectural and floristic characteristics of several medicinal plants in the Purwodadi Botanical Gardens collection is a descriptive study, with the type of medicinal plant used as the independent variable and the architectural and floristic characteristics as the dependent variables. The creation of a model or design for a miniature garden in a pot is an experimental study, with the independent variable being the number of miniature garden models in a pot and public appreciation as the dependent variable. Each treatment was repeated three times.

2.7. Data Analysis

Data regarding the architectural and floristic characteristics of medicinal plants were analyzed descriptively and presented in the form of photographs to provide a clear visual representation of the observed plant features. Meanwhile, data on public appreciation of the miniature garden designs were analyzed descriptively by calculating the percentage of respondents' assessments, which were categorized into "not good," "fair good," and "good" criteria for each garden model evaluated.

3. RESULTS AND DISCUSSION

3.1. Aesthetic Value of Endemic Medicinal Plants

Based on an initial selection conducted in a preliminary study, 20 medicinal plants were identified as having considerable potential as components of a miniature potted garden. Only two female respondents were selected, while 18 were male, so the male respondents' assessments cannot be compared with those of the female respondents.

3.1.1. The Beauty of Medicinal Plant Branching

Respondent assessments revealed that nine medicinal plants received an average score above 2, indicating they possess attractive branching patterns and have the potential to be used as components of miniature potted gardens. Based on these assessments, cat's whiskers and lempeni plants received the highest scores, with 2.4 each. Betawi pandan received a score of 2.2, while keci beling and cumin leaves received a score of 2.1. Pacing, poncosudo, sambiloto, and landep plants each received a score of 2.0.

Most of the selected medicinal plants are well-known to the public because they are often found growing wild in various places such as roadsides, ditches, rivers, gardens, and rice field embankments. Although many grow naturally without special care, some of these plants have also been used as ornamental and medicinal plants in home gardens. Plants such as landep are often used as hedges and yard decorations in both urban and rural areas. Furthermore, cat's whiskers, keci beling, and sambiloto have numerous and dense branches, forming a dense bush structure. These characteristics make these plants suitable for use as yard borders, hedges, or as walkway borders.

Plants with relatively tall growth are also considered to have aesthetic value in garden design. Plants with these characteristics can be used as a focal point in small gardens. When planted in pots and used as indoor ornamental plants, taller plants are generally more suitable for placement in corners, the center of a room, or as room dividers, creating a more appealing visual impact. Several other plants, such as lempeni, pandan betawi, cumin leaves, pacing, and poncosudo, are also quite popular as potted ornamental plants, although commonly found growing wild. Their attractive shapes and relatively good durability are factors supporting their use as decorative elements. These plants have been widely cultivated and sold as ornamental plants for home gardens, office parks, and public open spaces. In fact, pacing plants are quite often used as borders on garden paths and walkways.

Conversely, medicinal plants that receive a score below two are considered to have less attractive branching compared to other plant parts. This group of plants includes fragrant pandan, purple leaf, nerve leaf, ules wood, brotowali, katu, and ki tolod. The low aesthetic value for branching is thought to be due to the plants' generally wild growth or lack of care, making their growth form less appealing to respondents. Furthermore, the number of respondents who gave this group high scores was also relatively small; in fact, none gave the ki tolod plant a "good" rating. This suggests that the primary appeal of these plants likely lies more in their leaves, flowers, or fruit than in their branching structure.

Another factor contributing to the low ratings for some medicinal plants is respondents' limited knowledge of the branching form of the plants being assessed. This condition led some respondents to not provide a rating, thus affecting the final evaluation results. Plants such as manukan, daun otot, dlingo, and nampu fall into this category, as a significant number of respondents did not provide a rating. This situation suggests that the aesthetic assessment process will be more optimal if respondents can directly observe the

physical condition of the plants, either through plant exhibitions or visual media such as photographs and drawings, thus providing a more objective assessment. Branching pattern is a crucial aspect in determining the aesthetic value of ornamental plants, including medicinal plants that have the potential to be developed as miniature garden elements. Branching patterns significantly influence the overall architectural appearance of the plant. While plant form can be modified through pruning or specific shaping techniques, plants that naturally have attractive branching will provide greater aesthetic value because they require less maintenance. Therefore, branching pattern is a key consideration when selecting plants for a miniature potted garden design.

3.1.2. The Beauty of Medicinal Plant Leaves

The questionnaire results showed that most respondents were quite familiar with the leaf morphology of the medicinal plants they observed. This is evident in the low number of respondents who did not provide an assessment, which ranged from 5% to 25% of the total. The lowest percentages were found for purple leaf, muscle leaf, dlingo, cat's whiskers, and katu plants, while the highest percentage was found for manukan. Based on the leaf aesthetic assessment results, the purple leaf plant received the highest score of 2.7, followed by nampu with 2.6. Keci beling, pandan betawi, daun saraf, daun otot, and pandan wangi plants each received a score of 2.5. Next, cumin leaves received a score of 2.4, while dlingo and lempeni received a score of 2.3. Pacing and cat's whiskers plants received a score of 2.2, while poncosudo, ki tolod, and sambiloto received a score of 2.1. Katu plants received a score of 2.0, remaining in the category of plants with fairly good leaf aesthetic value. The high rating of the beauty of medicinal plant leaves is likely related to the easily recognizable morphological characteristics of the leaves. Some plants possess distinctive characteristics that provide both visual and sensory appeal. Purple leaf and nerve leaf, for example, are easily recognized due to their purplish color. Fragrant pandan is known for its distinctive fragrant leaves, while cumin leaves have a fleshy texture and a strong aroma. Sambiloto is better known for its bitter taste as a traditional medicinal plant, while katu is known as a vegetable with a distinctive leaf flavor. The pacing plant has a unique leaf arrangement on its stem, while other plants exhibit distinctive leaf blade shapes, such as the serrated shape of the keci beling and kumis kucing, the ribbon-shaped shape of the pandan betawi and dlingo, and the ovoid and lanceolate shapes of several others.

Several selected medicinal plants have also long been used as ornamental plants. Pacing, landep, cumin leaves, and poncosudo are among the tropical plants quite popular as decorative elements. The muscle leaf plant, which was initially often found as a weed in plantations and damp areas, has also begun to be used as a potted plant due to its attractive leaf shape. Similarly, nerve leaves are widely used as ground cover plants because they grow low and densely, making them suitable for placement along paths or in hanging pots. The beauty of the leaves is a key factor in determining a plant's aesthetic quality, as they are the most dominant and easily eye-catching part of the plant. Furthermore, leaves are present throughout most of the plant's life cycle, allowing for a longer enjoyment of their beauty than seasonal flowers or fruit. Variations in leaf shape, color, texture, and arrangement create compelling visual compositions, especially in tropical gardens, which are synonymous with lush, natural surroundings.

In tropical garden design, a combination of plants with contrasting leaf colors is often used to avoid the monotony of dense vegetation. The use of various plant species with varying color gradations creates a more dynamic and harmonious garden appearance. In this concept, the viewer's attention is drawn not only to the architectural form of the garden but also to the combination of leaf colors and textures of the constituent plants. Therefore, medicinal plants with varied leaf shapes and colors have great potential for use as components of tropical gardens or miniature potted gardens.

When used as indoor ornamental plants, ornamental foliage plants are generally preferred over flowering plants. This is because ornamental leafy plants tend to be more resilient to indoor conditions and their beauty can be enjoyed at any time without having to wait for the flowering phase. The appeal of ornamental leafy plants lies in the shape, color, texture, and composition of the leaves and stems. In contrast, ornamental flowering plants generally require specific environmental conditions for optimal flowering, making them often less suitable for indoor placement. Therefore, medicinal plants with attractive foliage have great potential to be developed as functional ornamental plants in miniature garden designs and interior spaces.

3.1.3. The Beauty of Medicinal Plant Flowers

Respondent assessments revealed eleven medicinal plants with highly attractive flowers. The landep and poncosudo plants received the highest scores, each with a score of 2.8. The kumis kucing and pacing plants received a score of 2.7, followed by the keci beling plant with a score of 2.6. The ki tolod plant received a score of 2.5, the manukan plant a score of 2.4, and the lempeni and katu plants each received a score of 2.3. The kayu ules plant received a score of 2.2, and the sambiloto plant a score of 2.1. All of these plants are considered attractive enough to be used as components of a miniature potted garden. The selected medicinal plants are generally easily recognized due to their distinctive flower characteristics, including shape, color, size, arrangement of flowers on the stem, and aroma. Landep, for example, is known for its brightly colored flowers and rapid growth, making it a popular choice in tropical and subtropical gardens. Meanwhile, cat's whiskers, keci

beling, ki tolod, manukan, and kayu ules have unique flower shapes and contrasting colors, creating strong visual appeal.

The attractive and striking floral characteristics make these medicinal plants suitable for use as elements in tropical gardens. In tropical-style gardens, plants are generally arranged closely together, requiring a variety of colors and shapes to create a dynamic, non-monotonous appearance. The presence of flowers with contrasting colors can enhance the garden's aesthetic value and serve as a visual focal point in the plant composition. Lempeni plants are also considered to have high aesthetic value because they produce small, red flowers that later develop into attractive fruit. In several countries, these plants have been widely cultivated as components of tropical and subtropical gardens and are widely cultivated as ornamental plants. Meanwhile, katu and sambiloto plants are highly regarded despite their relatively small flowers. Both plants are used not only as medicinal plants but also often as hedges and yard decorations.

Conversely, medicinal plants are not selected for selection due to several factors. Some plants rarely flower due to the plant's natural characteristics or the environmental conditions in which they grow. Furthermore, some plants have flowers with less striking shapes, sizes, or colors, so their beauty is overshadowed by other, more dominant plant parts, particularly the leaves. This is evident in purple-leafed plants, nerve-leafed plants, and muscle-leafed plants, which are better known for their beautiful leaves than their flowers. Respondents' knowledge of medicinal plant flowers also influenced the aesthetic assessment results. A lack of familiarity with the flowers of some plants led many respondents to fail to provide a rating, thus affecting the final score. Plants such as cumin leaves, brotowali, nampu, and dlingo fall into this category because many respondents were unfamiliar with their flower shapes. Dlingo, for example, actually has fragrant flowers, but because it is more often found growing wild in swamps, riverbanks, or other damp areas and is rarely used as an ornamental plant, it is less well-known among the public.

In general, the low level of public awareness of medicinal plant flowers is due to the relatively rare use of the flowers compared to the leaves and herbs. As a result, public attention to the characteristics of medicinal plant flowers is reduced. However, some medicinal plants have flowers with attractive shapes and colors, making them potential aesthetic elements in miniature or tropical garden designs.

3.1.4. The Beauty of Medicinal Plant Fruit

Based on the questionnaire results, only four medicinal plants were deemed to have attractive fruit shapes. The Kayu Ules (Ules wood) plant received the highest score of 2.6, while Lempeni (Katu), Katu (Katu), and Pacing (Pacing) each received a score of 2.5. The appeal of the fruits of these four plants lies not only in their shape but also in their contrasting and striking colors, providing high aesthetic value. Kayu Ules fruit has a distinctive, twisted shape, becoming the plant's primary visual characteristic. Meanwhile, Lempeni is widely known for its attractive fruit, featuring a combination of red and black. The beauty of Lempeni fruit makes it quite popular as an ornamental plant, grown both in pots and in home gardens. The fruit grows from flowers and generally appears in summer and can persist for several months, providing a relatively long-lasting decorative appearance.

Lempeni is also known to be widespread in various tropical and subtropical regions, as it is widely traded as an ornamental plant. Its natural spread is thought to be aided by birds that eat the fruit. Besides being used as an ornamental plant, the natural pigment content of lempeni fruit has also been studied for its potential use as a natural food coloring. This indicates that this plant not only has aesthetic value but also significant potential for other uses. Conversely, several medicinal plants are considered to have less attractive fruit in terms of shape, size, and color. Betawi pandan, keci beling, sambiloto, and daun otot fall into this category. The relatively small number of respondents who gave the fruit a "good" rating for these plants, indicating that their fruit characteristics are less visually appealing than other plant parts.

In addition to the less prominent aesthetics of the fruit, the low scores for some plants were also influenced by the large number of respondents who did not provide a rating. Compared with the previous criteria, the aesthetics of the fruit had the highest number of respondents who did not provide a rating. This condition indicates that the public's level of knowledge about medicinal plant fruits is still relatively low. The lack of use of medicinal plant fruits in everyday life is suspected to be the main reason respondents are not familiar with the characteristics of the fruit of the plants being assessed. Medicinal plants selected for potted miniature gardens are those that receive an aesthetic score of more than 2 on at least two assessment criteria. Based on the selection results, eleven plant species were deemed suitable for use in the next phase of research. However, the ules wood plant was not used further because its aesthetic value is primarily focused on its flowers and fruit, which are not always present and require specific environmental conditions for optimal growth.

In addition to plants that met more than one aesthetic criterion, several plants that excelled solely in their leaves were also used in the research. Nerve leaf and muscle leaf plants were chosen because of their creeping growth pattern and relatively low growth rate, making them suitable for covering the surface of the growing medium or as a counterbalance to taller plants. Using plants with this variety of growth forms creates a more harmonious and attractive visual gradation in the composition of a miniature potted garden.

3.2. Miniature Garden Design in Pots and Evaluation

3.2.1. Mini Garden Model in a Large Pot

This miniature garden model in a large pot is designed using eight types of medicinal plants of varying heights but requiring relatively similar growing conditions: high light intensity and relatively dry soil. The plants used include lempeni, landep, keci beling, ki tolod, poncosudo, kumis kucing, daun jinten, and katu. Because most of the plants in the garden have the potential to grow tall, the garden design was created using a height gradient concept. This gradient concept is implemented by placing taller plants at the back of the pot, while shorter plants are placed at the front. Based on this principle, lempeni, landep, keci beling, and katu are placed at the back of the pot as the main elements. Kumis kucing and poncosudo are placed in the center, with the poncosudo planted adjacent to the lempeni so it can climb up their stems. Meanwhile, ki tolod and daun jinten are placed at the front of the pot as filler plants and provide visual balance to the taller plants. Arranging plants in this pattern allows all plants to remain clearly visible and receive adequate lighting. Furthermore, arranging plants based on height gradients also helps create more suitable microclimates for the constituent plants. Taller plants can provide shade for plants less tolerant of full light, while dense planting helps retain moisture around the growing medium. Throughout the growing period, the miniature garden model was continuously evaluated to accommodate changes in plant shape, growth, and development. Some plants experienced quite rapid growth, such as the emergence of flowers and fruit on lempeni, landep, katu, ki tolod, and keci beling. Poncosudo began to grow as a vine, while the leaves of cumin and cat's whiskers grew denser and more clumped. Furthermore, new shoots emerged, making the initial garden composition less visible as some plants began to obscure others.

These growth changes necessitated revisions to the garden design to maintain the original concept. Revisions were made by pruning excessive leaves and branches to prevent them from obscuring other plants. In poncosudo plants, the stem growth direction is adjusted to twine around the lempeni stems, while overly long branches are pruned to prevent them from spreading to other plants and to stimulate flowering. In cumin leaves, some of the pruned plant parts are then replanted in the remaining empty areas of the growing medium to create a fuller and more even potting surface. Pruning is also carried out on cat's whiskers and ki tolod plants. Excessively long cat's whiskers branches are trimmed to create a neater, rounder crown and encourage flowering. In ki tolod, the branch growth direction is adjusted toward the front of the pot to fill the empty space and create a more balanced composition with the cumin leaves.

In addition to plant arrangement, additional elements such as small gravel are used to cover the remaining empty areas of the growing medium. The gravel serves not only as a decorative element but also helps disguise less attractive plant stems and reduces the risk of erosion in the growing medium. After evaluation and revision, the miniature garden in a large pot resulted in a more harmonious composition with plant height gradients. The poncosudo plant appears to be wrapped around the lempeni stem, while the cat's whiskers form a rounded crown in the center of the pot, while the cumin and ki tolod leaves grow to fill the front area of the pot, creating a more proportional and aesthetic garden appearance. The evaluation results show that controlling plant growth through pruning is an important part of maintaining the quality of the miniature garden design. Plants that grow too quickly or too tall can dominate the composition and detract from the overall aesthetic of the garden. Therefore, pruning is necessary to maintain plant shape, regulate light intake, maintain humidity and air circulation, and stimulate the growth of shoots, flowers, and fruit so that the miniature garden remains neat, balanced, and attractive.

3.2.2. Mini Garden Model in a Medium Pot

The miniature garden model in a medium-sized pot is designed using relatively small medicinal plants, namely pandan betawi and sambiloto. Nerve leaves were used as filler plants and to balance the height of the plants. These three plants were selected based on their suitable growth forms and ability to create a harmonious visual composition within the medium-sized pot. In the initial design, pandan betawi and sambiloto were planted close together at the edge of the pot, while the nerve leaves were placed in front of them. This placement aimed to create a gradation of plant heights, thus making the garden appear more proportional. The pandan betawi and sambiloto served as the main elements, while the nerve leaves served as a covering element, filling the bottom and front of the pot.

Nerve leaves were chosen because of their low, spreading growth characteristics, which balance the size of the other taller plants. Furthermore, these plants can grow densely and form effective clumps to cover empty areas of the growing medium. These characteristics enable the nerve leaves to function not only as an aesthetic element but also as a surface cover for a fuller, more natural-looking garden. During the evaluation and maintenance phase, the nerve leaves' growth direction was adjusted to surround the pandan betawi and sambiloto plants. Some branches were also allowed to grow over the front edge of the pot, camouflaging the pot and adding to the aesthetic value of the miniature garden. This adjustment created a softer and more dynamic appearance without altering the main composition of the plants.

The number of individual plants before and after the evaluation did not change significantly. However, during the growth period, some nerve leaf plants that died were replanted to maintain the garden's shape. Replanting was done to maintain compositional balance and ensure the planting medium remained well-covered. Unlike miniature gardens in large pots, miniature gardens in medium pots do not require additional hard elements such as stones or gravel. This is because the dense growth of nerve leaf plants is enough to cover most of the pot's soil surface. The nerve leaf branches hanging over the front of the pot also create a natural and attractive impression, enhancing the overall aesthetic value of the miniature garden design in medium pots.

3.2.3. Mini Garden Model in a Small Pot

The miniature garden model in a small pot is designed using one individual pacing and ki tolod plant, while three to four individual muscle leaf plants are planted. These three plants were chosen because they have similar growing environment requirements, particularly in moist soil and slightly shaded environments. The selection of these plants also took into account their size and growth pattern to suit the capacity of the small pot. The miniature garden design is created by placing the pacing plant in the center of the pot as the main element. Next, ki tolod and muscle leaf plants are used as filler plants, planted around the pacing. These two plants were chosen as complements because their relatively low growth structure prevents them from overshadowing the main plants and maintains visual balance in the garden composition.

During the plant's growth period, the condition and development of each component plant were evaluated. Several leaves were found to be drying on the pacing plant, requiring pruning. Furthermore, the distinctive spirochetal shape of the pacing leaf was initially suboptimal, thus reducing its aesthetic value. In the ki tolod plant, the growth of numerous new branches caused some of the plant to begin to overshadow the muscle leaf. Therefore, overgrown and excessively tall branches were pruned, while dried leaves were also removed to maintain a neat appearance.

Replanting was also carried out on the muscle leaf plants because some planted individuals wilted during growth. This condition caused the leaves to lose their freshness and eventually dry out. Plant replacement was carried out to maintain the garden's composition and maintain a visually appealing appearance. The evaluation and revision results showed that the miniature garden model in small pots produced a fairly harmonious appearance. In general, there were no major changes between the initial design and the design after the evaluation. This was because the revisions only involved replanting and rejuvenating the plants without increasing the number of individual plants. The main change was more visible in the growth of the plants during the maintenance period.

The pacing plant, which initially had only one branch, developed into three branches with a more distinct and attractive spirostic leaf arrangement. Furthermore, the growth of the constituent plants remained balanced so that they did not obscure each other. The plant height also remained proportional to the diameter of the pot, so the garden composition looked harmonious and pleasing to the eye. Grouping plants in a pot was primarily based on similar growing environment requirements, such as light intensity and humidity. Environmental factors such as light, water, temperature, humidity, growing medium, and fertilization are crucial factors influencing successful plant growth. If these environmental requirements are not met, plant growth and development can be hampered.

In general, medicinal plants grown in pots exhibit good growth. This is evident in the increase in plant height, the emergence of new branches, and the formation of flowers and fruit on some plants. In addition to utilizing dense planting to maintain humidity, environmental conditions during the rainy season also support plant growth because most of the water requirements are met from rainfall. Therefore, additional watering is relatively infrequent. Plant nutrient requirements are met through the growing medium and the application of organic fertilizer in the form of rotting leaves, which are widely available around the planting area.

3.3. Public Appreciation of the Miniature Garden in a Pot Model

Based on the results of the second phase of the questionnaire, the assessments given by 50 male and female respondents each for miniature garden designs in large, medium, and small pots showed relatively little difference. This indicates that the aesthetic assessment of the garden is not significantly influenced by the respondents' gender, but rather by each individual's subjective level of knowledge, experience, and personal taste. In general, the scores given by male respondents tended to be slightly higher than those of female respondents. However, this difference in scores was not large enough to indicate a significant difference in assessing the success of the miniature garden designs. Therefore, in the third phase of the questionnaire, respondent groups were no longer separated by gender, as its influence on the assessment results was deemed very small.

Differences in public appreciation of a garden design can essentially be influenced by various factors, such as mindset, habits, experiences, and the environmental conditions experienced by each individual. These factors can shape different aesthetic perceptions among individuals, resulting in widely varying assessments of garden beauty. Therefore, the likelihood of a direct influence of gender on garden aesthetic assessments is

relatively small compared to other subjective factors. The questions used in this research questionnaire fall into the category of questions related to respondents' attitudes, opinions, and feelings toward a specific object, namely the miniature garden design. Therefore, the answers provided by respondents are essentially subjective and reflect each individual's personal perceptions. The assessments that emerge as initial responses after respondents understand the purpose of the questions are generally the answers that best align with their personal attitudes and views toward the garden design being observed.

3.3.1. Mini Garden Model in a Large Pot

Based on the results of the second phase of the questionnaire, all aspects of the assessment of the miniature garden model in a large pot received an average score of less than 2. This indicates that both male and female respondents rated the ratio of plant size to pot size, the harmony of the plant combinations, the utilization of space, and the overall beauty of the garden as still lacking. The results of the second evaluation showed that the ratio of pot size to plant size and the harmony of the plant combinations each scored 1.6. Meanwhile, the utilization of space and the overall beauty of the garden scored 1.7. These scores indicate that the miniature garden model in a large pot still did not meet respondents' expectations in terms of aesthetics and design composition.

However, the results of the third evaluation showed an increase in public appreciation for the garden model. The ratio of pot size to plant size increased to 2.0, as did the utilization of space. The harmony of the plant combinations and the overall beauty of the garden also increased to 1.8 each. Although the overall beauty score did not reach the good category, this improvement indicates that the revision and development of the plants had a positive impact on respondents' perceptions. The evaluation results showed that the overall beauty of a miniature garden is greatly influenced by several key aspects: the appropriateness of the plant size to the pot, the harmony of the plant variety, and the optimal use of space within the pot. A good garden composition requires proportional plant placement, balanced plant sizes, and a harmonious visual relationship between plants, so the garden appears unified and not overdone.

One factor contributing to the low score in the second evaluation was the plants not yet flowering at the time of the exhibition. As a result, respondents could only judge the garden's variety based on the shape and color of the leaves of the constituent plants. Despite differences in leaf shape, the leaf color across the plants was relatively uniform, resulting in a lack of variety in the garden composition. In the third evaluation, the cat's whiskers plant had begun to flower, adding color and visual appeal to the miniature garden. This situation significantly increased respondents' appreciation of the garden model. Furthermore, the concept of plant height gradation applied in the garden design was also deemed inappropriate for the pot diameter. Placing the tallest plants at the back made the garden appear too tall and unbalanced when viewed from various angles. This model is considered more suitable for placement in a corner or in front of a wall, as the gradation of the plants can only be optimally appreciated from one viewing direction.

Some respondents believed that the garden concept would be more attractive if the tallest plant were placed in the center of the pot, surrounded by shorter plants. This arrangement allows the garden's beauty to be enjoyed from all directions and creates a more balanced composition. Placing taller plants in the center can also reduce the impression of dominance and make the overall garden appear more harmonious. The relatively low harmony score of the plant combinations is also thought to be influenced by a lack of variation in basic plant shapes and textures. The plants appear monotonous due to a lack of leaf shape and color diversity and the minimal number of flowers observed during the observation period. However, variation in plant texture and shape is an important element in creating a visually appealing garden.

Nevertheless, respondents considered that the use of space in the pots was quite optimal. Improvements focused on reducing the number of plant species to prevent the composition from appearing overcrowded. Some respondents suggested limiting the number of plant species to a maximum of three, but with more individual plants, for a more balanced and less crowded garden appearance. In addition to plant aspects, respondents also provided input regarding the use of pots. Some suggested that pots should be painted to reduce the appearance of the base material and enhance the overall aesthetic value of the garden. Based on the results of the assessment, it can be seen that the miniature garden model in a large pot has the potential to be further developed through improving the composition of plants, variations in color and texture, and adjusting the pot design to produce a more attractive and harmonious miniature garden.

3.3.2. Mini Garden Model in Medium Pot

The assessment results for the miniature garden model in a medium-sized pot showed that male respondents rated all observed criteria as being in the fair category. Meanwhile, female respondents gave fairly good ratings, particularly regarding the appropriateness of the pot size to the plant size and the utilization of space within the pot. Although there were slight differences in the assessments between the two groups, the final scores were relatively similar. Based on the results of the second phase of the questionnaire, the miniature garden model in a medium-sized pot received fairly good scores in almost all assessment aspects. The pot size-to-plant

ratio received a score of 2.1, while the harmony of the plant combination and the overall beauty of the garden each received a score of 1.9. The space utilization aspect received a score of 2.0. These results indicate that the miniature garden in a medium-sized pot was considered quite attractive by respondents.

In the third evaluation, scores increased across all assessment criteria. The pot size-to-plant ratio increased to 2.2, while the harmony of the plant combination and the utilization of space each increased to 2.3. The overall beauty score of the garden also increased to 2.4. These improvements indicate that the revisions and development of the plants during the maintenance period have successfully enhanced the aesthetic quality of the miniature garden. The plant composition in this miniature garden model is considered quite balanced. The tallest pandan plant, Betawi, is placed in the center of the pot and combined with a nearby bitter leaf plant. Furthermore, the nerve leaf plant, with its climbing nature, is placed around the two plants. This arrangement creates a more harmonious and visually balanced plant gradation.

The presence of the nerve leaf significantly contributes to the garden's aesthetics because its dense, spreading growth balances the height of the pandan and bitter leaf. Furthermore, the cylindrical and relatively tall shape of the pot helps create a balanced proportion between the pot's size and the plant's height. A choice of only three plant species is considered ideal for the pot size, ensuring the garden doesn't appear too crowded or too empty. The harmonious combination of plants is also considered quite good due to the contrasting leaf shapes and colors. The ribbon-shaped green pandan leaves create an interesting visual balance with the reddish-purple nerve leaf. The contrast in color and shape creates a more vibrant and less monotonous garden appearance.

The nerve leaf plants, which grow over the edge of the pot, also add aesthetic value. The hanging structure of the plants covers the edges of the pot and the growing medium, creating a softer and more natural feel. The use of trailing plants in garden design is considered effective in refining the garden's composition, especially when combined with upright, stiff-growing plants. Respondents highly appreciated the use of space in pots. Although only three plant species were used, the entire space within the pots was optimally utilized. The arrangement of the plants creates neither too dense nor too sparse impressions, creating a positive visual balance.

Overall, the miniature garden model in a medium-sized pot was considered quite attractive and has significant potential for further development. The assessment results indicated that respondents highly appreciated this garden design, particularly the balanced and harmonious plant composition. Improvements still needed primarily relate to the use of pots, as some respondents considered the pot shapes unattractive. Therefore, using pots with more varied designs or adding more decorative outdoor pots could be an alternative to enhance the overall aesthetic value of the miniature garden.

3.3.3. Mini Garden Model in a Small Pot

The evaluation results for the miniature garden model in a small pot showed that the scores given by male and female respondents did not differ significantly. However, male respondents tended to rate it higher than female respondents. This is evident from the fact that all criteria assessed by male respondents received scores above 2, indicating that the garden model was considered quite good. Conversely, female respondents only gave a fairly good score for the space utilization aspect, while other aspects were still considered less than optimal. Based on the evaluation results, public appreciation for the miniature garden model in a small pot decreased from the second to the third evaluation. In the second evaluation, the pot size-to-plant ratio and space utilization ratio each scored 2.0, while the harmony of the plant combination scored 1.9 and the overall beauty of the garden scored 2.1. However, in the third evaluation, all scores decreased, to 1.7 for the pot size and space utilization aspect, 1.8 for the harmony of the plant combination, and 1.9 for the overall beauty of the garden.

The high scores in the second evaluation indicate that the miniature garden model in a small pot initially had quite good visual appeal. This is due to the contrasting shapes and colors of each constituent plant, creating an attractive garden composition. The pacing plant provides aesthetic value through its distinctive stem shape and spirostratus leaf arrangement, while the ki tolod enhances the garden's beauty through its leaves and flowers, which appear almost year-round. Meanwhile, the muscle leaf adds visual variation through its broad, purplish-green leaves. The combination of the shapes and colors of these three plants creates a harmonious visual contrast, enhancing public appreciation of this miniature garden model. The diversity of plant characteristics was a key factor influencing the garden's aesthetic value in the second evaluation.

However, in the third evaluation, the condition of the constituent plants was no longer as good as before, influencing respondents' assessments. One of the pacing plant's branches, which had previously grown three branches, suffered from drought and had to be pruned, leaving only two branches. Furthermore, the number of ki tolod and muscle leaf plants also decreased due to suboptimal growth, and some plants died. These conditions made the garden less attractive than in the previous evaluation.

This phenomenon indicates that the beauty of the miniature garden reached its peak during the second evaluation, while during the third evaluation, several plants began to experience a decline in growth quality due to age and environmental conditions. The decline in the condition of the constituent plants directly impacts the overall visual quality of the miniature garden. The rise and fall of aesthetic value across the four assessment

criteria is strongly influenced by the growth of the constituent plants. Plants can grow less than optimally or even die if the environmental conditions do not meet their needs. Planting multiple types of plants in one pot can also lead to competition for nutrients and sunlight. Plants that lose out in this competition will experience stunted growth, while other plants become more dominant.

Competition between plants in a single pot is one of the main risks in creating a miniature garden. Competition for nutrients means that available nutrients must be shared among all the constituent plants, resulting in less than optimal plant growth. Furthermore, competition for light can occur when one plant shades another, disrupting growth [28], [29]. Maintenance also plays a crucial role in maintaining the quality of a miniature garden. Optimal plant growth will be hampered if watering, fertilizing, and pruning are not carried out properly. Both excess and insufficient water can negatively impact plants. During the planting period, some plants, such as the pacing and muscle leaf, exhibited yellowing and drying, suspected to be caused by excess watering due to high rainfall.

In addition to watering, fertilization is also crucial for maintaining plant growth [30], [31]. Even if organic fertilizer is used during the planting period, the available nutrients may not be sufficient to meet the needs of several types of plants in a single pot. This condition is evident in less than optimal plant growth, such as a lack of flowers and fruit, and less lush foliage. Regular pruning is also necessary to maintain plant health and maintain the attractive appearance of the garden. Pruning removes old leaves, wilted or dead branches, and overgrown plant parts to create a more compact and tidy appearance. Care taken from the early stages of plant growth will facilitate the creation of a miniature garden that matches your desired design.

The research results show that local Indonesian medicinal plants have high aesthetic potential for development as components of miniature potted gardens. The beauty of plants is evident not only in their flowers, but also in their branching structure, leaf shape, leaf color, and diverse fruit shapes. This demonstrates that medicinal plants can serve a dual purpose: as functional plants for health and as decorative elements in landscape design. The diversity of plant morphological characteristics creates attractive visual combinations, thereby enhancing the aesthetic value of limited spaces, particularly in urban environments with limited green space [16], [32].

The architectural character of plants is an important factor in determining the visual quality of miniature gardens [33], [34]. Neat branching, harmonious leaf arrangement, and variations in leaf color and texture create a more dynamic and balanced garden composition. This research indicates that plants with unique leaf characteristics tend to attract more attention than plants that rely solely on seasonal flowers. This suggests that vegetative elements such as leaves and branches play a significant role in maintaining the beauty of a garden over time, especially in miniature garden concepts that prioritize long-term aesthetics and ease of maintenance.

In addition to visual aspects, this research also indicates that the choice of pot size and combination of plant types significantly influence the level of public appreciation of miniature gardens. The garden model with medium-sized pots received the best rating because it achieved a good balance between plant size, space utilization, and harmonious plant composition. The less dense composition provides sufficient growing space for the plants while creating a more proportional appearance. Conversely, gardens with large pots tend to appear unbalanced when plants grow too tall, while small pots face the challenge of competition for growth between taller plants.

The change in public appreciation of miniature gardens at each evaluation stage demonstrates that garden aesthetics are dynamic and influenced by the evolving conditions of the plants [35], [36]. Plant growth, flower emergence, changes in crown shape, and even plant health directly influence public perception. This demonstrates that the success of a miniature garden is determined not only by the initial design but also by ongoing maintenance. Activities such as pruning, watering, replacing plants, and adjusting the direction of plant growth are crucial in maintaining the aesthetic quality of a miniature garden.

The use of medicinal plants as elements of miniature gardens also has educational and conservation value. The public not only benefits visually from the garden but also learns about local medicinal plants and their benefits [37], [38]. This can raise public awareness of the importance of preserving Indonesian medicinal plants amidst increasing urbanization and changing modern lifestyles. Thus, a miniature garden based on medicinal plants can be a simple conservation tool that supports the preservation of local biodiversity while strengthening the cultural identity of the community.

The impact of this research is a significant contribution to the development of landscape concepts based on local Indonesian plants. The results can serve as a reference for park managers, landscape architects, and the community in designing aesthetic, educational, and functional green spaces on limited land [39], [40]. Furthermore, this research also opens up opportunities for developing medicinal plants as ornamental plants with high economic value. Academically, this research enriches the study of the relationship between plant architecture, landscape aesthetics, and public perception in miniature garden design based on local plant conservation.

However, this study still has several limitations. The study was conducted only on the medicinal plant collection at the Purwodadi Botanical Garden, so the results may not necessarily represent the full character of

Indonesian medicinal plants. Furthermore, public aesthetic assessments are subjective, so the results may be influenced by the experience, knowledge, and preferences of each respondent. This study also did not examine in-depth aspects of long-term sustainability, such as plant resilience in various environmental conditions or the efficiency of miniature garden maintenance over time. Therefore, further research is needed involving more types of plants, variations in landscape design, and a broader quantitative approach to obtain a more comprehensive understanding of the development of mini gardens based on local medicinal plants.

4. CONCLUSION

Based on the research results, it is known that several endemic medicinal plants have quite high aesthetic value in various parts of the plant. In terms of branching, medicinal plants that are considered to have beauty are cat's whiskers, lempeni, pandan betawi, keci beling, cumin leaves, pacing, poncosudo, sambiloto, and landep. The beauty of these plant branches is considered to be able to provide visual appeal so that it has the potential to be used as a component of a mini garden in a pot. In terms of leaves, medicinal plants that have aesthetic value include purple leaves, nampu, keci beling, pandan betawi, nerve leaves, muscle leaves, fragrant pandan, cumin leaves, dlingo, lempeni, pacing, cat's whiskers, poncosudo, ki tolod, sambiloto, and katu. The beauty of the leaves is influenced by variations in shape, color, texture, and interesting leaf arrangement so that it can increase the visual value of the mini garden. Meanwhile, medicinal plants with aesthetic value in their flowers include landep, poncosudo, kumis kucing, pacing, keci beling, ki tolod, manukan, lempeni, katu, kayu ules, and sambiloto. The beauty of these flowers is demonstrated through their shape, color, size, and arrangement, which create a contrasting effect and enrich the garden's appearance.

Regarding fruit, medicinal plants considered aesthetically valuable are kayu ules, lempeni, katu, and pacing, primarily due to their attractive fruit shape and color. Research also indicates that medicinal plants have considerable potential to be developed as components of miniature potted gardens. This potential is evident in the high public appreciation of the miniature garden models that have been created. However, this level of public appreciation can change over time. For miniature gardens in large and medium pots, public appreciation tends to increase, while for miniature gardens in small pots, appreciation decreases due to changes in the condition of the constituent plants. The overall beauty of a miniature potted garden is influenced by several important factors: the appropriateness of the plant size to the pot size, the harmony of the combination and variety of the constituent plants, and the optimal use of space in the pot. In addition, the time factor also influences the level of beauty of a miniature garden because the growth, development, and condition of the constituent plants can change as the plants age and the environmental conditions in which they grow. Future research is recommended to examine more local medicinal plant species with different landscape design variations to develop more innovative miniature garden models that are adaptive to various environmental conditions. Furthermore, further research should include a broader quantitative analysis of community preferences and the sustainability of miniature garden maintenance to optimize their aesthetic, educational, and conservation benefits.

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AUTHOR CONTRIBUTIONS

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CONFLICTS OF INTEREST

The authors declare no conflict of interest.

USE OF ARTIFICIAL INTELLIGENCE (AI)-ASSISTED TECHNOLOGY

Not applicable.

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