

Biophilic design patterns and local knowledge of plants application in Baba-Nyonya heritage shophouses' courtyard

Azizi Bahauddin^{1*}, Rani Prihatmanti², Josephine Ong³

^{1,3} Interior Architecture Programme, School of Housing, Building and Planning, Universiti Sains Malaysia, Penang, Malaysia

² Interior Architecture Department, School of Creative Industry, Universitas Ciputra Surabaya, Indonesia



ARTICLE INFO	ABSTRACT
<p><i>Article history:</i> Received November 29, 2020 Received in revised form Dec. 06, 2020 Accepted January 21, 2021 Available online August 01, 2021</p> <p><i>Keywords:</i> Baba-nyonya heritage shophouses Biophilic design patterns Courtyard Local knowledge Local plants</p> <p>*Corresponding author: Azizi Bahauddin Interior Architecture Programme, School of Housing, Building and Planning Universiti Sains Malaysia Email: azizigt@gmail.com ORCID: https://orcid.org/0000-0002-0050-7499</p>	<p><i>Biophilic design is a well-known design philosophy based on human-nature relationships. However, it has not been explored extensively in the Malaysian context and most of the previous studies were based on plants which were not suitable for tropical climate. This paper analyses the application of biophilic design and the usage of local edible and medicinal plants in Baba-Nyonya heritage shophouses' courtyards in George Town UNESCO World Heritage Site, Penang, Malaysia. The aim of this research is to enhance the human quality of life through biophilic design with local knowledge application in the urban setting. Qualitative method strategies were applied to collect the data: photographic survey, plant inventory and building observation. Three heritage shophouses that had been adaptively reused into contemporary cafes were selected for this study. Significant results showed that Biophilic Design Pattern under the 'visual connection with nature (PI)' has been achieved through the application of edible and medicinal plants. Unfortunately, the local knowledge for applying edible and medicinal plants for achieving biophilic design compliance is weak. In the future, a further study is needed to identify the species of local edible and medicinal plants which can be applied in the Baba-Nyonya heritage shophouses courtyards.</i></p>

Introduction

Recently, most of the traditional Baba-Nyonya shophouses in the UNESCO World Heritage Site (WHS) in George Town, Penang are being altered and refurbished to suit new purposes of the exterior and the interior of these properties. Courtyard, which is located at the centre of the shophouse, could be considered as the 'heart' of the building due to its cultural, climatic, and psychological significances. It is a multi-purpose semi-outdoor space where the daylight can penetrate and exposed to the outdoor air. Despite of its long and narrow rectangular form, shophouses were purposely built to be

climatically comfortable with the presence of the courtyard. However, the current usage of air conditioner has altered the original courtyard purposes. Furthermore, the opening on top of the courtyard was intentionally covered with the translucent polycarbonate sheet to prevent the cool air dissipating from the building, to prevent the rainwater from entering the building, and as a safety measure. By covering the courtyard's opening, shophouse has become a tight building. According to (Burchett, Torpy, and Tarran 2008), human spend 90% of the time in indoor built environment. Indoor air quality has become more polluted compared to the outdoor air. Moreover, a building that has undergone changes from its

original purpose could create a problematic condition to the building occupants. This condition will reduce the building occupants' well-being and their productivities due to the poor quality of the indoor environment, particularly the indoor air (Prihatmanti and Bahauddin 2014). Piko (2006) also agreed that the indoor environment is an essential determinant of human well-being. Therefore, human well-being is a concern in the indoor environment of these heritage shophouses.

There is sufficient evidence being highlighted focusing on the visual connection with indoor plants promoting a better health psychologically, physiologically, and cognitively. The relationship between human and nature is crucial to re-establish a built environment that is conducive to the human health; known as 'biophilic design' (Kellert 2008). Apparently, the previous studies were based only on ornamental plants and conducted in contemporary buildings: in a greenhouse (Lee et al. 2015), in an indoor office (Jumeno and Matsumoto 2015), in a reverberation chamber of a university (Asdrubali et al. 2014; D'Alessandro, Asdrubali, and Mencarelli 2015), and many others. In Malaysia, the use of Malay local knowledge in edible and medicinal plants can be found in villages and smaller rural towns. Nevertheless, there are limited studies conducted regarding planting edible and medicinal plants in Baba-Nyonya heritage shophouses, namely the courtyard areas. With exposures to daylight and outdoor air, this area has potential to be an indoor green space that is integrated with the building. Having greeneries in the building will be beneficial to the occupants. Therefore, the aim of this paper is to examine the application of local edible and medicinal plants based on the Biophilic Design Patterns and Baba-Nyonya local knowledge in heritage shophouses' courtyards.

Humans are biologically well adapted to the natural environment and obtain basic physical and emotional needs from the natural environment that is essential for human survival and well-being. Humans also depend on nature to seek protection from predators, weather, and nutritional food sources (Orians and Heerwagen 1992); and their behaviours evolved and shaped through their natural environment. The concept of 'biophilia' describes humans to having innate tendency to focus on life and life-like processes (Wilson 1984); strengthened by the local knowledge understanding in a concept of claiming that humans need nature at physical

level for spiritual, aesthetical, intellectual, and cultural needs.

Biophilic design definition

The Biophilic Design contains the 'organic or naturalistic' and the 'place-based or vernacular' dimensions (Karima, Firzal, and Faisal 2020). The organic dimension is defined as the forms and shapes in the built-up environment that directly, indirectly, and symbolically reflect human innate attraction by nature (Widodo 2019). On the other hand, 'vernacular dimension' refers to the built environment that is reflecting the culture and ecology of a locality or geographic area. Kellert (2008) implementing biophilia concept into the design of built environment in order to re-join the relationships between human and nature is known as Biophilic Design. Ryan et al. (2014) established the 14 Biophilic Design Patterns and categorised it into three: Nature in the space, natural analog, and nature of the space (table 1).

Table 1. The 14 biophilic design patterns

Categories	Biophilic Design Patterns
Nature in the Space	P1. Visual Connection with Nature
	P2. Non-Visual Connection with Nature
	P3. Non-Rhythmic Sensory Stimuli
	P4. Thermal and Airflow Variability
	P5. Presence of Water
	P6. Dynamic & Diffuse Light
	P7. Connection with Natural System
Natural Analogs	P8. Biomorphic Forms and Patterns
	P9. Material Connection with Nature
	P10. Complexity and Order
Nature of the Space	P11. Prospect
	P12. Refuge
	P13. Mystery
	P14. Risk/Peril

Source: (Ryan et al. 2014)

There were a number of studies proving that the presence of nature in built environment can enrich human well-being such as in reducing stress (Bringslimark, Hartig, and Patil 2007; Ulrich et al. 1991); improving cognition (Lohr 2010); positive mood and task performance (Shibata and Suzuki 2004; Larsen et al. 1998) and reducing discomfort symptoms such as coughing, dry skin, and eye irritation (Fjeld and Bonnevie 2002). Ryan et al. (2014) stated that Biophilic Design Pattern 1 (P1) which is the 'visual connection with nature' refers to human sight connection with natural elements application such as foliage plants, flowers, water feature, and animals in man-made environment. Thus, plants are continuously brought into the indoor

environments in private and commercial spaces for their aesthetics and cultural values, edibility and medicinal purposes.

Baba-Nyonya local knowledge

Based on the Baba-Nyonya local knowledge, plants are used as natural resources for food and beverages, flavourings, medicine and poison, essential oils, aromatherapy, and ritual and ceremonial materials (Samy, Sugumaran, and Lee 2014; Leipzig 1996). The usage of a wide variety of edible plants in Malaysia were recorded among the indigenous people of Peninsular Malaysia (C. H., A., and M. 2012). Today, the local knowledge of edible native plants is still being applied by urban people in their compounds such as courtyard, balcony, and indoor kitchen (Salleh, Rashid, and Sakip 2016; Milow et al. 2014; C. H., A., and M. 2012). According to Prihatmanti and Taib (2018), growing plants in the semi-outdoor space is possible to be conducted due to its climatic condition. In a semi-outdoor environment, the daylight intensity is significantly reduced compare to the outdoor environment. Daylight is essential for the metabolic process of plants which will affect the growth performance. Therefore, shade-loving plants are suitable to be grown in place with limited amount of daylight.

Baba-Nyonya heritage shophouse courtyard

A good biophilic design should fulfil two main dimensions, the 'organic or naturalistic' and the 'place-based or vernacular' dimensions. Hence, this study focuses only on the local edible and medicinal plants application in heritage shophouses especially in the central courtyard area. In general, shophouse can be defined as a multifunctional deep rectangular urban building, with a shop or business on the ground floor and residential on the above. It could be one or more shops in a single building (figure 1) (Wooi 2015). Shophouses are normally built-in rows with interconnecting walkway on the front, known as the 'kaki lima' or five-foot walkway. The façade is narrow, around six to seven metres wide, but it could reach up to thirty metres in length (Ahmad 1994). Due to its length, each shophouses is equipped with air-well or courtyard to control the microclimate in the building and to illuminate the interior. Courtyard is also used as a thermal barrier and for acoustic and visual privacy (Sthapak and Bandyopadhyay 2014). Traditionally, there are three important known

implications in a courtyard namely the cultural, climatological, and psychological implications.

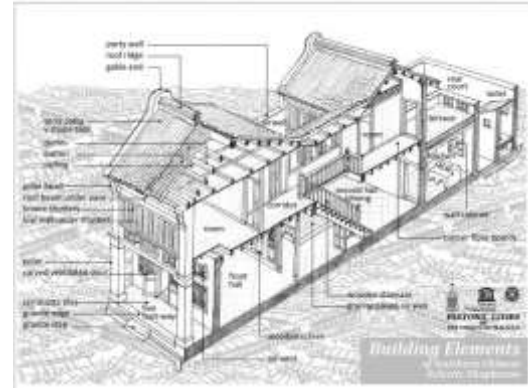


Figure 1. Axonometric view of traditional Penang shophouse

Source: (Wooi 2015)

Cultural implications

According to Knapp, Ong, and Wang (2010), courtyard (figure 2) is an architectural component that suits the local culture as well as the local society. In addition, the main courtyard is usually for family members private use only (GTWHI 2017b). Unfortunately, after George Town has been listed as the UNESCO World Heritage Site (WHS) in 2008, most of the shophouses courtyards had been altered from private into public spaces for commercial purposes. These changes could affect the authenticity of the sites and the Outstanding Universal Value (OUV) if too many unmonitored alterations being undertaken and neglecting the conservation guidelines.

Climatological implications

Courtyard, or air-well, is one of the most significant architectural features in traditional shophouse. It was designed to be fully open to the sky as a passive cooling system in the centre of the narrow and deep rear of the traditional shophouse without relying on the air conditioning system. It is a cooling source for the surrounding area of the shophouse. According to Zakaria, Kubota, and Toe (2015), the indoor temperature in the living hall and the bedroom on the first floor are 0.3-1.7°C lower than the outdoor air during daytime. The prevailing wind speed relatively increased during the daytime; therefore, the ventilation rate is high from both courtyards. Moreover, cross-ventilation occurred from the rear courtyard to the front courtyard. This will

enhance the cooling effect, particularly on the ground floor. In contrary, the indoor air temperature during the night-time were 0.8-1.9°C higher than the outdoor

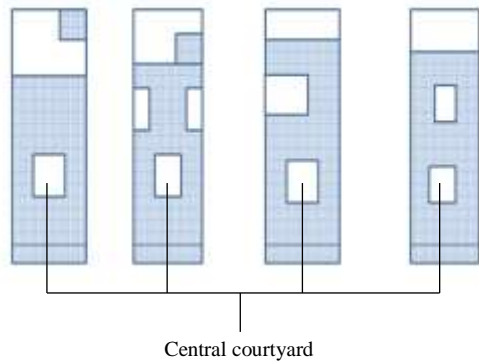


Figure 2. Central courtyard layout on different shophouse typology
Source: (GTWHI 2017a)

Plants and water elements are usually placed in the courtyard which help to increase the humidity and enhance the level of thermal comfort in tropical climate. However, since the mean air temperature has increased by 0.25°C per decade in the Peninsular Malaysia (NRE 2015), air conditioning system is commonly installed in the shophouses to achieve a thermally comfortable indoor environment. Tang (2019) also reported, extreme rainfalls and wind also increased for the past three decades. These conditions have initiated the shophouses owners to cover their courtyards with polycarbonate roofing to keep the courtyards dry. Other reasons include to prevent the droppings of foreign objects and to avoid the dissipating of cool air from the air conditioner system installed.

Psychological implications

Beside cultural and climatological implications, courtyard also has the psychological implications towards the occupants. Courtyard is known to provide a sense of enclosure and privacy to the residents who lived in there. It is visually obstructed by a full-height wooden screen (divider) from main entrance (Sthapak and Bandyopadhyay 2014). In the other hand,

courtyard also acts as a noise absorber within the shophouse and noise barrier from outdoor. This creates a safe, quiet and private feeling for the shophouse residents. Recently, in most shophouses courtyard in George Town, it becomes an enclosed indoor public space such as café, bar, and souvenir corner.

Method

To obtain the objective, this study was carried out in the Core Zone in the UNESCO World Heritage Site (WHS) George Town, which focuses only in the Special Zone. According to the Special Area Plan, this zone is considered special because it has the strictest form of land use control. It also contains a complex layering of cultural, socio-economic, religious, and residential morphologies (Penang State Government 2016). Within this area, there are many significant cultural sites and buildings which are listed under Category I building. Those are the buildings that are more than 50 years and officially listed in the National Heritage Act 2005, including the heritage shophouses. Most of these buildings are well-kept and lived-in by multi-cultural residents. Contemporary café is selected as case studies in this research due to their potential of using edible plants in their food menus. These cafés served fusion Malay and/or Baba-Nyonya cuisines and Western foods with local influences. The selection of the case studies was based on these criteria: (i) located in the Special Zone of the UNESCO World Heritage Site, (ii) part of heritage shophouses, (iii) the courtyards were still intact and not covered with polycarbonate sheets. Based on the criteria stipulated, there were three cafés for the study. Those are the Edelweiss Café, Armenian House Café, and Art of Dragon Gallery which were located within one area (figure 3). Qualitative method was used to examine and analyse the indoor plants application in shophouse courtyards using architectural observation and documentation, plant inventory and identification of the species, and followed by descriptive analysis.



Figure 3. Location of the selected case studies

Result and discussion

Edelweiss café

Edelweiss café is a European café in a 'Southern Chinese' Eclectic Style. The building was built between the year 1840 until 1910 (figure 4a). The courtyard was well maintained and converted as a semi-outdoor dining area. The opening of the courtyard remained uncovered to allow the natural daylighting, air ventilation, and rainwater to penetrate the courtyard. Due to the security issue, metal grill was installed on the opening (figure 4b, 4c). The natural daylighting in the courtyard brought in positive effects towards human's health, satisfaction, attention, and performance (Edwards and Torcellini 2002; Gray and Birrell 2014). It showed Biophilic Design Pattern (P6) was achieved in the courtyard. The presence of natural air ventilation in the café allowed a breezing air movement in the courtyard for a better human comfort. This has achieved the Biophilic Design Pattern (P4). On the other hand, natural materials (P9) such as wood features could be found in the courtyard. The differences in wood features and colour tones created the feeling of balance, harmony and simplicity; and it brought positive effects on human comfort and relaxation (Nyrud and Bringslimark 2010; Ikei,

Song, and Miyazaki 2017; Tsunetsugu, Miyazaki, and Sato 2007; Kelz, Grote, and Moser 2011).



Figure 4. The façade and courtyard of Edelweiss café

Table 2. Types of plants in Edelweiss café

Scientific name	Common name	Usage	Biophilic design patterns
<i>A. 'Dud Unyamane'</i>	Chinese evergreens	Ornamental ¹	(P1) achieved
<i>A. commutatum</i>	Chinese evergreens	Ornamental ¹	(P1) achieved
<i>A. nidus</i>	Bird's nest fern	Ornamental ¹	(P1) achieved
<i>S. podophyllum</i>	Arrowhead plant	Ornamental, air purifier ^{1,2}	(P1) achieved
<i>Neoregelia sp.</i>	Blushing bromeliad	Ornamental ¹	(P1) achieved
<i>L. chinensis</i>	Chinese fan palm	Ornamental ¹	(P1) achieved
<i>C. lutescens</i>	Golden cane palm, Areca palm.	Ornamental, toxic gas removal, air purifier ^{1,2}	(P1) achieved

Scientific name	Common name	Usage	Biophilic design patterns
	Yellow palm		

Source: (National Parks Board 2020¹, Wolverton 1996)²

Potted plants were also found in the courtyard with the listed of plants (table 2). The indoor plants were pure ornamental foliage plants without medicinal properties of *Aglaonema 'Dud Unyamane'* (Chinese evergreen), *Aglaonema commutatum* (Chinese evergreen), *Asplenium nidus* (Bird's nest fern), *Syngonium podophyllum* (Arrowhead plant), *Neoregelia sp.* (Blushing bromeliad), *Livistona chinensis* (Chinese fan palm), and *Chrysalidocarpus lutescens* (Golden cane palm) (National Parks Board 2020). According to Wolverton (1996), *S. podophyllum* and *C. lutescens* could act as air purifiers. The latter is effective in removing toxic gas. The presence of indoor ornamental foliage plants is merely as aesthetics to beautify the courtyard environment. The patrons were able to visually access the courtyard with relaxing and calming feeling while enhancing their biophilia experience (P1). According to Asdrubali et al. (2014) and Wolverton (1996), plants can act as sound absorbers.

Armenian house café

Armenian house café is categorised as the 'early straits' eclectic style shophouse that was built between 1890s-1920s. This shophouse was influenced by the European architecture style seen in the pilasters and other façade architectural details (figure 5a).



Figure 5. Façade and courtyard of Armenian house café

The courtyard was not covered in order to maximise the air circulation (P4) and the amount of natural daylighting penetration (P6). Water

feature was available at the centre of the courtyard in the form of granite millstone water fountain and a mini pond made from clay vase. In Biophilic Design the presence of water (P5) created a tranquil and restoring environment through visual and auditory sound (P2) (White et al. 2010). The potted plants grown were ornamental foliage plants with Biophilic Design Pattern (P1) (figure 5b) and without local edible and/or medicinal plants. Those were *Chlorophytum comosum* (Spider plant), *Dracaena fragrans* (Dracaena 'corn plant'), *Echinodorus palaeifolius* (Mexican sword plant), *Epipremnum aureum* (money plant), *Sansevieria trifasciata var. laurentii* (Mother-in-law's tongue), *Nephrolepis exaltata* (Boston fern), and *Dracaena reflexa* (Song of India) (table 3). According to Wolverton (1996) and (National Parks Board 2020), *C. comosum*, *D. fragrans*, *E. aureum*, *S. trifasciata var. laurentii*, and *D. reflexa* are recommended to be placed in an indoor environment to purify the air. Boston fern or *N. exaltata* is also an air purifier as well as a noise absorber (Wolverton 1996; Asdrubali et al. 2014). *E. palaeifolius* is neither the purifier nor noise absorber. In addition, the usage of timber elements in wooden blinds and wooden balusters were seen surrounding the courtyard (P9).

Table 3. Types of plants in Armenian house café

Scientific name	Common name	Usage	Biophilic design patterns
<i>C. comosum</i>	Spider plant	Ornamental, Air purifier ¹	(P1) achieved
<i>D. fragrans</i>	Dracaena corn plant	Ornamental, Air purifier ¹	(P1) achieved
<i>E. palaeifolius</i>	Mexican sword plant	Ornamental ³	(P1) achieved
<i>E. aureum</i>	Golden pothos, Money plant	Ornamental, Air purifier ¹	(P1) achieved
<i>S. trifasciata var. laurentii</i>	Snake plant, Mother-in-law's tongue	Ornamental, Air purifier ¹	(P1) achieved
<i>N. exaltata</i>	Boston fern	Ornamental, air purifier, noise absorber ^{1,2}	(P1) achieved
<i>D. reflexa</i>	Song of India	Ornamental, air purifier ¹	(P1) achieved

Source: (Wolverton 1996¹; Asdrubali et al. 2014²; National Parks Board 2020)³

Art of Dragon gallery

This café is situated within a row of 'Southern Chinese' Eclectic Style shophouses. This building was built between the year 1840 until 1910.

Compare to the previous case study, this café had a minimum conservation work. This could be seen from the condition of the façade and the courtyard (figure 6a-c). In this café, the courtyard remained not covered; therefore, the daylight, outdoor air, and rainwater could penetrate the courtyard naturally (figure 6c). Thus, Biophilic Design Patterns Thermal and Airflow Variability (P4), and Dynamic and Diffuse Light (P6) were achieved coupled with a mini portable water cascade in the courtyard (P5). The courtyard had a combination of ornamental foliage, artificial, and edible plants (P1) (table 4). The indoor plants observed in the courtyard were a combination of life and artificial plants (figure 6b, c). The plants were grown in pots for easy maintenance and cost-saving. The life plants were *Pandanus amaryllifolius* (Pandan leaf), *S. podophyllum* (Arrowhead plant), and one unidentified ornamental plant. There were also artificial plants in the courtyard that looked like water lily in pond and creepers on the wall. Based on the information given by the proprietor, *P. amaryllifolius* was purposely grown as an ingredient for their signature beverage; and for colouring and flavouring of desserts and cakes and having medicinal properties (Nor et al. 2008). It is proven as a natural pest repellent, anti-virus, antioxidant, anti-diabetic, anti-hyperglycaemic, and anti-rheumatism (National Parks Board 2020; Saenthaweek, Naowaboot, and Somparn 2016). Hence, this plant was not only contributed to Biophilic Design Pattern (P1), but also Biophilic Design Pattern (P2) through other human senses of smell, touch and taste.



Figure 6. Façade and courtyard of Art of Dragon gallery

Table 4. Types of plants in Art of Dragon gallery

Scientific name	Common name	Usage	Biophilic design patterns
<i>P. amaryllifolius</i>	Pandan leaf	Food colour, fragrance, medicinal ²	a. (P1) achieved. b. (P2) achieved.
<i>S. podophyllum</i>	Arrowhead plant	Ornamental, air purifier ¹	(P1) achieved
<i>Nymphaeaceae</i>	Water lilies	Medicinal, ornamental, ritual and ceremony material ^{3,4}	(P1) achieved
<i>E. aureum</i>	Golden pothos, Money plant	Ornamental, air purifier ¹	(P1) achieved
<i>S. trifasciata var. laurentii</i>	Snake plant, Mother-in-law's tongue	Ornamental, air purifier ¹	(P1) achieved
<i>N. exaltata</i>	Boston fern	Ornamental, air purifier, noise absorber ^{1,2}	(P1) achieved
<i>D. reflexa</i>	Song of India	Ornamental, air purifier ¹	(P1) achieved

Source: (Wolverton 1996¹; Nor et al. 2008²; De Carvalho 2011³; Singh and Jain 2017)⁴

Conclusion

There were six types of Biophilic Design Patterns found in the case studies. With the combination of Biophilic Design Pattern (P4) and (P6), it enabled the indoor plants to be grown well in the courtyards. Most of these plants served for ornamental purposes to beautify the indoor environment and to flourish human well-being through visual connection with nature (P1). Seven out of fifteen life indoor plants functioned as indoor air purifiers. Only *P. amaryllifolius*, or pandan leaf, was edible, grown in courtyards of the cafés; and categorised as herb. It could be concluded that the presence of local knowledge of edible plants in heritage shophouse courtyard was not extensive. In Malaysia, the sun shines throughout the year allowing the planting of edible and medicinal plants. Moreover, the climatic condition in the courtyards of the chosen Baba-Nyonya heritage shophouses were suitable for the semi-outdoor and indoor plants. Hence, the courtyards could become the alternative green spaces integrating with the buildings. Growing plants on the five-foot walkway is discouraged by the local authority since it will obstruct public activities and circulation. By having plants in the building, the regularity of maintenance needs to

be considered to obtain the maximum benefits from the plants. In-depth study on the Baba-Nyonya local knowledge of edible and medicinal plants suitable for the indoor and semi-outdoor environments is further required. These plants are important to enhance human well-being in indoor environment, to improve the indoor air quality, as well as to provide herbs, foods, and traditional medicine at domestic level.

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Author(s) contribution

Azizi Bahauddin contributed to the research concepts preparation, methodologies, investigations, data analysis, visualization, articles drafting and revisions.

Rani Prihatmanti contribute to methodology, supervision, and validation.

Josphine Ong contribute to methodology, supervision, and validation.