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EKOLOGI, HABITAT MANUSIA & PERUBAHAN PERSEKITARAN DI ALAM MELAYU

EHMAP-11

27-28 Julai 2023

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Penyunting:

Razanah Ramya
Deni Efizon
Muhamad Shafiq Mohd Ali

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KANDUNGAN

PRAKATA

Dengan nama Allah yang Maha Pengasih Lagi Maha Penyayang

Alhamdulillah, syukur ke hadrat Ilahi serta berkat junjungan besar Nabi Muhammad S.A.W, Seminar Antarabangsa kali ke-11 Ekologi, Habitat Manusia & Perubahan Persekitaran di Alam Melayu (EHMAP 11) yang bertemakan "Ke arah Pembangunan Anjakan Paradigma Dalam Bidang Ekologi, Habitat Manusia & Perubahan Persekitaran di Alam Melayu" yang diadakan pada 27 dan 28 Julai 2023 bertempat di AnCasa Residences, Port Dickson, Malaysia. Seminar EHMAP 11 merupakan kerjasama antara Institut Alam dan Tamadun Melayu, Universiti Kebangsaan Malaysia (UKM) dengan Fakultas Perikanan dan Ilmu Kelautan, Universitas Riau (UNRI), Indonesia. Sejarah kembali tersingkap apabila pihak UKM dan UNRI memperkukuhkan jalinan kerjasama ini melalui Pemeteraian Memorandum Perjanjian Persefahaman (MOA) Bersama.

Perubahan dan tekanan yang berlaku terhadap ekologi dan habitat manusia memberi kesan bukan sahaja kepada pertumbuhan dan perkembangan habitat manusia malahan boleh mengancam kemapanan ekologi dan kualiti hidup yang memerlukan pendekatan multidisplin dan transdisiplin. Justeru itu, tujuan seminar ini adalah menyediakan sebuah platform perkongsian oleh ahli-ahli pemikir dan penyelidik sama ada sebagai ahli akademik, pembuat dasar dan orang awam untuk mencerakinkan penelitian di peringkat tempatan dan hubungan rentas sempadan Alam Melayu serta mengetengahkan isu dan cabaran semasa mengenai habitat semula jadi, habitat manusia dan perubahan persekitaran yang merangkumi pelbagai aspek multidisplin. Hal ini telah diterjemahkan melalui skop bidang yang bukan sahaja terhad kepada kemapanan ekologi dan perubahan persekitaran, habitat manusia dan impak terhadap persekitaran, impak pencemaran terhadap ekologi dan habitat manusia, perubahan persekitaran, arkeologi, sejarah dan budaya dan pelancongan dan warisan malahan telah diperluas kepada bidang etnobotani, petunjuk ekologi dan perikanan dan alam semula jadi.

Akhir kalam, Seminar EHMAP 11 pada kali ini bukanlah titik pengakhiran bagi ahli akademik dan penyelidik bertemu dan berkongsi hasil penyelidikan masing-masing. Namun, ia akan menjadi titik tolak dalam menghubungkan jaringan penyelidikan terutamanya di alam Melayu ini.

Kalau ada sumur di ladang,
Boleh kami menumpang mandi,
Kalau ada umur yang panjang,
Boleh kita berjumpa lagi.

Sekian, salam hormat.

Razanah Ramya
Ketua Editor
Julai 2023

THE USE OF MALAY CULTURAL ETHNOBOTANY AS NATURAL COLOURANTS IN ECO-FRIENDLY DYEING

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ABSTRACT

Since ancient times, natural dyes have been used for the colouration of food products, cosmetics, textiles, and pharmaceuticals. The current ‘back to nature’ trend has served to raise the value and popularity of natural-plant-based dyes. The benefits that come with the use of natural and organic products include that they are environmentally friendly, sustainable, and safe to use. The health and environmental benefits as well as practicality of natural dyes render them significantly more advantageous than synthetic colourants. In the food industry, natural colourants are used to enhance the appearance of products, provide consistent colour, and replace synthetic colourants, which may have adverse health effects. In terms of the cosmetics industry, in order to avoid the harmful effects of harsh chemicals associated with synthetic colourants, natural colourants are preferred for the creation of shades of makeup, hair dyes, and personal care products. Natural colourants are used in the pharmaceutical industry to colour medications so that they are more easily identified and differentiated. In the context of the textile industry, natural colourants are used for the creation of environmentally friendly clothing dyes. This paper explores the various plant-based pigments that the Malay community uses as natural dye colourants. Annatto *(Bixa orellana)*, henna *(Lawsonia enermis)*, mangosteen *(Garcinia mangostana)*, betel nut *(Areca catechu)*, red pitaya *(Hylocereus polyhizus)*, *mengkudu (Morinda citrifolia)*, butterfly pea flower *(Clitoria ternatea)*, and sappan wood *(Caesalpinia sappan)* are some of the many plants from which natural colourants can be derived. Generally, the choice of natural colourants over synthetic colourants contributes towards the well-being of the environment and human health.

Keywords: Natural colourants, Malay ethnobotany, Malay cultural heritage, eco-friendly dyeing, environmental sustainability

INTRODUCTION

The current use of more than 100, 000 types of dyes worldwide is, for the most part, associated with the textile industry. According to (Kadhom et al. 2020) an estimated 300000 tonnes of industrial waste are discharged into waterways each year. The long degradation time of synthetic colourants render them significantly hazardous to the environment (Khan et al. 2021). The extensive use of synthetic dyes is attributed to their availability, wide colour range, and practical application process (Pringgenies et al.

2021). The release of wastewater containing substantial amounts of detrimental and non-biodegradable chemical pollutants; such as organic dyes, metal ions, pesticides, and pharmaceuticals; poses a serious threat to the environment, particularly with regards to water bodies. The use of petroleum during the artificial colourants manufacturing process gives rise to the generation of organic components; such as alcohols, ketones, and pyridines. To produce synthetic colourants, organic components are combined with inorganic acids and salts and subjected to a series of chemical reactions; such as halogenation, hydroxylation, nitration, oxidation, and suffocation (Othman et al., 2021). Artificial colour additives not only taste unpleasant but frequently cause health issues; such as allergic and intolerant reactions. Several fatalities stemming from the addition of copper sulphate and lead chromate as artificial colourants for processed foods have also been reported (Ahmad Bhat et al. 2019).

ECO-FRIENDLY DYES

Colour is a phenomenon that has fascinated intellectuals; Aristotle, Plato, Newton, and Leonardo Da Vinci included; for centuries. Light, shade, and colour are the components which enable us to distinguish different objects and the parts making up each of these objects. These three components, which portray our visible environment, come into play during activities such as painting, clothing beautification, and the enhancement of food appearance. Natural colourants were used exclusively in the textile industry until the year 1856, when William Henry Perkin of Britain unintentionally synthesised a purple colourant from aniline, one of the simplest chemical components of coal tar, while attempting to synthesise the anti-malarial drug quinine and realised its potential for the dyeing of silk materials (Openlearn, 2007).

It is anticipated that the arrival of the green technology approach and the practice of sustainable waste management will serve to curb the production and usage of synthetic dyes, which have been linked to health problems and the release of toxins into the environment (Ashokhan et al., 2019). Unlike synthetic dyes, natural colourants are both safe to use and environmentally friendly. Other than the pigment of edible plants, natural colourants are also obtainable from sources which include fungi, algae, cyanobacteria, and insects (Mortensen 2006).

In the food, textile, and pharmaceutical industries, natural colourants derived from plants are growing in popularity as alternatives to synthetic dyes. The value of these natural colourants increases if they also improve health (Dhahri et al., 2019). Natural dyes, which are extracted from plant organs; such as fruits, flowers, leaves, skins, tubers, and rhizomes are used to colour yarns and fabrics as well as cosmetics and food (Rusja et al. 2018). The identification of sources for natural dyes and the conservation of the dye-contributing plant species are essential for ensuring sustainability and reducing the dependence on imported synthetic dyes (Mukhlis, 2011). The rapidly growing need for bioactive compounds generated from plants has prompted researchers to fully utilise *in vitro* plant lines at factories to innovate phytochemical research while ensuring natural biodiversity preservation (Hassan et al., 2018).

MALAY ETHNOBOTANY

Local knowledge is knowledge passed down from one generation to the next by individuals or communities living in the same environment (Esa et al., 2018). Such knowledge is looked upon as information and guidance with regards to a way of life, which represents the uniqueness of an ethnic group (Eizah et al., 2019). Fundamental wisdom is derived from living in sync with nature. It is related to culture in society, which is acquired and passed on. While wisdom can be both conceptual and practical, they stem from information gathered through life experiences (Mungmachon 2012). Each culture has a distinct traditional behaviour, which has evolved and been passed down from generation to generation (Zeyneloğlu & Kısa 2018). Culture, customs, and belief are a system of values associated with the religious rituals, marriage ceremonies, diet and food preparation as well as disease treatments that an individual or group adheres to (Siti Hasmah, 1987). According to Purwanto (1999), plant use, which differs from one community to another, is dependent on the knowledge gained by each community with respects to this issue.

The use of natural dyes has evolved into a colouring process applied by Malay weavers to enhance the attractiveness of a base woven textile, particularly with regards to the *kain limar, cindai*, and *songket*. Other than for its decorative appeal, natural colour is also used for establishing the various hierarchy levels within the Malay social structure (H. Hussin et al. 2009). Generally, knowledge regarding plant use is undocumented and verbally passed down from one generation to the next (Styawan et al. 2016). Attractive colours, readily available from natural flora and wildlife, have revived interest in the use of natural colorations in the textile industry. The main issues hindering the application of traditional dyeing methods are the limited colourants available and the low fastness quality of plant-based dyes (Khan et al. 2021). The Dayak Iban community uses natural dyes acquired mostly from *curculigo latifolia* (lumbah bukit) to colour yarn for weaving and rattan for craft-painting, which are either sold or used for cultural events (Wahdina et al. 2021). The *artocarpus heterophyllus* (jackfruit) leaf extract used in traditional textiles delivers a mid-brown hue to silk thread (Ali & Taif, 2020). Local players in the dyeing industry consider the red colour extract, derived from the seed of *bixa orellana*, most favourable for the dyeing of yarn (Aziz, 2006). Natural dye colours; such as green from *pandan* leaves and yellow from the tuber of c*urcuma longa* (turmeric); are currently used to dye textiles (Faridah 2006). The colour of gambier-based dyes on batik cloth is brown, with varying degrees of saturation depending on the mordant employed. Fabrics treated with mordant lime and iron have significantly higher colour intensity than fabrics treated with mordant alum (Sofyan et al., 2021). Weavers in Sambas and Sintang in West Kalimantan use 36 native plant species; such as *Pychotria megacoma, Symplocos ophirensis, Litsea angulata, Eusideroxylon zwageri*, and *Fibraurea chloroleuca*; to produce dyes (Muflihati et al. 2019). The use of natural dye for traditionally woven fabrics enhances the uniqueness of these fabrics and increases their value, particularly in terms of the international market. Meanwhile, natural colourants sourced from plant species; such as *Oryza sativa, Curcuma xanthorrhiza, Vitex trifolia, Melastoma malabathricum, Psidium guajava, Aloe vera,* and *Cucumis sativus*; are used in the cosmetics, food, and pharmaceutical industries (Styawan et al. 2016).

Developments in the fields of science and technology have led to improvements in terms of the extraction process and colour range of natural colourants. This paper examines plant-based pigments as well as the Malay community's use of natural colourants sourced from various plant species. This research is in line with the Malaysian government's commitment to support the National Biological Biodiversity policy, which aims to raise the sustainability of biological components while minimising the impact of human activities on biological diversity. The 'back to nature' catchphrase of the Malaysian government represents efforts directed at decreasing the level of pollution in the ecosystem. The following are descriptions of selected plant dyes used in traditional Malay ethnobotany.

***Bixa orellana* (Annatto)**

Bixa orellana L., or achiote, is a plant that is native to tropical America and probably originated in Brazil's Amazon region. It is grown extensively in Colombia, Mexico, Ecuador, and the Peruvian Andes as well as in other tropical regions of the world. In previous studies, achiote gathered from 40 different locations in Mexico were subjected to an overall morphological and biochemical characterisation. Experiments were also conducted to establish the bixin content of this plant. A perennial tree, achiote can grow to a height of nine metres. It produces white or pink blooms and ovoid fruit capsules. Each capsule may contain between 30 and 45 cone-shaped seeds encased in a thin reddish-orange layer of viscous aril (Fonnegra & Jimenez, 2007). Native Americans have long been aware of the benefits of using achiote as body and facial paint as well as a natural food colourant. Achiote is also referred to as achiote of the mountain, achioti, bixa, bija bijol, bijo, urucu, onoto, annatto orellana, orlean, pumacua, bicha, caituco, and chacan garicua (Janick, 2012). The crude pigment extract derived from achiote is known as annatto. Annatto contains bixin and norbixin as well as other carotenoids in varying amounts. Norbixin is hydro-soluble while bixin is soluble in fat. Achote is currently regarded among the most appealing plant source for vegetable colourants. This can be attributed to its capacity to deliver a variety of water-soluble colourants depending on the extraction process, solvent, and temperature used (Smith, 2006).

***Lawsonia enermis* (Henna)**

The scientific name for henna is *Lawsonia inermis* L. The Dewan Bahasa dan Pustaka Dictionary (Fourth Edition) defines henna as a small tree with leaves which are used as nail and finger polish. Henna, a herbaceous shrub capable of reaching a height of six meters, is characterised by dicots and produces fruits every alternate year. Henna leaves sprout in pairs on the sides of the trunk and branches. The henna plant matures at the age of two years (Chaudhary et al. 2010). The variety of names referring to henna include camphire (English, King James Version of the Bible) (James, 2008), *henna* and cypress shrub (English), *inai* (Malay), *hana* (Arab), *henne* (Spanish), *hinna* and *panna* (Persian), *kopher* (Hebrew) (James, 2008), *kuravamee* (Telugu), *kurinji* (Tamil), *kypors* (Greek) (Farooqi, 2003), *mhendi* (Hindu, Urdu, Gujarati, and Bengali), *medhika*, *medika*, *dviranta*, and *kokanda* (Sanskrit) (Chaudhary et al. 2010), *pacar jawa* (Indonesia) (Burkill, 1995).

According to the findings of previous studies, the henna plant holds chemical compounds. The *L. inermis* extract contains almost 70 phenolic compounds isolated from the roots, bark, flowers, and leaves of the plant. It has been demonstrated that these substances perform a variety of biological functions (Badoni Semwal et al., 2014). Othman et al. (2020) used an 80:20 ethanol to water ratio solvent formulation to isolate 27 phenolic compounds from henna, including coumarin, flavonoids, naphthalene, and gallic acid. The pharmacological features of the henna plant include anti-inflammatory, antibacterial, antimicrobial, antifungal, antivirus, antiparasitic, antioxidant, antifertility, tuberculostatic, and anticancer (Othman et al., 2020). According to Salleh et al. (2019), the henna plant also has antivirus properties. Upon maturity in the late summer or dry season, thorns begin to sprout on the tips of the henna leaves. Mature henna leaves are dark green interspersed with black dots and typically 40 to 45 seeds in each henna leaf. The flowers of the henna plant come in different colours. White henna flowers, known as alba, are the source for yellow, pink, and red dyes. While both stem cuttings and seeds can be used for henna propagation, they are highly dependent on moisture and can only endure a short spell of extreme dryness (Jain et al. 2010).

Garcinia mangostana **(Mangosteen)**

The mangosteen (G*arcinia mangostana Linn*), known as the ‘queen of fruits’, belongs to the *Clusiaceae* (*Guttifereae*) family. Cultivated mostly in Southeast Asia, tropical Africa, and Central America (Dembitsky et al., 2011), this fruit is made up of a white inner pulp and a purple pericarp. The sweet and juicy pulp can be consumed directly or processed into a slightly acidic tasting and aromatic juice, jam, or syrup (Martin, 1980). More than half the fruit’s weight is made up of the pericarp, which is typically discarded as agricultural waste (Chisté et al. 2010a). The hard fruit peel is used as a natural homemade pigment in the fruit’s native region (Bunsiri et al., 2003). Cyanidin 3-sophoroside and cyanin 3-glucoside are the primary and minor anthocyanin compounds, respectively, which contribute to the purple colour of the mangosteen peel (Du & Francis, 1977). It has been established that the medicinal attributes of anthocyanins include their anti-inflammatory, anti-bacterial, and anti-oxidant effects (Lapidot et al., 1999; Baydar et al., 2004). Anthocyanin consumption is also believed to reduce the risks of coronary heart disease and atherosclerosis (Lapidot et al., 1999). Due to their capacity for scavenging free radicals and combining with metals to form chelates, most of the positive effects associated with anthocyanins can be attributed to their anti-oxidant activity. The nonexistence of toxic effects, with regards to the use of anthocyanin, renders it a good natural colourant option (Chisté et al. 2010b). According to Palapol et al. (2009), anthocyanin concentrations in the mangosteen pericarp ranges from 182.4 to 423.5 mg/100g. Mangosteen’s high anthocyanin content is comparable to several commercial sources of anthocyanin such as grapes, which have an anthocyanin content of 6 to 600 mg/100g, and red cabbage, which have an anthocyanin content of 25mg/100g (Giusti & Wrolstad, 2001). The high regard for mangosteen pericarp as a source for natural colour can be attributed to its availability and elevated anthocyanin concentration.

Areca catechu **(Betel Nut)**

Typically, this palm species (also known as the betel tree) thrives in the tropical regions of Asia and Eastern Africa (Heatubun et al. 2012). Other than for consumption, the areca nut is used in the manufacture of cosmetics, medications, and natural textile dyes (Maskromo & Miftahorrachman, 2007). Although the commercial potential of the areca nut is considered promising, its development is currently curtailed by poor management (Tjipto Soepomo, 1994). According to Sulastri (2009), the leaves, stems, fibres and seeds of this plant can be used in a variety of applications. The leaves hold numerous essential oils. Its seeds are rich in tannins and alkaloids, the fibres of its fruit are used as medicine for the treatment of beriberi, oedema, constipation, and indigestion while its stems are used for various building structures. (Soun Jung 2017) reported that areca nuts contain a high quantity of tannins, alkaloids, fats, essential oils, and water as well as a low quantity of sugar. The tannins in areca nuts are extracted with the use of water and ethanol as solvents. Tannin is regarded a significant chemical in the medicine manufacturing industry (Endang Suryadi, 1984).

***Hylocereus polyrhizus* (red pitaya)**

Red pitaya (*Hylocereus polyrhizus*), also referred to as dragon fruit or pita berry, belongs to the *Cactaceae* family (Jamilah et al., 2011). This fruit, which turns purple-red when mature, holds delectable, tender flesh evenly interspersed with small black seeds. Malaysia, Vietnam, Thailand, and Taiwan are among the countries with large-scale red pitaya orchards. The fast-growing demand for red pitaya can be attributed to its health benefits claims, particularly in relation to the lowering of dyslipidaemia (Mohd. Adzim Khalili et al., 2009). Apart from its health benefits; which include eyesight improvement, hypertension prevention, and the treatment of anaemia; the pitaya fruit’s red pulp has drawn considerable attention as a natural red colour source for the food and cosmetics industries (Raveh et al., 1998; Too, 2002; Stintzing et al., 2002). Esquivel et al. (2007) investigated the contribution of phenolics towards the antioxidant capacity of purple-red pitaya. According to their findings, betalains are the major contributor towards the antioxidant capacity of purple pitaya juice while non-betalain phenolic compounds play a significantly lesser role with regards to this issue. A separate study by Wybraniec and Mizrahi (2002) found that the antioxidant properties of the pitaya fruit is partly attributable to betacyanin. Ali Jaafar et al. (2009) presented proximate analyses of purple-red pitaya while Ariffin et al. (2009) described the extraction of pitaya seed oil and performed an analysis of its essential fatty acids content. Both the red pitaya flesh and peel are rich in polyphenols, with a higher level detected in the peel (Wu et al., 2006). As the betacyanin pattern in the peel and flesh is identical (Stintzing et al., 2002), it is assumed that the latter possesses the same set of betalain-forming enzymes. Pitaya peel is frequently discarded, particularly by beverage manufacturing companies, after processing (D et al., 2009; Harivaindaran et al., 2008). The potential of pitaya peel, in terms of a natural colourant, thickening agent, or moisturiser in the cosmetics industry was mentioned by Stintzing et al. (2002).

***Morinda citrifolia* (Mengkudu)**

The scientific name for the noni plant is *Morinda citrifolia* which is derived from the Latin words ‘*morus’* meaning mulberry and ‘*indicu’* meaning Indian. This plant belongs to the *Rubiaceae* family (Nelson 2006) and is called *noni* (Hawaii); Indian mulberry, *nuna*, or *ach* (India); *mengkudu* (Southeast Asia); and the painkiller bush or cheese fruit (Caribbean Islands) (Chan-Blanco et al., 2006).

Originating from Southern Asia, *M. citrifolia* currently thrives in the Indo-Pacific region at latitudes of roughly 19° West or South. Eastern Polynesia (Marquesas, Cook Islands, Hawaii, and Lime Island), Western Polynesia (Samoa, Tonga, Rothmas, and Tuvalu), Melanesia (New Guinea, Fiji, and the Solomon Islands), Micronesia (Pohnpei, Guam, Palau, the Marshall Islands, and Northern Marianas), Indonesia, Australia, and South East Asia are all a part of this region. *Noni* has also been naturalised on the open coasts of Central and South America, several West Indian islands, Florida, the Bahamas, Bermuda, and parts of Africa (Sudha et al. 2019)

M. citrifolia L. has long been regarded an effective medicinal herb for the treatment of a variety of physiological conditions. Walburga Bui and Lapailaka (2022) stated that it has been used as an anthelminthic, analgesic, antibacterial, anticancer, anti-inflammatory, and immunostimulant medication for the traditional treatment of a variety of disorders. It is also been used as a healing option for gastritis, skin illnesses, respiratory infections, menstrual and urinary tract disorders, fever, diabetes, and venereal diseases. The large fruit of *M. citrifolia* has drawn the interest of *Drosophila* researchers, who are looking into the genetic resilience of a fruit fly species (*Drosophila sechellia*) capable of consuming the ripe fruit, which is toxic to most insects, without succumbing to its toxicity (Jones, 2005; Kopp et al., 2008). According to Susanto (1980), *M. citrifolia orinda citrifolia* has traditionally been used as a batik dye. The presence of morindin and morindon compounds in the root and bark of *M. citrifolia* renders it an available source for textile dyes (Walburga Bui & Lapailaka 2022). Morindin, with the chemical formula $C_{27}H_{30}O_{14}$ and a molecular weight of 578, is a disaccharide-derived molecule from anthracenedione (anthraquinone). Morindin generates the colour yellow while morindon; which is the product of hydrolysing morindin glycoside, has a chemical formula of $C_{15}H_{10}O_{8}$ and a molecular weight of 270; generates the colour red (Hamid & Mukhlis, 2005).

Clitoria ternatea (Butterfly pea flower)

Clitoria ternatea, also known as the butterfly pea flower, is a perennial twiner in the *fabaceae* family (Lakshan et al. 2019). *C. ternatea* is referred to by a variety of names, including *bunga telang* (Malaysia), *ang chan* (Thailand), *pukingan* (Philippines) (Lim, 2012; Ravindran, 2017), *aparajita* (India), and *die dou* (China) (Lim, 2012; Al-Snafi 2016; Ravindran, 2017). *C. ternatea*, an exceptional ornamental climber, has numerous lines or cultivars adorned with flowers of different colours that render it essential for the collection of ornamental plant enthusiasts (Micheal Gomez & A. Kalamani, 2003). This plant can be separated into two types based on the colour of the petals, which are blue and white (Lakshan et al., 2019). According to Al-Snafi (2016), the variety of petal colours is primarily due to the chemical structure of various anthocyanins present in the flower. A 'double blue' line in a petal indicates an assembly of numerous polyacylated anthocyanins and ternatins while a white line indicates the absence of anthocyanins. Previous studies led to the detection of large amounts of secondary metabolites; such as flavanols, glycosides, myricetin, quercetin (Al-Snafi 2016), phenolic acids, kaempferol (Jamil et al. 2018), and anthocyanins in the *clitoria ternatea* flower (Havananda & Luengwilai, 2019). Extensively used as a food colourant, the *C. ternatea* flower gets its brilliant blue colour from the accumulation of anthocyanins in its petals (Nur Faezah Syahirah et al. 2018). The colour stability and antioxidant qualities of this plant is determined by several environmental factors; such as sunlight, Ph level, soil moisture content, fertilisers used, soil aeration condition, and temperature. The antioxidant capacity of *C. ternatea*, due to the presence of anthocyanin pigments in its flower, is deemed high in comparison to other medicinal plants (Jamil et al., 2018). The antioxidant capacity of *C. ternatea* has been found to impart antidiabetic, antimicrobial, anticancer and anti-inflammatory effects (Havananda & Luengwilai, 2019).

Caesalpinia sappan (Sappan wood)

Sappan wood (*Caesalpinia sappan*) is well-known natural colourant for traditional foods and beverages. According to Batubara et al. (2022), the dye from sappan wood has been adulterated by mixing it with synthetic dyes or other natural dyes to acquire a better colour appearance. Mostly found in Southeast Asia, Africa and the United States, Sappan wood (*Caesalpinia sappan*), which is known as *kayu secang* in Indonesia, belongs to the *Caesalpinaceae* family. In several Asian countries, including India, Indonesia, Korea, and Thailand, dry sappan wood is used in the preparation of a traditional herbal drink (Lioe & Adawiyah 2012). The *C. sappan* extract generates the colour red (Padmaningrum et al. 2012). The colour of sappan wood changes depending the Ph level. At Ph 6 to 7, it is a vibrant red and turns a purplish red at higher Ph levels. It is often used for food with a neutral Ph, such as snacks (Kurniati et al. 2012). It is well-known in Indonesia as a natural red dye for traditional beverages such as *secang* tea in South Sulawesi, *wedang uwuh* by Javanese people, and *bir pletok* by the Betawi people in Jakarta. Other than for these traditional beverages, the *caesalpinia sappan* extract is also used for the preparation of traditional medicines (Batubara et al. 2022). The conventional extraction method for this colourant involves simply the boiling of the sappan wood. Several researchers investigated the ethanol and methanol dye extracts of sappan wood for their antiinflammation (Ye et al. 2006), antioxidant (Jun et al., 2008), and antibacterial properties (Lim et al. 2007). There is also evidence indicating the use of sappan wood dye in ancient artworks and fabrics (Karapanagiotis et al., 2005; Karapanagiotis et al., 2008). The main active ingredient in this plant, which is also its unique identification indicator, is brazilin. The flavonoids and phenolic substances identified in *C. sappan* include 4-O-methylsappanol, protosappanin A, protosappanin B, protosappanin E, brazilein, caesalpinia J, brazilide A, neosappanone, caesalpinia P, sappanchalcone, 3-deoxy sappanone, and 7, 3, 4-trihydroxy-3- benzyl-2H-chromene (Batubara et al., 2010).

APPLICATIONS OF NATURAL DYES

Plant-based natural colourants, which are known for their medicinal and herbal applications, are mainly phenolic compounds (Alihosseni & Sun, 2011). The colourants derived from nature can be classified according to their origins, chemistry, application methods, and the main colours they produce (Zerin et al. 2020) (Figure 1). Natural dyes are a sustainable source of colourants. Apart from textiles, they are also used to colour foods, medicines, and handicraft items. However, although natural colourants are environmentally friendly, hypoallergenic, and visually appealing, their capacity for bonding with textile fibre materials is inadequate. Therefore, mordanting with metallic mordants, some of which are not environmentally friendly, is required to facilitate the fixation of natural dyes onto textile fibres (Virendra 2019b).

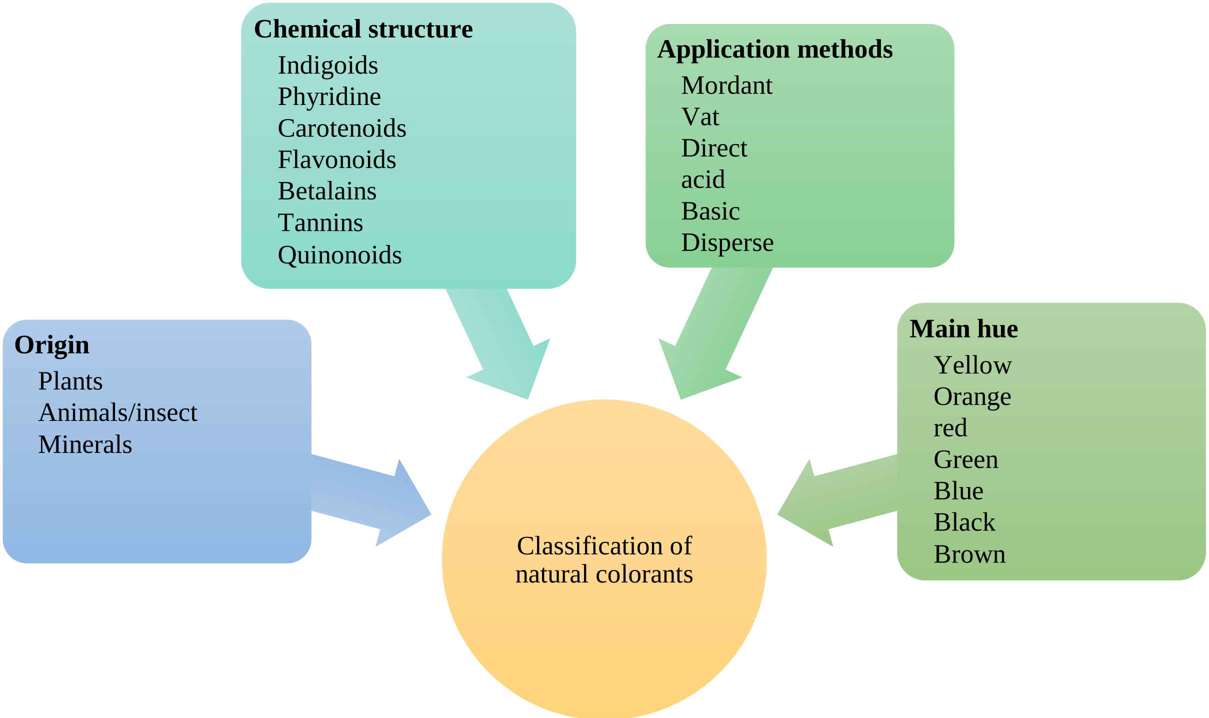

Figure 1. Different classification of natural colorant (Zerin et al. 2020)

Other than for colouring, dyes can also be utilised as agents for improving the durability of textiles and fibres. Specifically coloured textiles are displayed to represent identity, culture and local dyeing knowledge (N. S. M. Hussin et al. 2020). Dyes derived from natural or synthetic materials are organic molecules that are or can be rendered water soluble depending on its intended use. Derived from plants, animals, minerals, and microbes (S. Saxena & Raja 2014), natural dyes have a strong affinity for animal fibres, particularly wool, silk, and mohair with satisfactory results. Cotton flax or linen, ramie, jute hemp, and many other plant fibres primary contain cellulose. On the other hand, synthetic dyes are made from synthetic resources such as chemicals, petroleum by-products, and earth minerals (Ziarani et al. 2018). Although synthetic dyes provide solutions to complex dyeing, they significantly damage the environment.

Natural fibres are those that occur naturally in the environment. They are classified as either vegetable or cellulosic fibres; such as cotton, linen, sisal, and jute; or animal or protein fibres; silk, wool, and cashmere (Ado et al. 2014). Meanwhile, manufactured or human-made fibres can be classified as synthetic polymers such as polyester, polyamide, and acrylic; regenerated fibres such as viscose, modal, and acetate; and inorganic materials such as carbon, glass, ceramic, and metallic (Lara et al. 2022). The dyeing parameters for textile substrates include fibre structure, dye bath temperature, time, pH, and dye molecule characteristics (Virendra 2019b). Natural dyes are a sustainable source of colourants, which can improve the durability of textiles and fibres, while representing the identity, culture, and local dyeing knowledge. Natural dyes have a strong affinity for animal fibres while synthetic dyes derived from synthetic resources are detrimental to the environment.

Traditional and modern methods of natural dye extraction for textiles

The Malay dyeing process begins with the gathering of appropriate raw materials such as the inner wood or bark of trees or the skin of fruits. Prior to the extraction process, the selected raw materials are cut into small portions and left to dry in an open area. The dried materials are then combined with mordant and boiled to facilitate the fixing of the colour onto the fibre. Lime, salt, leaves, and several other raw materials containing alum and iron compounds are among the natural mordants used for the mordanting and dyeing operations (Barkeshli et al. 2003). As described by Samanta and Agarwal (2009), the preparation for the dyeing of cotton cloth with a natural colourant involves the dunking, washing, bleaching, and steaming of the fabric followed by alkaline steeping and rinsing. The cloth is then submerged in a hard solution before being left to dry. The following pre-mordanting process entails the immersing of the cloth in an alum and water solution. The cloth is then subjected to boiling in an aqueous solution of a specific natural dye until such time the colouring matter is fully absorbed by the cloth. The dyed fabric is then washed and left to dry under the sun. Water is sprinkled over the cloth occasionally to heighten the colour of the dye. This is repeated for a period of two to four days. Most of the equipment required for the small-scale dyeing of fabrics is easily acquired. The equipment required is listed below along with a brief explanation regarding its usage (SCTD, 2009):

I. Pestle and mortar
II. Mordanting and dyeing pans
III. Stirring rods
IV. Thermometer
V. Measuring jugs
VI. Storage container
VII. Plastic bowls and buckets
VIII. Strainer
IX. Weighing scales
X. Protecting equipment

The application of modern technology has led to the development of many natural dye extraction methods. These methods involve the use of organic solvents, a mixture of solvents, microwaves, alkaline solutions, acids, super critical fluids, or even ultrasonic waves. It has been established that the yield from these methods surpasses the yield derived through the conventional aqueous approach (Saxena & Raja, 2014), which varies according to the Ph level and the duration of the extraction process (Zerin et al. 2020) (Table 1). The selection of an extraction procedure determines the natural colourant yield and the stability of the dye (Hassan & Che Abdul Rahim 2021). Plant pigments can be classified under four families: tetrapyrroles (chlorophyll), carotenoids (beta- carotene), polyphenolic compounds (anthocyanins), and alkaloids (betalains) (Othman et al., 2017).

Table 1. Methods extraction of natural dyes

Extraction methods	Process	Reference
Aqueous/ water	The dye-containing materials are broken into small pieces or powdered, then soaked in water overnight. To	(Virendra 2019a)

	remove non-dye materials, it is boiled and filtered. The disadvantage of this technique is that some of the dye decomposes during the boiling process.	
	Potential use of natural dyes extracted by aqueous medium from different plant sources; Coffea seed, *Camellia sinensis*, *Allium cepa*, *Tamarindus indica*, *Lawsonia inermis*, *Cymbopogon citratus*, *Elettaria cardamomum*, *Beta vulgaris* and *Crocus sativus*	(Zerin et al. 2020)
Acid and alkaline	Most natural dyes are glycosides, which can be extracted in either acidic or alkaline conditions. The alkaline solution is appropriate for dyes with phenolic groups in their structure. This method can be used to extract dyes from annatto seeds, lac dye from lac insects and red dye from safflower.	(Virendra 2019a)
	Cuminum cyminum (cumin seeds) extract has a potential of the natural dyes for color yield, fastness quality and economical for industrial.	(Tayade & Adivarekar 2013)
Ultasonic microwave	This method has several advantages over aqueous extraction. In this technique, less solvent (water) is required for extraction. Compared to aqueous extraction, the treatment is carried out at a lower temperature and for a shorter period. It is a novel technique that saves time, money, and energy while providing a high dye uptake value and more effective than conventional heating in the dye extraction and dye-uptake of wool fibres with lac dye, with an improved effect of 41% and 47%, respectively. Microwave heating is more effective than traditional heating in terms of dye extraction and the colour strength of silk fabrics.	(Ali et al., 2019a); (El-Khatib et al. 2014) ; Kamel et al., 2005; (Virendra 2019a)
Fermentation	The fermentation of natural colour-bearing substances is accelerated in the presence of bio enzymes, and natural dyes are extracted. Indigo extraction is the best example of a fermentation extraction method. The indimulsin enzyme degrades glucoside indicators into glucose and indoxyl. The enzyme method is also used to extract anatto natural dye.	(Virendra 2019a)
Solvent	In the extraction of natural dyes, organic solvents such as acetone, petroleum, ether, chloroform, and ethanol are used. When compared to aqueous extraction, it is a very viable technique. The dye yield is good, and the water required is minimal. The extraction is carried out at a lower temperature.	(Virendra 2019a)

Traditional and modern methods of natural dye extraction for food

Other than enhancing their appeal, food colour also influences the preferences, attractiveness, and approval of food products. The key factor for the assessment of food quality is colour. The natural pigments present in plant and animal components furnish food with its distinctive colouring. During processing operations, a significant amount of food colour is lost. Artificial and natural colourants are used not only for restoring this lost colour but also for intensifying the existing colour and for tinting food lacking in colour to render food products more appealing to consumers (Lakshmi 2014). The use of natural colours for food products ensures low toxicity, a renewable resource, and a pollution-free setting. On the other hand, the application of synthetic colourings to food is likely to negatively affect human health (Ahmad et al. 2018). Food colourants can be separated into two types: natural food colourants and synthetic food colourants. The food colourants market is growing at 4.6% annually with an estimated world market share of 2.3 billion dollars. Food colourants are used to:

1. Prevent the loss of appeal of the original food
2. Enhance the colour of a food and convince consumers of its quality
3. Preserve vitamins vulnerable to flavour and light
4. Maintain the image, character, or identity of the food

According to Mohd et al. (2011) and Terci and Rossi (2002), the dyes extracted from plant tissues can be utilised as a colorimetric pH indicator. The colour changing capacity of these dyes is facilitated by the presence of phenolic or conjugated chemicals; such as anthocyanins, which undergo alterations in their chemical structure in response to pH variations (Shahid et al. 2013). As such, the use of a Ph indicator will assist in maintaining the food's quality and freshness. The application of a pH indicator can also serve to detect the presence of reproductive metabolites of microorganisms in food (Kerry et al. 2006).

Table 2. Types and uses of natural colours towards food

Natural colourants	**Pigment colour**	**Uses in food**
Anthocyanin	Blue-reddish shades	Soft drinks, alcoholic drinks
Annatto	Orange shades	Dairy & fat products & desserts
Beet powder	Bluish red	Frozen ice cream & falvourd milk
Beta- carotene	Yellow-orange	Butter, fat, oils, soft drinks, fruits juices, ice cream
Carmine	Bluish red	Soft drinks, sugar & flavour confectionary, pickles, sausages
Chlorophyll	Olive green	Soups. Fruits products, jams
Canthoxanthin	Orange red-red	Soups, meat & fish dishes
Leutin	Yellow	Ice cream, dairy product, sugar, flour
Paprika	Orange-red	Meat products, snacks, soups, salad
Riboflavin	Yellow	Cereal products, sherbet, ice cream

Sandal wood	Orange-orange red	Fish processing, alcoholic drinks, sea food dressings, meat product
Safflower	Yellow	Soft drinks, alcoholic drinks
Saffron	Yellow	Baked goods, rice dishes, meat dishes, soups
Tumeric	Bright yellow	Yogurt, frozen products, pickles

Sources: (Parmar & Gupta 2015)

Traditional and modern methods of natural dye extraction for cosmetics

Cosmetics are expected to be sprayed, rubbed, sprinkled, or otherwise applied to the body to clean, enhance, or improve the appearance of body parts. The demand for natural colourants in the cosmetics industry has prompted the creation and advancement of natural cosmetic products (Patil & Datar 2016). Due to the potential adverse effects of synthetic colourants on human skin, it is anticipated that the creation of cosmetics products using natural colourants will flourish. The use of natural colourants for cosmetics includes body butter, lipstick, nail polish, foundation cream, eye and face make-up, body care products, hair care products, baby skincare products, and coloured contact lenses as well as creams and lotions for skin care (Daughton & Ternes 1999). Patil and Datar (2016) reported that manufacturers are currently in pursuit of natural colouring ingredients with multifunctional properties; such as UV protection, anti-ageing, antioxidant, and antibacterial properties; for foundations, lip care products, hair dyes and other cosmetics. Among the many plants exploited for cosmetics and hair colouring products, the following are most frequently used, due to their sustainability and accessibility:

Table 3. Plants used for produce lipstick and haircare

Cosmetics	**Natural plant**	**Colour**	**Reference**
Lipstick & Balm	*Bixa orellana*	The fruit which is yields colouring pigment called bixin, is harvested from the seed coat and it provides cosmetics the red hue.	(Paryanto et al. 2014)
	Beta vulgaris	It contains betaines, a red colouring agent that is also highly medicinally significant	(Dlim et al. 2013)
	L. coccinea	Using several types of mordants while dying with I. coccinea dye produces a variety of colours, including pink, lilac and grey shades.	(Patil & Datar 2016)
Haircare	*Emblica officinalis*	This plant's significant cosmetic uses are for stimulating hair growth and preventing greying of the hair.	(Dhale & Mogle 2011)
	Hibiscus rosa-sinensis	Shoe flower can be used as a hair colour to turn grey hair a natural shade of black	(Adeel et al. 2018)

	Lawsonia Inermis	The plant is typically used as a source of orange colour dye for hair, nail colour, and in the international adornment of the soles of feet and the palms of hands. Fresh and dried leaves of the plant are also commonly used	(Morgan & Cartwright-Jones 2010)
	Chamomile flower	Extracts of chamomile flower performs as a hair bleaching agent	(Adeel et al. 2018)
	Brazilian wood tree	This tree produces brown dyes that are used for colouring hair	(Adeel et al. 2018)

Source: (Adeel et al. 2018)

The restrictions put in place by various environmental protection agencies to curb the manufacture synthetic products have served to promote the use of sustainable raw materials among a growing number of hair dye manufacturers. In order to sustain the availability of natural dyes, it is essential that new sources of plant-derived dyes be identified and expanded.

ADVANTAGES OF NATURAL DYES

Global concerns with regards to environmental degradation issues have led to a growing interest in the application of plant-based dyes for natural fibres (A. K. Samanta & Agarwal 2009). Other than the manufacture of natural dyes, the sustainable propagation, harvest, and sale of natural dye-producing plants can serve as a source of income for the population in developing countries (Jothi 2008). Unlike synthetic dyes, natural dyes are (a) safe to use, (b) easy to extract and purify, (c) sustainable, (d) unencumbered by demanding dyeing conditions, (e) derived from renewable resources, and (f) do not generate effluents during their generation (Virendra 2019b). According to (Samanta, 2020), the functional and environmental benefits of natural dyes include:

i. Less toxic, less pollution-causing, less harmful to health, and non-carcinogenic
ii. Agro-renewable and derived from biodegradable sources
iii. Different mordant types and concentrations can be used with the same dye to obtain different colours
iv. Several natural dyes have antibacterial, antimicrobial, insect-repellent, antioxidant, and UV protection properties

The plant parts used to make natural dyes include the roots, leaves, branches, stems, heartwood, bark, flowers, fruits, and seeds. Certain bacteria produce pigments that can be used to dye textiles a variety of shades including black, white, brown, gold, silver, fluorescent green, gemstone, and blue (Yildirim et al. 2020). The benefits of using natural dyes include:

i. Production of the desired quantity regardless of climate fluctuations, geographic conditions, and unexpected changes in the weather
ii. Undemanding production processes
iii. Different colours and tones can be obtained without gene interferences

iv. The propagation of dye-producing plants is trouble-free while the cost of producing natural dyes on an industrial scale is considered low

According to Zerin et al. (2019), in comparison to synthetic dyes, natural dyes are:

i. Biodegradable, nontoxic, and non-allergic
ii. Typically demonstrate colour shades that are subtle, lustrous, and visually appealing
iii. Easily derived from plant parts; such as the leaf, bark, root and flower; and insects, animals, and minerals
iv. Possesses medicinal qualities such as the ability to decrease the risk of melanoma via UV absorption as well as anti-allergen and antibacterial properties

The positive effects of natural dye, in terms of the environment and society in general, include:

i. The accumulation of carbon credit by reducing the use of petroleum-based synthetic colourants
ii. The creation of job opportunities associated to the cultivation of dye-producing plants as well as job opportunities associated to the dye extraction and application operations
iii. The utilisation of wastelands for the large-scale cultivation of dye-producing plants
iv. The option of recycling natural dye waste into a bio-fertiliser for agriculture or into the biomass for energy generation
v. The creation of an inclusive sustainable system

DISADVANTAGES OF NATURAL DYES

Notwithstanding the benefits, the use of natural dyes is not without its drawbacks. Natural dyes costs significantly more than synthetic dyes as its colour component extraction procedure is arduous, its colour value is low, and its dyeing process takes a long time to complete (Siva 2007). Furthermore, the drawbacks of using natural dyes to dye natural fibres include poor colour fastness, lack of reproducibility of shades, lack of available standard colour guidelines and methods as well as the use of metallic mordants, some of which are not eco-friendly (Virendra 2019b). While natural dyes are environmentally friendly, hypoallergenic, and visually appealing, their capacity for bonding with textile fibre materials is exceedingly poor. Natural dye fixation on textile fibres necessitates mordanting with metallic mordants, some of which are not eco-friendly. Natural dyes account for less than 1% of all dyed textile substrates. Lastly, natural dyes come in a limited colour range that is not reproducible with low yield and medium fastness properties. The fastness of dyeing is a measure of its resistance to fading or colour change when exposed to a given agent or treatment (Lara et al. 2022). Table 3 shows a SWOT analysis of natural dyes.

Table 3. SWOT analysis on natural dyes

Strength	Weakness	Opportunity	Threat
Environmental friendly	Poor colour fastness	Applicable for natural fibre	Threat to biodiversity if there is no new cultivation
Skin-friendly	High cost	Biodegradable and renewable	
Visual appearance	Low colour value	Different colours can be obtained by exploring the different concentrations or mordant	
biodegradable, nontoxic, and nonallergic	A longer period of time to extract	Antioxidant, antibacterial, antifungal and anti repellent	
Aesthetically value	Poor bonding with textile	Creating a job for cultivationd production	
Less toxicity towards the environment			
Low carbon			

CONCLUSION AND RECOMMENDATIONS

The Malay community's use of plants for various purposes is closely associated with their culture and traditions. More often than not, these plants are available within the vicinity of their homes. The rapidly increasing preference for natural raw materials in the fabric, food and cosmetics industries can be attributed to their non-toxic qualities and their minimal impact on the environment. It is clear that the extensive plant resources available in Malaysia have not been fully utilised. More in-depth research is required to consider the potential of commercial-scale cultivation involving various dye-producing plant species. Currently, the economically worthwhile manufacture of synthetic dyes in Malaysia is hampered by the lack of expertise in terms of the extraction and colouring process. Furthermore, the low colour value and extended processing time associated to natural dyeing renders it substantially more expensive than synthetic dyeing. Several plant species, including *Annatto (Bixa orellana), henna (Lawsonia enermis), mangosteen (Garcinia mangostana), betel nut (Areca catechu), red pitaya (Hylocereus polyhizus), mengkudu (Morinda citrifolia), butterfly pea flower (Clitoria ternatea)* and sappan wood *(Caesalpinia sappan)*, are known to play a significant role in the daily lives of the Malay community. It is essential that the natural dye generation process involving these plants, from extraction to mordanting, be documented. To delay would increase the risk of losing knowledge regarding the use of our natural resources to generate natural dyes. Future efforts in this area should focus on the limitations posed by natural dyes as well as the documentation, assessment, and description of Malaysian plants from which natural dyes can be derived.

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