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Harnessing The Plant Based Color: A Sustainable Appoach To Dyeing

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INTRODUCTION

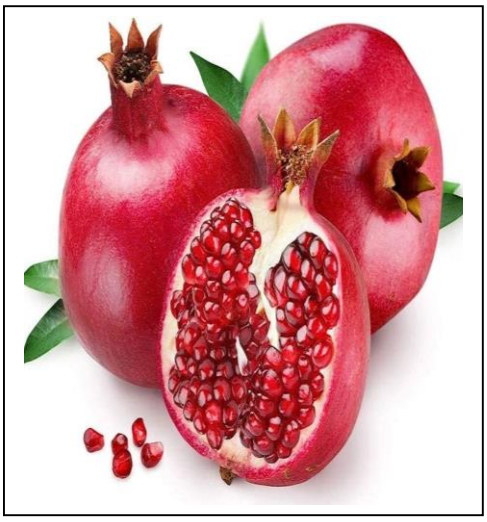
Natural dyes are colorants derived from plants, minerals, and, to a lesser extent, animals. These dyes have been used for centuries to impart rich, vibrant colors to textiles, leather, paper, and other materials. The process of creating natural dyes often begins with gathering raw materials such as roots, bark, leaves, flowers, fruits, and insects. Each source produces a unique hue; for instance, indigo plants yield deep blues, madder root provides reds, and turmeric offers bright yellows. Natural dyes are prized for their environmental benefits, as they are biodegradable and often less toxic than synthetic dyes. Plant-based natural dyes have been used for a long time, offering a sustainable and eco-friendly alternative to synthetic dyes. Derived from various parts of plants such as roots, leaves, bark, flowers, and fruits, these dyes provide a rich palette of colors that are both vibrant and diverse. The process of extracting dyes from plants is often straightforward and can be done using traditional methods, making it accessible for small-scale artisans and hobbyists. Not only do plant-based dyes reduce the environmental impact associated with synthetic dyes, which often involve harmful chemicals and significant water pollution, but they also promote biodiversity by encouraging the cultivation of dye plants. Additionally, the use of natural dyes supports traditional knowledge and cultural heritage, as many indigenous and local communities have perfected these dyeing techniques over generations.

1. Butterfly Pea: Butterfly pea *(Clitoria ternatea L),* commonly known as butterfly pea is found in great abundance in Malaysia. Butterfly pea flower is the selected candidate in the studies of floral anthocyanins. *Clitoria ternatea L.* Fabaceae a perennial climber herb, is distributed in tropical countries. It has been implicated to have several medicinal properties. It has several different flower colours; namely dark blue, light blue, mauve, and white. The plant bears solitary, axillary papillionaceous bright blue petals flowers with white or light yellow at the centre (Abdullah *et al.,* 2010). Colorants are important ingredients in food, cosmetics, pharmaceuticals, fabrics, paints, toys and many other products. The butterfly pea flower is known to be used as a dye for colouring material in food and herbal drinks (Mehmood *et al.,* 2019). Anthocyanins in Butterfly pea have been chosen to be extracted to form natural dye. Anthocyanins are colour pigments that provide red, violet and blue colours.

Extraction of dye from Butterfly pea

When mix the butterfly pea flower tea in hot water, it gets a deep blue colour, but when added in different ingredients like lemon or hibiscus, it can change the presentation to other bright colours like fuchsia or a bright red. The change occurs because of the change in PH levels. At its normal pH level, butterfly pea flower ranges from 6.0-8.0. By adding ingredients like hibiscus or lemon, the flower will go outside of its normal pH level, causing the colour to change. Butterfly pea is often added to herbals and tisanes and since they are often used for health benefits, make sure you check with a medical practitioner before drinking them. The natural colorant must first be extracted from the plant material. A variety of factors affect the overall extractable yield, or the percentage of desired compounds that are derived from original plant material, but the primary ones are the choice of solvent or liquid medium, extraction temperature, extraction duration and the ratio of extractable solids (flowers) to solvent volume. Various procedures exist for the extraction of plant material, and traditionally direct addition of a powdered form of the dried flowers into food, fabrics and other products is most common.

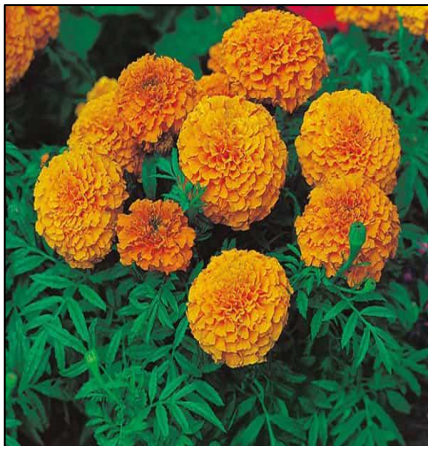
2. Pomegranate: Pomegranate (*Punica granatum*), bush or small tree of the family Lythraceae and its fruit. The juicy arils of the fruit are eaten fresh, and the juice is the source of grenadine syrup, used in flavourings and liqueurs. Pomegranate is high in dietary fibre, folic acid, vitamin C, and vitamin K. It grows in all warm countries of the world and was originally a native of Persia. Extracts from the seeds of pomegranates are used in skincare products as they contain antioxidant compounds and are also included in beauty products for their exotic, sweet fragrance. Pomegranate seeds can be eaten raw or juiced. They are a good source of fibre, vitamins, and minerals. Ancient cultures used pomegranates in remedies for digestive disorders, skin disorders, intestinal parasites and for dying of cotton cloth. Pomegranate seeds can also be used to dye paper, or rather paint on it. Many of these traditions continue to this day. The rind of pomegranate contains a considerable amount of tannin, about 19% with pelletierin. The main colouring agent in the pomegranate peel is granatonine which is present in the alkaloid form N-methylgranatonine (Satyanarayana *et al.,* 2013).



Extraction of dye from Pomegranate

Traditional way, remove your fibres from their mordanted bath, gently remove the excess of water. Fill a big pot with water then add your pomegranate cut into big chunks. Heat up the water but don't let it reach the boiling point. Let the pot of water simmer for 1 hour. Turn the heat off and let it cool down a bit. It'll give you richer and deeper colours if you leave it the whole night or at least several hours before straining your dye bath. Now, it's time to strain your dye bath. Remove your fibres from their mordanted bath, gently remove the excess of water and let them soak all the colour up by immersing them in the dye bath. Heat up the pot slowly again so it can simmer for about 1 hour. Let it cool down. Once again, it's better to leave your fibres several hours or a whole night in the dye bath. This way, the colour will only get deeper. Once it's cool down, rinse the fibres in cold water, let it dry and dye cloth is ready with natural yellow to light brown colour.

3. Marigold: Marigold (*Targetes spp),* of 50 species of annual or perennial, mostly herbaceous plants in the family Asteraceae. The common name in English, marigold, is derived from Mary's gold, a name first applied to a similar plant native to Europe. Marigold species vary in size from 0.1 to 2.2 m tall. Most species have pinnate green leaves. Blooms naturally occur in golden, orange, yellow, and white colours, often with maroon highlights. Floral heads are typically 4–6 cm diameter, generally with both ray florets and disc florets. In horticulture, they tend to be planted as annuals, although the perennial species are gaining popularity. They have fibrous roots. The flowers of marigolds are very beautiful with a lot of benefits make a garden as more attractive. Marigold and its extracts are highly useful in therapeutic treatments like headaches, swelling, toothache, wounds and numerous skin problems. In addition, they have been used in cooking. Marigold was one of the earliest cultivated flowers. The ancient Greeks used the petals of marigold for decorations and other purposes like make-up, colouring food (stews, soups, pudding, etc), dying fabrics and as part of medicines.



Extraction of dye from Marigold

Marigold dye extraction involves harvesting the vibrant petals of marigold flowers, known for their rich yellow and orange hues. The petals are typically dried to remove moisture, which helps in preserving their color properties. Once dried, the petals are crushed into a fine powder. This powder is then subjected to a solvent extraction process, often using water or an alcohol-based solvent to draw out the natural pigments. The mixture is heated gently to facilitate the release of the dye. After sufficient extraction, the solution is filtered to remove any solid residues, leaving behind a concentrated liquid dye. This extract can be further purified and concentrated, depending on the desired intensity and application. Marigold dye is prized in textiles for its natural, eco-friendly properties and is also used in cosmetics and food coloring, making it a versatile and sustainable alternative to synthetic dyes.

4. Beetroot: Beetroot *(Beta vulgaris),* one of the four cultivated forms of the plant *Beta vulgaris* of the amaranth family (Amanranthaceae), grown for its edible leaves and taproot. Beets are believed to originate along the coasts of the Mediterranean (sea beets) and were first cultivated for tier edible leaves. Beetroots are a good source of riboflavin as well as folate, manganese, and the antioxidant betaine. Beet greens are a source of riboflavin, iron, and vitamins A, C, and K. The beetroot is a biennial plant that produces seeds the second year of growth and is usually grown as an annual for the fleshy root and young leaves. The *Beta vulgaris* has three basic varieties: chard, grown specifically for its leaves; beets, grown for its bulbous root, with edible leaves (with varieties in white, yellow and red roots); and sugar beets, grown for making sugar from the long, thick root. Beet root is a source of water-soluble nitrogen-containing pigment, known as betalain or betanin, which is used as food colorant and food additive as well. Betalains have some properties which are beneficial to our health due to which they are also used to enrich food products (Azeredo, 2009). Betalains extracted from Beetroot are also known as "beetroot red".

Extraction of dye from Beetroot

The process begins with selecting fresh, healthy beetroots, which are then thoroughly washed and peeled to remove any contaminants. The beetroots are chopped into small pieces and blended or grated to create a fine pulp. This pulp is mixed with a solvent, usually water or ethanol, to facilitate the extraction of the dye. The mixture is then heated gently to enhance the release of pigments, followed by filtration to separate the liquid dye from the solid residues. The extracted dye can be further purified through techniques such as centrifugation or chromatography to remove any remaining impurities. Beetroot dye is prized for its vibrant color and is widely used in food coloring, cosmetics, and textile dyeing due to its natural and non-toxic properties.

CONCLUSION

Plant based natural dyes represent a sustainable alternative to synthetic dyes, offering cultural significance, environmental benefits, and aesthetic appeal in textile production. As global awareness of environmental issues grows, the integration of natural dyes into mainstream fashion presents opportunities for innovation and socio-economic development. Continued research and collaboration across disciplines will further enhance the viability and acceptance of natural dyes in the global marketplace.

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