

Natural Ink Synthesis from Plants

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Article DOI Link: <https://zenodo.org/uploads/18660263>

DOI: [10.5281/zenodo.18660263](https://doi.org/10.5281/zenodo.18660263)

Abstract

The art of writing and printing requires ink which can be of natural or synthetic origin. Synthetic inks owing to their merits have an edge over natural inks. However, Volatile Organic Compounds and the non-degradable nature of synthetic ink pose a threat to the individual engaged with it and the environment. Thus, to overcome these issues this study was carried out with the objective to synthesize natural inks from the from *Azadirachta indica* Juss., *Beta vulgaris* L., *Bougainvillea spectabilis* Willd, *Clitoria ternatea* L., *Curcuma longa* L., *Coffea arabica* L., *Hibiscus rosa-sinensis* L., *Lantana camara* L., *Nyctanthes arbor-tristis* L., *Rosa indica* L. The Ink was produced were bright and well resisted to rubbing. The ink produced is eco-friendly, non-toxic and non-polluting.

Keywords: Ink, fastness, mordant

Introduction

Art of writing developed in growing civilization with reformation. It is a skill by which a person expresses his thoughts, ideas, feelings and emotions. For centuries, ink is made from natural products such as berries, barks, and extracts of leaves. These have been used as raw materials to create various colours and to produce ink, dye, or paint when mixed with other substance. Modern ink contains many substances aiming to improve ink characteristics. Chemically inks are a mixture and composed of colorant, a vehicle and additives. The art of using natural colour is very old and in china dated 2600 BC which was the first country to use natural dyes. Dye based inks are made with solvent that dry rapidly as they have a tendency to soak into paper. The specific objectives of the present work i) to prepare plant dye-based inks. ii) to compare colour retainability in paper using mordant. iii) to analyze the fastness properties of plant dye.

Materials And Methods

Collection of Plant Material

The leaf of *Azadirachta indica*. Juss. flower of *Rosa indica* L., *Nyctanthes arbor-tristis* L., *Hibiscus rosa-sinensis* L., *Clitoria ternatea* L, seed of *Coffea arabica* L., perianth of *Bougainvillea spectabilis* Willd, the rhizome of *Curcuma longa* L., the tuber of *Beta vulgaris* L., fruit of *Lantana camera*.L. were collected from in and around Nagercoil.

Ink Extraction

The cleaned samples (200 g) were taken in a beaker and 100 mL of double distilled water was added and boiled at 70oC for 15 minutes on a flame. After boiling the solution was cooled for 5 minutes. This solution was again boiled at 70oC for 10 to 15 minutes and after cooling 2-3 drops of vinegar was added. The synthesized ink was filtered with the help of Whatman filter paper (No. 1) (Nagrle et al.,2022).

pH of Ink

pH was measured using pH paper. The measurement is performed by dipping into the sample, matching the color of the pH paper, and observing the pH value of the sample.

Floatation Test

Selected writing samples were cut into 60 by 60 mm square sheets.150ml of the produced ink was respectively applied on the cardboard and paper samples. A stop watch was set to determine the time taken for the upper surface of the test samples to become fifty percent discoloured by the penetration of the ink, using visuvalassessment.It is a good indicator of penetration times, however, and is fairly reproducible if the same person runs the test from day to day. The method is greater value for paper than paperboard, due to the excessive penetration times of the latter Noah et al. (2014).

Solar Test

The plant-based ink was coloured in the white paper then the paper is exposed to sunlight for 24 hours. The synthesized ink was tested for discolouration by exposure to solar radiation. Colour fastness was noted. (Nagrle et al.,2022).

Eraser Test

The plant-based ink is filled in ink pens and then write a text using the plant ink filled pen, then erase the text using the eraser. Time taken to erase the text were note

Fastness Test

Evaluation of Colour Fastness

Fastness properties such as wash, rub and light were analysed using the dyed fabrics. Colour fastness to washing of the dyed fabric samples was determined as per ISO: 105-A02 – 1995, following ISO-3 wash fastness method. The wash fastness rating was assessed using grey scale as per ISO-105-A02 (loss of shade depth) and ISO-105-A03 extent of staining. Colour fastness to rubbing (dry and wet) was assessed manually by hand rubbing one sample ten times and grey scale as per ISO-105-A03 extent of staining. Light fastness of dyed cloth assessed by exposing the cloth in sunlight for 24 hours.

Results and Discussion

The synthesized inks were free-flowing, non-clogging, and bright. The permanency of the colour and stability was stable.

Table 4.1 Plants that yielded substantive inks.

S.no	Binominal name	Family	Plant part
1	<i>Azadirachta indica</i> Juss	Meliaceae	Leaf
2	<i>Beta vulgaris</i> L.	Amaranthaceae	Tuber
3	<i>Bougainvillea spectabilis</i> Willd	Nyctaginaceae	Perianth
4	<i>Clitoria ternatea</i> L.	Fabaceae	Flower
5	<i>Curcuma longa</i> L.	Zingiberaceae	Rhizome
6	<i>Coffea arabica</i> L.	Rubiaceae	Seeds
7	<i>Hibiscus rosa-sinensis</i> L.	Malvaceae	Flower
8	<i>Lantana camara</i> L.	Verbenaceae	Fruit
9	<i>Nyctanthes arbor-tristis</i> L.	Oleaceae	Flower
10	<i>Rosa indica</i> L.	Rosaceae	Flower

The ink colour was light green in *Azadirachta indica* Juss., dark pink in *Beta vulgaris*, pink colour in *Bougainvillea spectabilis* Willd, blue colour in *Clitoria ternatea* L., yellow colour in *Curcuma longa* L, pale yellow colour in *Coffea arabica* L., dark pink colour in *Hibiscus rosa-sinensis* L, black colour in *Lantana camara* L, orange colour in *Nyctanthes arbor-tristis* L., red colour in *Rosa indica* L.



***Azadirachta indica* Juss.**



***Coffea arabica* L.**



***Beta vulgaris* L.**



***Hibiscus rosa-sinensis* L.**



***Bougainvillea spectabilis* Willd**



***Lantana camara* L.**



***Clitoria ternatea* L.**



***Nyctanthes arbor-tristis* L.**



***Curcuma longa* L.**



***Rosa indica* L.**

Plate 1. Natural dye yielding plants used in the present study

Table 4.2. Plant dye-based ink produced from different plant parts

s.no	Binominal name	family	Plant part	mordant	Ink colour
1	<i>Azadirachta indica</i> Juss	Meliaceae	Leaf	Vineager	Green
2	<i>Beta vulgaris</i> .L	Amaranthaceae	Tuber	Vineager	Dark pink
3	<i>Bouvgaivellia spectabilis</i> Willd	Nyctaginaceae	Perianth	Vineager	Pink
4	<i>Clitoria ternatea</i> .L	Fabaceae	Flower	Vineager	Blue
5	<i>Curcuma longa</i> .L	Zingiberaceae	Rhizome	Vineager	Yellow
6	<i>Coffea arabica</i> .L	Rubiaceae	Seeds	Vineager	Brown
7	<i>Hibiscus rosa-sinensis</i> .L	Malvaceae	Flower	Vineager	Red
8	<i>Lantana camera</i> .L.	Verbenaceae	Fruit	Vineager	Black
9	<i>Nyctanthes arbor-tristis</i> . L.,	Oleaceae	Flower	Vineager	Orange
10	<i>Rosa indica</i> . L.,	Rosaceae	flower	Vineager	Red

pH of the Ink

pH of the synthesized natural ink was *Ciltoria ternatea* L. is 7, pH noted in *Azadirachta indica*.Juss. *Curcuma longa* L. *Coffea arabica* L. *Lantana camera* L. *Nyctanthes arbor-tristis* L. *Rosa indica* L., pH 5 is noted in *Beta vulgaris* L. *Beta vulgaris* L. *Hibiscus rosa-sinensis* L. The pH 0 – 6 indicates acidic/ pH 7 neutral, pH 8 – 14 indicates alkaline, low pH of ink can cause skin irritation (patel and patel 2024).

Table 4.3. pH of the ink

S.no	Ink yielding plant	pH of ink
1	<i>Azadirachta indica</i> Juss	6
2	<i>Beta vulgaris</i> L.	5
3	<i>Bouvgaivellia spectabilis</i> Willd	5
4	<i>Clitoriaternatea</i> L.	7
5	<i>Curcuma longa</i> L.	6

6	<i>Coffea arabica</i> L.	6
7	<i>Hibiscus rosa-sinensis</i> L.	5
8	<i>Lantana camera</i> L.	6
9	<i>Nyctanthes arbor-tristis</i> L.	6
10	<i>Rosa indica</i> L.	6

Floatation Test

The penetration time of the ink produced from extract of *Azadirachta indica* Juss. leaf on the selected writing surface 2 sec. The penetration time of the ink produced from extract of *Beta vulgaris* L. on the selected writing surface 4sec. The penetration time of the ink produced from extract of *Bouvgaivellia spectabilis* Willd on the selected writing surface 5 sec. The penetration time of the ink produced from extract of *Clitoria ternatea* L. on the selected writing surface 5sec. The penetration time of the ink produced from extract of *Curcuma longa* L. on the selected writing surface 3 sec. The penetration time of the ink produced from extract of *Coffea arabica* L. on the selected writing surface 6 sec. The penetration time of the ink produced from extract of *Hibiscus rosa-sinensis* L. on the selected writing surface 6 sec. The penetration time of the ink produced from extract of *Lantana camera* L. on the selected writing surface 7 sec. The penetration time of the ink produced from extract of *Nyctanthes arbor-tristis* L. on the selected writing surface 8 sec. The penetration time of the ink produced from extract of *Rosa indica* L. on the selected writing surface 7 sec.

Table 4.4. Penetration time of ink

S.No	Binomial name	Penetration time of ink Seconds
1	<i>Azadirachta indica</i> Juss	2sec
2	<i>Beta vulgaris</i> L.	4 sec
3	<i>Bouvgaivellia spectabilis</i> Willd	5 sec
4	<i>Clitoriaternatea</i> L.	5 sec
5	<i>Curcuma longa</i> L.	3 sec
6	<i>Coffea arabica</i> L.	6sec
7	<i>Hibiscus rosa-sinensis</i> L.	6 sec
8	<i>Lantana camera</i> .L.	7 sec
9	<i>Nyctanthes arbor-tristis</i> L.	8 sec
10	<i>Rosa indica</i> L.	7 sec



Plate 3. Floatation test for natural ink

Solar Test

The natural inks synthesized from these plant products from the aforementioned procedure were filled in an ink pen and tested for discolouration after writing on paper. After writing, these written papers were exposed to solar radiation for 24 Hours. The *Beta vulgaris* L., *Bougvaivellia spectabilis* Willd., *Clitoria ternatea* L., *Hibiscus rosa-sinensis* L., *Rosa indica* L., *Azadirachta indica* Juss. The *Coffea arabica* L., *Lantana camera*.L., *Nyctanthes arbor-tristis* L., *Curcuma longa* L. Ink was mildly discolored on the exposure of sunlight.



Plate. 4. Solar test of the natural ink dyed paper

Eraser Test

The Ink was produced from *Azadirachta indica* Juss., *Beta vulgaris* L.,

Bouygaivellia spectabilis Willd, *Clitoria ternatea* L., *Curcuma longa* L., *Coffea arabica* L., *Hibiscus rosa-sinensis* L., *Lantana camera*. L., *Nyctanthes arbor-tristis* L., *Rosa indica* L. well resisted to rubbing.

Pigment, often known as ink coloring, is one of its basic components. Density and viscosity have an influence on pigment ink; the greater the density and viscosity values, the more pigment ink is produced (Patel and Patel 2024).

The performance characteristics of these natural dyebased inks highlight their potential as sustainable alternatives to synthetic inks. The ability to formulate inks with distinct colors, fast drying times, and varying degrees of eras ability demonstrates the versatility of these plant-derived pigments. The strategic use of additives, such as citric acid and potassium aluminum sulfate, further enhanced the desired properties of the inks, showcasing the importance of optimizing the ink formulations to maximize the benefits of natural colorants. Unlike many synthetic inks, plant – based inks break down naturally and don’t contribute to long – term pollution. These inks are free from harmful chemicals, making them safer for humans and the environment. Using local or easily sources plants to create ink reduces the need for industrial production and transportation.

Table 4. 5.Colour Fastness of Natural Ink

Sl. No .	Binomial name	Fastness											
		Wash fastness				Light fastness				Rub fastness			
		1	2	3	4	1	2	3	4	1	2	3	4
1	<i>Azadirachta indica</i> Juss			✓				✓				✓	
2	<i>Beta vulgaris</i> .L		✓			✓							✓
3	<i>Bouygaivellia spectabilis</i> Willd		✓				✓						✓
4	<i>Clitoriaternatea</i> . L		✓		✓							✓	
5	<i>Curcuma longa</i> . L		✓					✓				✓	
6	<i>Coffea arabica</i> . L			✓					✓				✓
7	<i>Hibiscus rosa-sinensis</i> . L			✓				✓					✓
8	<i>Lantana camera</i> . L				✓				✓				✓
9	<i>Nyctanthes arbor-tristis</i> . L				✓				✓				✓
10	<i>Rosa indica</i> .L			✓					✓				✓



Plate 5. Natural ink filled in ink pens

Summary and Conclusion

Azadirachta indica Juss., *Beta vulgaris* L, *Bougainvillea spectabilis* Willd, *Clitoria ternatea* L, *Curcuma longa* L, *Coffea arabica* L, *Hibiscus rosa-sinensis* L, *Lantana camera*. L. *Nyctanthes arbor-tristis*. L., *Rosa indica*. L. produced Green, Dark pink, pink, blue, yellow, brown, red, black, orange and red. The ink produced is eco-friendly, non-toxic and non-polluting.

pH of the ink ranged from 5-7. The penetration time of ink ranged from 2-8 seconds. No notable discoloration of ink was noted. The natural ink resisted to rubbing.

As the demand for eco-friendly alternatives to traditional inks continues to grow, the future prospects for plant extract inks are promising. Research and development in this field are expected to focus on several key areas to enhance the performance, sustainability, and commercial viability of plant-based inks. One of the primary research directions will be to improve the performance characteristics of plant-based inks, such as their color intensity, durability, and resistance to water and light. This may involve the discovery of new plant sources with superior pigment properties or the development of novel formulations that enhance the stability and quality of the ink. Research will likely explore a wider variety of plant species to identify new sources of pigments and other ink components. This diversification can help ensure the sustainability of the ink production process by reducing reliance on a limited number of plant species.

Furthermore, the integration of these plant-derived colorants in food coloring, ink production, and stamp pad manufacturing proved successful. Beetroot,

Nyctanthes arbor-tristis and turmeric dyes were able to impart attractive hues to food substrates, create high-quality inks, and produce long-lasting stamp impressions, demonstrating their versatility and adaptability. The findings of this study highlight the significant advantages of natural dyes over their synthetic counterparts. These plant-based colorants offer ecofriendly, sustainable, and often safer alternatives that can meet the growing demand for environmentally conscious and health-conscious products. With further optimization of extraction and application techniques, the scope for utilizing these natural resources in diverse industries can be further expanded. In conclusion, this research underscores the immense potential of beetroot, red cabbage, and turmeric as viable natural dye sources, paving the way for their wider adoption and integration across various fields. The successful demonstration of their performance in textile dyeing, paper indicators, food coloring, ink manufacturing, and stamp pads reinforces the feasibility of these plant-based alternatives as sustainable and environmentally friendly solutions.

Natural inks from plants offer a beautiful environmentally conscious option for artists, calligraphers and those seeking eco – friendly alternatives, However, they come with certain limitations like fading and consistency issues, requiring care and creativity to use effectively.

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