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Extraction of natural dye from flowers and dyeing cotton

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Abstract

Flowers produce bright shade dyes due the presence of pigments such as Anthocyanins, Carotenoids and Flavonoids. These pigments can be extracted in acidic, alkaline and neutral mediums. Flowers such as *Clitoria ternatea, Caesalpinia pulcherrima* (Pink) and *Tagetes erecta* were selected for this study of dye extraction. The experiment was conducted in two factor factorial, complete randomized design (CRD) with three replicates. Microwave dried and crushed flowers were Extracted in citric acid solution 5% (w/v), baking soda solution 5% (w/v) and water. Mordants such as, vinegar (20% v/v), baking soda 4% (w/v), salt 4% (w/v), cream of tartar 4% (w/v) and water were used to fix the extracted dye in the cotton fabric. Colour intensity of the dyed cloths was estimated from the lightness values obtained by colorimeter. The data were subjected to analysis of variance using SAS (9.1) software and the means were separated using Duncan's multiple range test. Blue colour *Clitoria ternatea* flower gave blue, pink and dark green colour shades for aqueous, acidic and alkaline extracts, respectively. *Caesalpinia pulcherrima* produced purple, dark pink and brown shade colours for aqueous, citric acid and baking soda extracts, respectively. *Tagetes erecta* produced different shades of yellow colour for all the extracts. The results indicated that, pH influences in colour of the dyes extracted from flowers and the colour intensity of the dyed cloths vary according to both the extractants and the mordants used. The present study clearly revealed the potentialities of natural dye extraction and dyeing of fabrics using natural flowers.

Key words: Cotton, Extractants, Mordants, Flowers, Natural dye.

1. Introduction

Flowers are ephemeral, beautiful, complex structures. They are the defining feature of Angiosperms (flowering plants), which today make up approximately 90% of land plant biodiversity in terms of species number [1]. Since ancient times, scientists, gardeners, and artists have all been astounded by the variety of flower colour. Flowers produce colour by reflecting only a portion of the white light's spectrum, giving them a coloured look. This is accomplished either by using chemical pigments that absorb specific wavelengths, or by the usage of using structures that only reflect specific wavelengths. One of the most amazing variances is in bloom colour, which comes in an almost infinite variety of colours ranging from near black to pure white. Petals are often the most colorful and showy part of the flower.

Nowadays, people enjoy having a wide variety of colours in their attire. Due to their wide colour spectrum, outstanding colour fastness qualities, usability, and reproducibility, several types of synthetic dyes are now in high demand for the creation of coloured fabrics. As a result, the textile dyeing industry is one of the most polluting industries which produces a significant amount of harmful coloured effluent Synthetic dyes can be harmful to human health when used on household fabrics and cause environmental contamination during all stages of production. Artificial colours are difficult to break down. They accumulate biologically in the environment [2].

Natural dyes are more popular due to its non-hazardous and wide applicability such as pharmaceuticals food, cosmetics, leather, and in different art of dyeing. Due to the non-biodegradable and carcinogenic nature of synthetic dyes, there is currently a high demand for the usage of natural colours all over the world [3]. Natural dyes are the safest colours since they do not produce any undesirable by-products and, at the same time, contribute to environmental regeneration [4].

The hue of extracts from anthocyanin-rich flowers can be a valuable source for textile dyeing. Colors of dye obtained from plants are due to presence of Tannins, Anthocynins, Flavonoids and other Phytochemicals thus a single compound is not responsible for color of plant-based dye. Mordants are typically used in natural colouring. Many natural dyes that would otherwise just wash out are able to achieve adequate wash fastness thanks to the mordant. A mordant, which holds the colour, stays in the fibre forever [5].

The use of natural dyes in the colouring of textile materials is regaining interest as a result of the stringent environmental regulations in textiles and apparel enforced by nations concerned with nature and health protection [6]. People are being forced to choose natural dyes due to the toxicity and allergic reactions of synthetic dyes. Natural dyes are an environmentally friendly source of colouring agents. In addition to textiles, it is used to colour meals, medicines, and other goods. Although natural dyes are safe for the environment, skin-friendly, and eye-pleasing, they have very poor bonding with textile fibre materials and must be fixed on textile fibres using metallic mordants, some of which are not environmentally friendly. This calls for more recent studies on the use of natural dyes on various textiles. This study was conducted to study the possibilities of extracting dyes from different flowers using various extractants and to study the effects of different mordants on fixing the dye on cotton fabric

1.1 Subsections

Divide your article into clearly defined and numbered sections. Subsections should be numbered 1.1 (then 1.1.1, 1.1.2, ...), 1.2, etc. (the abstract, Acknowledgements, and References are not included in section numbering). Use this numbering also for internal cross-referencing: do not just refer to "the text". Any subsection may be given a brief heading. Each heading should appear on its own separate line.

1.2 Format

Text should be produced within the dimensions shown on these pages; each column 8.47 cm wide with 0.85 cm middle margin, total width of 17.78 cm and a maximum length of 21cm on the first page and 23.5cm on the second and following pages. Make use of the maximum stipulated length apart from the following two exceptions: (i) do not begin a new section directly at the bottom of a page, but transfer the heading to the top of the next column; (ii) you may exceed the length of the text area by *one line only* in order to complete a section of text or a paragraph.

You must use 1.0 (single) line spacing. However, when typing complicated mathematical text, it is important to increase the space between the text lines in order to prevent sub- and superscript fonts overlapping one another and making your printed matter illegible.

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Research Manuscript Sections for Original Research paper may include Introduction, Material and Methods, Results and Discussion and Conclusion. For the Review articles another may select desired section depending on the nature of article or section of review article may include Introduction, Body, Discussion and Conclusions.

2. Materials and Methods

2.1 Study area

The experiment was carried out at Crop Science Laboratory, JICA (Japan International Cooperation Agency) Training and Research Complex, Department of Agronomy, Faculty of Agriculture, University of Jaffna from March 2022 to July 2022.

2.2 Experimental design

The experiment was conducted in two factor factorial complete randomized design (CRD) with three replicates. The extractants used to extract the dye from the flowers and the mordants used to fix the dye in the fabric were taken as treatments. The treatment combinations tested in the experiment were given in Table 1.

Table 1
Treatment and their Combinations.

Extractants	Mordants	Treatment code
Water – Control (E1)	Water – control(M1)	E1M1
	Vinegar (M2)	E1M2
	Baking soda (M3)	E1M3
	Salt (M4)	E1M4
	Cream of tartar (M5)	E1M5
Citric acid (E2)	Water – control (M1)	E2M1
	Vinegar (M2)	E2M2
	Baking soda (M3)	E2M3
	Salt (M4)	E2M4
	Cream of tartar (M5)	E2M5
Baking soda (E3)	Water – control (M1)	E3M1
	Vinegar (M2)	E3M2
	Baking soda (M3)	E3M3
	Salt (M4)	E3M4
	Cream of tartar (M5)	E3M5

2.3 Selection of flowers for the extraction

Three flowers were selected for this experiment. They are, *Clitoria ternatea, Caesalpinia pulcherrima*(Pink) and *Tagetes erecta*

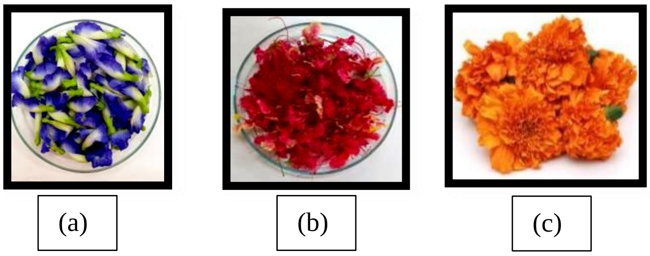


Fig 1: Flowers used to extract the dye, (a). *Clitoria ternatea, (b). Caesalpinia pulcherrima(*Pink*), and (c). Tagetes erecta*

2.4 Equipment

Microwave oven, grinder, weighing balance, water bath shaking machine, pH meter and colorimeter were used in this study.

2.5 Preparation of flowers for extraction

Petals are the parts of the flower which bear colourful pigments, therefore only the petals were removed and the other flower parts were left out. Then the petals were placed in a microwave oven in medium heat for 2 minutes. After the petals were fully dried, they were crushed into fine particles with the help of the grinder machine. Then the crushed petals were weighed to 4g for further processing

2.6 Preparation of extractants

For the extraction, acidic, alkaline and neutral solvents were used. For the acidic medium, 5g of citric acid was dissolved in 100 ml of water to make 5% (w/v) solution and for the alkaline medium, 5g of baking soda was dissolved in 100ml of water to make 5% (w/v) solution. Water was used as the neutral medium (control).

2.7 Extraction

4g of crushed petals were dissolved in 100ml of each solutions and kept in a water bath shaking machine at 50ºC for 1hour. After that, the extracted dye was filtered by using a clean cotton cloth to remove tiny floral trashes. The pH values of the extracted dyes were measured using a pH meter and the lightness of the dyes were measured by the colorimeter.

2.8 Mordanting

Mordanting was done to fix the dye in the cotton fabric. Pure white cotton cloths with the size of 10cm x 10cm were taken and Mordant solutions were prepared.
Mordants used for the study were,

- Water - control
- Vinegar – 20% (v/v)
- Baking soda – 4% (w/v)
- Salt – 4% (w/v)
- Cream of tartar – 4% (w/v)

Cotton cloths were soaked in 250 ml of each mordant solutions and kept in the water bath shaking machine at 80ºC for 1hour for mordanting process.

2.9 Dyeing

After 1hour of mordanting, the cotton cloths were taken out of the mordant solutions and soaked in the dyebath for 24 hours. Then, the dyed fabrics were washed well in the water and allowed to dry in the room temperature. The dried cloths were taken to measure the colour intensity.
Colorimeter was used to measure the lightness values of the dyed fabric. Lightness values were taken for 3washes of the dyed samples. The readings obtained from the colorimeter were subjected to analysis of variance by using SAS 9.1 computer software package and the mean separation was done by using Duncan's Multiple Range Test.

3. Results and Discussions

3.1 pH values of the extracted dyes

The pH values of the dyes extracted by the water showed the neutral pH, ranging between 6 and 7. Among those, the dyes obtained from *Tagetes erecta* showed slightly lower pH than the neutral. The dyes extracted by citric acid solution gave acidic pH, ranging from 2 to 3 and the dyes obtained by baking soda solution extraction, gave alkaline pH ranging from 8 to 9.

Table 2
pH values of the extracted dyes

Flowers	Water (E1)	Citric acid (E2)	Baking soda (E3)
Clitoria ternatea	6.14	2.49	8.34
Caesalpinia pulcherrima (Pink)	6.76	2.61	8.39
Tagetes erecta	5.87	2.51	8.47

3.2 Lightness values of the extracted flower dyes

The lightness (L*) values were obtained from the colorimeter readings. A lightness value of L*=0 represents the darkest black whilst a value of L*=100 is equivalent to the brightest white. Therefore, the colour intensity of the dyes are higher, when the lightness values are lower.

Table 3
Lightness values of the flower dyes extracted from different solutions

Flowers	Water (E1)	Citric acid (E2)	Baking soda(E3)
Clitoria ternatea	7.39	9.76	13.79
Caesalpinia pulcherrima (Pink)	14.91	11.9	4.31
Tagetes erecta	10.47	16.82	8.94

3.3 Colour shades of the extracted dyes and the dyed cloths

Clitoria ternate

The major pigment responsible for the colour of *Clitoria ternatea* flower is anthocyanin [7,8]. Anthocyanin have the tendency to change colours according to the pH [9,10]. At pH lower than 3.2, red and red shade colours exist, when pH ranges from 3.2 to 8.2, blue and blue shaded colours exist and when pH is greater than 8.2, dark green colour exist (Table 4).

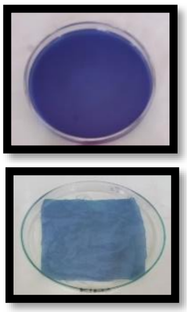
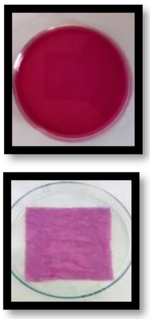
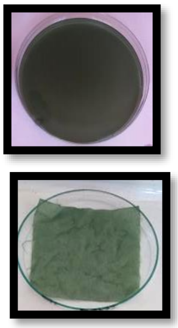
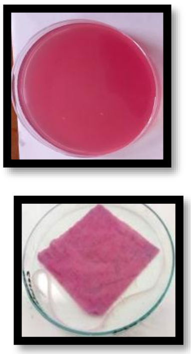
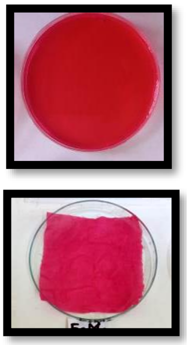
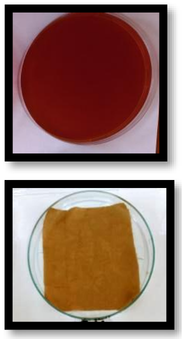
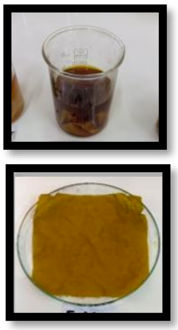
***Caesalpinia pulcherrima* (Pink)**

The major pigment responsible for the colour of the *Caesalppinia pulcherrima* flowers anthocyanin [11]. The usage of citric acid (E2) as a solvent to extract anthocyanin shown good stability than the other solvents.

Tagetes erecta

Marigold flowers have a high lutein content (zeaxanthin), which is responsible for the intensity of the colour of the dyed cloths [12].

Table 3 Flower dye and dyed cloth using dye extracted by the different extractants

	Water (E1)	Citric acid (E2)	Baking soda(E3)
Clitoria ternatea			
Caesalpinia pulcherrima (Pink)			
Tagetes erecta			

3.4 Colour washing fastness of the dyed cloths from each extractants

Wash fastness of dye is influenced by the rate of diffusion of dye and state of dye inside the fiber. For each extractants, the mordanted cloths with high lightness value gave light colour meanwhile the mordanted cloths with low lightness value gave dark colour comparatively. The overall lightness values of dyed cloths increased after every wash. It shows that the colour intensity of the dyed cloths decreased after washing.

The washing fastness of the dyed cloths under different extractant are given in Table 05.
Among all extractants citric acid was performed well than other extractants but there was no any significant difference among the extractants. Most of the natural dyes have no substantively on cellulose or other textile fibers without the use of a mordant. The majority of natural dyes need a mordanting chemical (preferably metal salt or suitably coordinating complex forming agents) to create an affinity between the fiber and dye or the pigment molecules of natural colorant. These metallic salts as mordant form metal complexes with the fibers and the dyes [13]. After mordanting, the metal salts anchoring to the fibers, attracts the dye/organic pigment molecules to be anchored to the fibers and finally creates the bridging link between the dye molecules and the fiber by forming coordinating complexes. In the study of *Clitoria ternatea* and *Caesalpinia pulcherrima* flowers; The cream of tartar, baking soda and vinegar were performed well as mordants than others in water, citric acid and baking soda extractants, respectively. In the study of *Tagetes erecta*; vinegar, salt and baking soda were performed well as mordants than others in water, citric acid and baking soda extractants, respectively.

Table 5: Colour washing fastness of the dyed cloths from each extractants

	Extractants	Mordants	*Clitoria ternatea*	*Caesalpinia pulcherrima* (Pink)	*Tagetes erecta*
Wash 1	Water(E1)	Water(M1)	56.08^{a}	52.58^{a}	60.19^{a}
		Vinegar(M2)	52.03^{c}	50.06^{b}	59.21^{b}
		Baking soda(M3)	45.07^{e}	49.60^{c}	52.61^{e}
		Salt(M4)	49.12^{d}	45.92^{d}	54.69^{b}
		Cream of tartar(M5)	56.17^{b}	49.74^{e}	56.64^{c}
	Citric acid(E2)	Water(M1)	54.22^{b}	40.13^{e}	44.34^{e}
		Vinegar(M2)	54.47^{a}	48.27^{a}	49.21^{b}
		Baking soda(M3)	50.24^{d}	42.49^{c}	47.51^{c}
		Salt(M4)	49.17^{e}	44.48^{b}	46.14^{d}
		Cream of tartar(M5)	51.68^{c}	41.04^{d}	50.31^{a}
	Baking Soda(E3)	Water(M1)	60.16^{b}	46.33^{e}	59.47^{a}
		Vinegar(M2)	63.69^{a}	48.58^{d}	54.19^{c}
		Baking soda(M3)	55.14^{d}	54.48^{a}	55.02^{b}
		Salt(M4)	53.63^{e}	50.43^{c}	50.42^{d}
		Cream of tartar(M5)	58.48^{c}	52.25^{b}	49.32^{e}
Wash 2	Water(E1)	Water(M1)	59.28^{a}	57.13^{a}	62.49^{b}
		Vinegar(M2)	58.92^{b}	54.54^{b}	63.50^{a}
		Baking soda(M3)	52.17^{e}	51.62^{c}	57.79^{e}
		Salt(M4)	52.67^{d}	49.34^{d}	60.31^{d}
		Cream of tartar(M5)	58.23^{c}	47.67^{e}	61.51^{c}
	Citric acid(E2)	Water(M1)	58.33^{b}	43.39^{d}	57.49^{d}
		Vinegar(M2)	59.47^{a}	51.46^{b}	65.46^{a}
		Baking soda(M3)	52.84^{d}	43.75^{d}	59.56^{c}
		Salt(M4)	51.34^{e}	48.39^{c}	54.52^{e}
		Cream of tartar(M5)	53.82^{c}	58.45^{a}	61.42^{b}
	Baking Soda(E3)	Water(M1)	67.60^{a}	50.17^{e}	59.46^{a}
		Vinegar(M2)	63.05^{c}	56.16^{d}	54.50^{c}
		Baking soda(M3)	59.62^{d}	64.32^{b}	55.33^{b}
		Salt(M4)	58.54^{e}	58.12^{c}	50.63^{d}
		Cream of tartar(M5)	63.39^{b}	65.04^{a}	49.61^{e}
Wash 3	Water(E1)	Water(M1)	61.56^{a}	58.48^{a}	73.69^{a}
		Vinegar(M2)	60.65^{b}	55.65^{b}	63.55^{c}
		Baking soda(M3)	55.67^{c}	53.29^{c}	60.49^{e}
		Salt(M4)	54.59^{d}	56.31^{b}	62.25^{d}
		Cream of tartar(M5)	60.64^{b}	52.75^{c}	64.70^{b}
	Citric acid(E2)	Water(M1)	60.75^{b}	45.49^{c}	60.49^{c}
		Vinegar(M2)	62.62^{a}	53.52^{b}	66.37^{a}
		Baking soda(M3)	54.30^{d}	45.59^{c}	62.56^{b}
		Salt(M4)	53.61^{d}	52.78^{b}	56.31^{d}
		Cream of tartar(M5)	56.56^{c}	61.29^{a}	62.53^{b}
	Baking Soda(E3)	Water(M1)	67.68^{b}	54.54^{d}	63.22^{a}
		Vinegar(M2)	69.46^{a}	60.39^{c}	57.60^{b}
		Baking soda(M3)	62.32^{d}	66.65^{b}	56.22^{c}
		Salt(M4)	61.51^{e}	61.18^{c}	53.58^{d}
		Cream of tartar(M5)	66.39^{c}	68.54^{a}	52.52^{e}

Means with the same letter within given type of extractants are not significantly different at p=0.05

Conclusions

Natural dyes can be successfully extracted from the flowers of *Clitoria ternatea*, *Caesalpinia pulcherrima* and *Tagetes erecta*. Natural dyes could be able to extract from the eco-friendly extractants. The whole process of extraction and dyeing is ecologically safe. Different shades of color were obtained by using different chemical mordants in all the extractants systems. Good lightness and washing fastness exhibited by the dyed cloth is because of the mordants used. All the solvent extracts exhibit unique shades and affix it deeply to the cotton fabric. The extracted dyes could be successfully applied to the cotton fabrics with the presence of the mordants as fixative agents.

Conflicts of Interest

There are no conflicts to declare.

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