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Research Article

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Fabric dyeing with natural dye extracted from *Basella alba* fruit and spectroscopic analysis of the extract at different conditions

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ABSTRACT

The present investigation was carried out to extract natural pigment from the fruits of Basella alba plant. The dye was extracted with methanol and then centrifuged at 10000 rpm and the supernatant was taken for analysis. The Basella alba fruit dye was used for dyeing the scoured cotton cloth as such and also using mordants like alum, $FeSO_4$ and $CuSO_4$. The dye component was extracted and dyeing of cotton was also studied. The spectroscopic characteristics of natural dyes on fabrics and also with the biopolymer carboxymethyl cellulose were also determined. The effect of pH on the extracted dye was studied and it was found that at different pH range dyed fabrics have different color. The interaction between natural dye and cationic surfactant like N-Cetyl Pyridinium Chloride monohydrate (NCPC) & anionic surfactants like sodium dodecyl sulphate (SDS) was also done for improving the dyeing process in respect of theoretical, technological, ecological and economical points of view. It is found that pigments from Basella alba fruits was moderately applicable in dyeing of cotton fibre as well as other fibres also. These findings also suggest that Basella alba is a rich source of betalains and could have potentiality for use in the development of food colorants, cosmetics, paper coloring, use as acid-base indicator and nutraceuticals in future.

Keywords: Natural dye, *Basella alba*, mordants, surfactant, scouring, fabrics.

INTRODUCTION

Dyeing is the most important part in the production of fabric. But the use of natural dyes for textile dyeing purposes, decreased to a large extent after the discovery of synthetic dyes in 1856[1]. Although available at a cheaper cost, use of synthetic dyes led to such consequences as carcinogenicity and inhibition of benthic photosynthesis [2]. The chemicals used for dying purpose are toxic to the environment also. Textile processing industry is one of the major environmental polluters. It is estimated that 10-15% of the dye is lost in the effluent during the dyeing process [3].
Environmental impact of textile processing can be controlled by two ways. One is to construct sufficiently large and highly effective effluent treatment plants and the other way is to make use of dyes and chemicals that are environment friendly. Therefore, more interest has been shown in the use of natural dyes and a limited number of commercial dyes since the mid 1980s, and small businesses have started to look at the possibility of using natural dyes for coloration [4]. Plants are known to produce some of the most valued dyes in the world for their natural, beautiful and durable colours. The natural dyes are clinically safer than their synthetic analogues in handling and use because of non-carcinogenic and biodegradable nature.

Natural dyes have become a part of human life since time of immemorial. Natural dyes exhibit better biodegradability and generally have a higher compatibility with the environment; also they possess lower toxicity and allergic reactions than synthetic dyes [7]. Natural dyes have many excellent properties such as little side effect, high safety factor, biodegradable, green environmental protective. Some natural dyes have certain therapeutic effect and health function. Natural pigments from plants have attracted great attention for their usefulness, not only in the food and cosmetic industries but also in nutraceutical and pharmaceutical developments.

Sometimes dyeing textile using natural dyes are found to yield poor colour, have inadequate fastness properties. To overcome such hassle mordants are used. Metal ions of mordants act as electron acceptors for electron donors to form co-ordination bonds with the dye molecule, making them insoluble in water. Common mordants used are alum, chrome, stannous chloride, copper sulphate, ferrous sulphate etc. [5]

Surfactants containing both hydrophilic and hydrophobic moieties are extensively used in our daily life and also in various industrial processes like textiles industry. Surfactants are required for level dyeing and so on. The surfactants act mostly in two ways, either they can form a complex with ionic dyes or they can be absorbed into the fiber. Surfactant-dye associations are important in various dyeing process such as textiles dyeing, photography and in pharmaceuticals processes. Generally surfactants are added to the dyeing system to thicken the dye product solution for better handling and to help to get homogeneous dyeing results.

The studies on the interaction between natural dyes and surfactants are important and interesting for improving the dyeing process from theoretical, technological, ecological, and economical points of view. However, not much attention has been made on the interaction between natural dyes and surfactants. Recently, the interaction between some natural dyes (Rubia cordifolia and Punica granatum) with anionic and cationic surfactants has been made and the results were found to be encouraging. Therefore, it is worthwhile to make further studies involving some more natural dyes.

The fruit extract of *Basella alba* could be successfully used for dyeing of cotton to obtain a wide range of soft and light colours by using combination of mordants. *Basella alba*, commonly known as Spinach or Malabar spinach belongs to the family Myrt Basellaceae.

Taxonomy of the Plant:
Kingdom: Plantae
Phylum: Magnoliophyta
Class: Magnoliopsida
Order: Caryophyllales
Family: Basellaceae

Genus: Basella
Species: alba

In the present investigation fruits from *Basella alba* plant were used for extracting the dye and examined its possible usage in textile colouration. The effect of mordants employed in the dyeing with the *Basella alba* dye were also studied. The current studies also dealt with the spectroscopic properties of the natural dye in presence of polymer and surfactants.

EXPERIMENTAL SECTION

2.1 Materials:
The following materials are used during the investigation:
1) Polymer: Carboxymethyl Cellulose (CMC)
2) Surfactants: Sodium Dodecyl Sulphate (SDS) as anionic surfactant and N-Cetyl Pyridinium Chloride monohydrate (NCPC) as cationic surfactant.

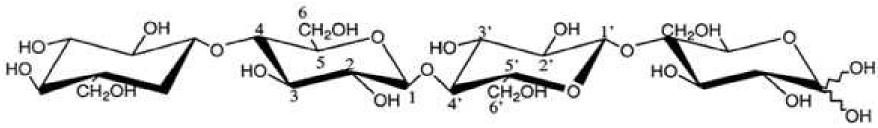


Fig-1: Structure of Carboxymethyl Cellulose (CMC)

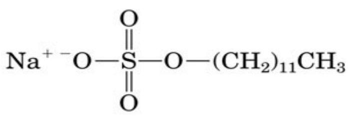


Fig-2a: Structure of SDS

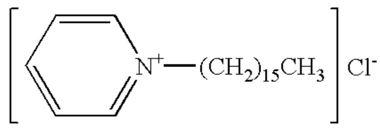


Fig-2b: Structure of NCPC

3) Mordants: Alum, Copper sulphate ($CuSO_4$) and Ferrous sulphate ($FeSO_4$)
4) Cotton fiber
5) Extracted *Basella alba* pigment

2.2 Method of Extraction of the Dye for dyeing cotton:

2.2.1 Sample collection:
Basella alba fruits were collected from Agartala, West Tripura and stored in sealed polyethylene bag at 4^0C until extraction.

2.2.2 Extraction of the dye:
0.5gm of *Basella alba* were treated with 10 ml acidified methanol, the mixture was centrifuged at 10,000 rpm for 10 min and supernatant was taken for analysis.

2.3 Confirmatory tests for the pigments:

2.3.1 Test for flavonoid:
Test 1: 1 ml of sample extraction was added with a small amount of $FeCl_3$. In the presence of $FeCl_3$, the acidified extract showed brown color which confirms the presence of flavonoids.

Test 2: 1 ml of sample extraction was added with 5% of $AlCl_3$ solution. In the presence of aluminum chloride the same extract showed dark color which confirms the presence of flavonoids.

2.3.2 Test for betacyanin:
Test 1: 1 ml of the sample extraction was added with 2ml of 2(M) HCl for 5 minutes at 100^0C. The extract was unstable after adding 2(M) HCl which confirms the presence of betacyanin.

Test 2: 1 ml of the sample extraction was added with 2ml of 2(M) NaOH. The extract changes the color to yellow after adding 2(M) NaOH which confirms the presence of the pigment betacyanin

2.4 Method of dyeing:

2.4.1 Chemicals used:

The basic chemicals used were sodium-carbonate and alum, ferrous-sulphate & copper-sulphate as mordants.

2.4.2 Scouring of cotton:

Cotton cloth was washed in a solution containing 0.5 g/L sodium carbonate and 2 g/L non-ionic detergent solution at 50^0C for 25 min. The ratio maintained during scouring was 1:40. This was followed by washing of the scoured material thoroughly with running water and then with de-ionized water which was then allowed to dry out completely at room temperature.

2.4.3 Mordanting:

The scoured material was soaked in de-ionized water for 30 min and then mordanted with different mordent like alum, chrome, ferrous- sulphate and copper-sulphate. 16g mordant was dissolved in 200ml de-ionized water to make the liquor. The wetted sample was then entered into the mordant solution which was then brought to heating in the dye bath at 80^0C for a period of half an hour and was left in that state of heating for half an hour. The mordant material was then rinsed, squeezed and dried. Mordant cotton clothes needed be used immediately for dyeing because some mordants are very sensitive to light. Different cloths have different texture after mordanting.

2.4.4 Dyeing:

The cotton cloth samples was dyed with fruit extract solution directly and gently boiled for 45 min by maintaining the temperature at 75^0C on a hot plate. The pH was maintained at 4. The samples were kept overnight along with the boiled fruit extract, next day then air dried. Washing of the clothes were performed first with running water and then with washing soap to see the consistency of the color.

2.5 Spectroscopic analysis of the extract at different conditions:

2.5.1 Absorption spectra of the dye:

To perform the absorbance studies the main extracted dye was used directly and hence the used solution was the stock solution of the dye. It was kept in dark. Absorbance of the solution was measured at wavelength ranging from 330-640nm with a UV-VIS spectrometer model LT-29 (wavelength 200-700nm, light used tungsten lamp for visible range 350-700nm).

2.5.2 Spectral behaviour of the dye under different pH range:

For spectral studies of the dye at different pH, three solutions were prepared as in the table-

Solution	*pH Value*	*Colour of the solution*
Water (3cc) + Dye (2cc)	5.1	Violet
Buffer (pH= 4) + Dye (2cc)	4.45	Dark Violet
Buffer (pH= 9) + Dye (2cc)	8.14	Pink

The solutions were kept in the dark and protected from light by wrapping the container with black paper. Absorbance of the solutions were measured at wavelength ranging from 350-700nm.

2.5.3 Interaction of the dye with polymer (CMC):

To study the interaction of the extracted dye with polymer different polymer/dye ratio was made. The absorbance of the solution was measured.

2.5.4 Interaction of the dye with surfactant:

For studying the miceller effect on the dye, to a fixed concentration of dye, increasing amounts of surfactants were added and spectral measurements of each solution was measured at 300-650nm.

RESULTS AND DISCUSSION

The present investigation dealt with the studies on the physical properties of the dye extracted from *Basella alba* and several physico-chemical properties of the dye in respect of interaction with the polymer, surfactant and also effects at different pH on the spectral behaviour of the dye.

From the physical properties of the dye, it was observed that the pH of the main extracted dye is 4.9 (measured by the pH meter). The original color of the dye is violet. But a sharp change of color can be observed with the change in pH. At pH 5.1 it remains violet but at pH 4.45 the color changes to deep violet and at pH 8.14 the color becomes pink.

The color of the extracted dye is mainly due to the presence of two pigments namely**;** Betacyanin and Flavanoid were confirmed by their specific test as described earlier.

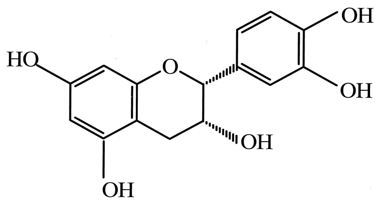


Fig-3a: Structure of flavanoid

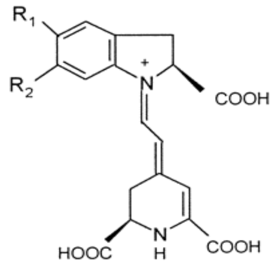


Fig-3b: Structure of betacyanin

The literature survey revealed that the major red pigment present in dye extract is gomphrenin-I (fig-4a). Gomphrenin-I must be the compound of betalain family, an important betacyanin compound. *Basella alba* is also a rich source of β-carotene (fig-4b). The quality of gomphrenin-I increased with the increase of fruit maturity. The gomphrenin-I extract yield from ripe fruits was 36.1mg/100g of fresh weight.

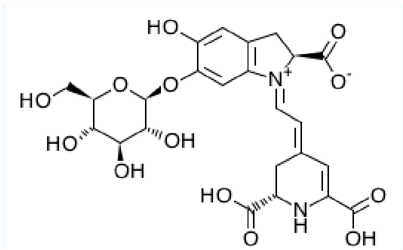


Fig-4a: Structure of Gomphrenin-I

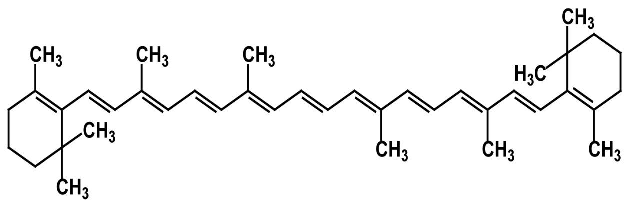
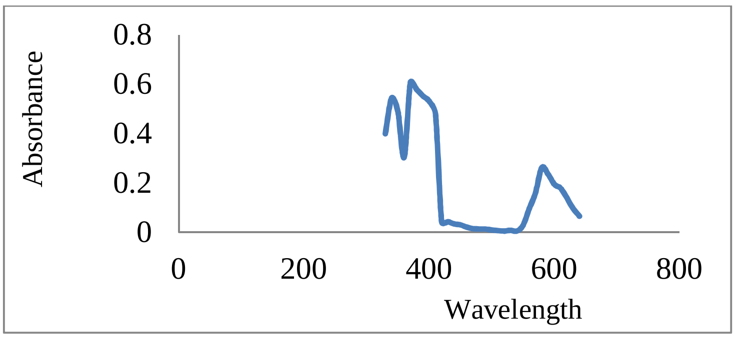


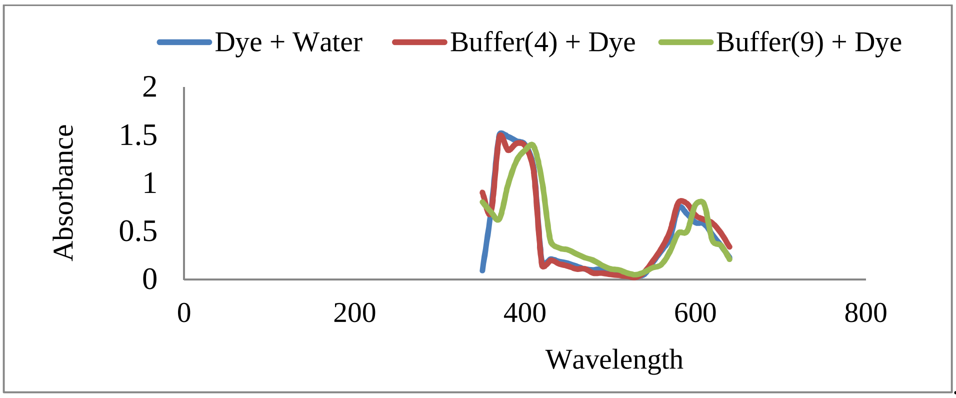
Fig-4b: Structure of β-Carotene

Different spectrochemical studies were carried out with the dye extracted from *Basella alba* fruit using UV-VIS Spectrophotometer (Model LT-29). From the absorbance v/s wavelength graph (Scheme-1) of the original dye, it can be observed that there are several peaks of varying intensities. Two prominent peaks at around 340nm and 590nm wavelength are observed of intensities 0.5 and 0.3 (approximately) respectively, which confirms the presence of mixture of coloring pigments.



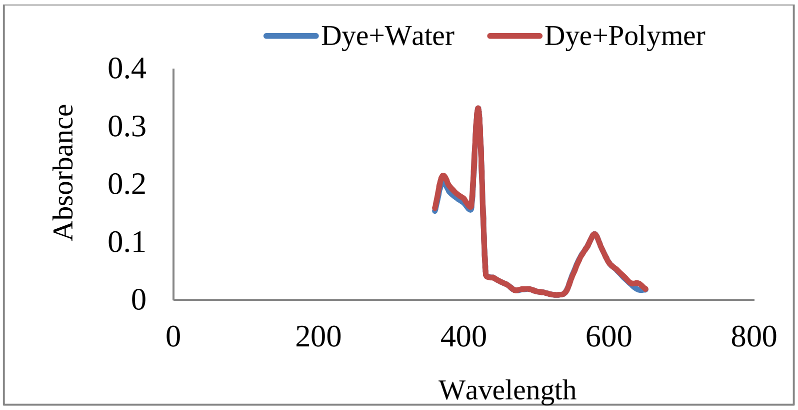
Scheme-1: ***Absorbance v/s Wavelength graph for the original dye extract***

With the change of the pH, the color of the dye goes on changing and hence a significant variation of spectral graph with respect to wavelength and intensities of peaks are expected. The graph shows a small variation with change in pH that supports the variation of color of the dye at different pH.

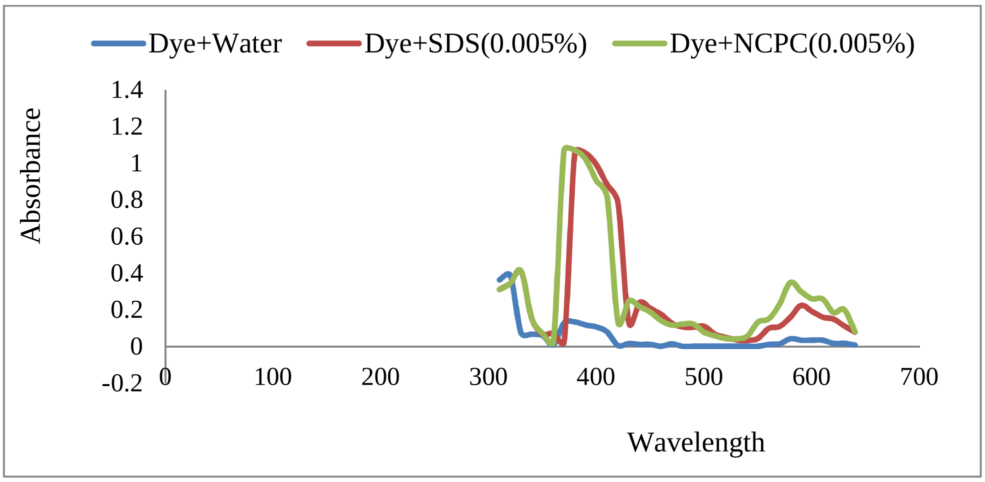


Scheme-2: ***Absorbance v/s Wavelength graph for dye/buffer interaction***

No fruitful result was found in dye-polymer interaction, as Scheme-3 showed no significant change in the measurement of intensities and wavelengths. The two graphs overlap with each other and hence we can say that the dye and the polymer under investigation did not interact with each other. Detailed study on this may give more information in future.



Scheme-3 ***Absorbance v/s Wavelength graph for dye/polymer interaction***



Scheme-4: Absorbance v/s Wavelength graph for dye-surfactant interaction

Interaction with the Surfactants was investigated with SDS and NCPC at different concentrations of the surfactants using. The interaction with the surfactants (Scheme-4) was much more satisfactory at concentration 0.005%. It was found that the rate of dye formation in the dyeing solution increase with the increase in the concentration of surfactants. Further there is a little variation of change in colour with the addition of surfactants which is understandable from the graph.

Further we had seen that with using different types of mordants we can input different color to the fabric. Mordants play very important role in imparting color to the fabric. In this context ferrous sulphate and copper sulphate plays an important role, have the ability of forming co-ordination complexes. In presence of alum dyeing was not very satisfactory. Most of the metal salts exhibited greater color strength due to their ability to form coordination complexes with dye moles. This strong co-ordination tendency of metals enhances the interaction between the fiber and the dye, resulting in high dye uptake, while all other metals show similar co-ordination [8].

The mordants used in combination in different ratios gave varying shades. Better color strength results are dependent on the metal salt used. The good light fastness is due to the formation of a complex with transition metal which protects the chromophore from photolytic degradation. The mordanted cotton cloth was immediately used for dyeing because some mordants are light sensitive. The chromophore of the dye makes it resistant to photochemical attack, but the auxochrome may alter the fastness [4].

Fig-5a: Dyed cotton at low pH 4.45 with & without mordant

Fig-b5: Dyed cotton at high pH 8.14 with & without mordant

CONCLUSION

1) The present investigation isolated from *Basella alba* fruits are moderately applicable on dyeing of cotton fibre.
2) *Basella alba* fruit extract can effectively be used as a coloring agent in paper industries.
3) The pigments could be useful as hair dyeing and as colorants in food and cosmetics by proper conditioning.
4) As the extracted dye is natural it is safer and environment friendly.
5) The color of the dye is pH sensitive as it gives different color at different pH (Violet at acidic and pink at basic)

6) In the dyeing process mordant played vital role as the cotton cloth mordanted with $CuSO_4$, $FeSO_4$ and alum showed different colour to the fabric.
7) Surfactants also have effective role in fabric dyeing as observed in spectral studies.

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