Extraction Of Pigments from Peels of Musa Acuminata and Musa Acuminata Red Dacca and Their Applications in Textile Fabrics

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***Abstract*— Natural dyes have been receiving considerable importance due to their eco-friendly, biodegradable, and non-toxic nature compared to synthetic dyes. The present study is focused on the extraction, characterization, and utilization of natural pigments like carotenoids and anthocyanins from Musa acuminata and Musa acuminata red dacca. The natural pigments are extracted by using suitable organic solvents. The presence of bioactive compounds is detected by conducting preliminary confirmatory tests. Fourier Transform Infrared (FTIR) spectroscopy is conducted to confirm the presence of the natural pigments. In the FTIR spectrum, the presence of hydroxyl, carbonyl and aromatic compounds is detected. Dynamic Light Scattering (DLS) test was conducted for analyzing the particle size of the extracted pigments, and it showed that they have moderate particle sizes with varying degrees of dispersion. The extracted dyes were used for dyeing various fabrics using different mordants for assessing the efficiency of dyeing. The color change, texture and absorbance properties of the fabrics were found to vary depending on the interaction of fabrics and mordants. Furthermore, the fastness properties of the dyes, i.e., washability, light resistance, ironing stability, and rub fastness, were also assessed. The results showed satisfactory washability, heat stability, moderate light fastness, and satisfactory rub fastness. These results suggest the potential of natural pigments from banana peel sources for dyeing purposes. It is evident from the results that the natural pigments from banana peel sources have the potential to be used as alternative dyes in the textile industry.**

***Index Terms*— Natural dye, carotenoids, anthocyanins, pigment, mordants, biodegradable**

I. INTRODUCTION

The textile industry has traditionally relied on synthetic dyes for fabric coloration due to their strong coloring ability and stability. However, the extensive use of synthetic dyes has resulted in significant environmental pollution and health concerns. Synthetic dye production generates toxic effluents containing hazardous chemicals that contaminate water bodies and pose risks to ecosystems and human health. As a result, there has been growing interest in eco-friendly and sustainable alternatives such as natural dyes (Janani et al., 2022)

Natural pigments derived from plants, microorganisms, and animals have been used historically for textile dyeing. These pigments are biodegradable, non-toxic, and environmentally safe compared to synthetic dyes. Plant-based pigments such as carotenoids, anthocyanins, betalains and chlorophyll are responsible for the vibrant colors found in fruits and vegetables. In addition to providing color, these pigments possess beneficial biological activities including antioxidant, antimicrobial, and anti-inflammatory properties (Saravanan et al., 2011)

Banana - Musa acuminata is one of the most widely consumed fruits worldwide. The peel constitutes nearly 30–40% of the total fruit weight and is generally discarded as waste. Banana peel is rich in bioactive compounds such as carotenoids, flavonoids, phenolic compounds and anthocyanins. These compounds possess strong pigmentation properties and can potentially be utilized as natural dyes (Kadolph 2008). Utilization of banana peel as a natural

dye source offers several advantages. It helps reduce agricultural waste, promotes sustainable resource utilization, and provides an eco-friendly alternative to synthetic dyes. Furthermore, pigments extracted from banana peel may impart additional functional properties to textiles, including antimicrobial activity and antioxidant effects (Scarlett et al., 2018)

II. MATERIALS AND METHODS

Collection of samples

The sample collected was Musa acuminata and Musa acuminata red dacca. The samples were collected from the Mettupatti village, Namakal and Panchamadevi village, Karur.

Preparation And Extraction of Pigments

The collected Musa acuminata and Musa acuminata red dacca was shade dried for 3-4 days and made into dry powder. Solvent-assisted extraction was carried out by using acetone using the Soxhlet Method at 100 rpm in a Rotatory shaker for 6 hours then filtered through Whatmann No.1 filter paper and kept at 20°C for 30 mins in a condenser.

Confirmatory tests for the pigments

The confirmatory test for acetonic extract of Musa acuminata and Musa acuminata red dacca peels were performed and reported.

Thin Layer Chromatography

TLC is used to estimate the carotenoids and anthocyanins by comparing the sample spot's intensity.

FTIR analysis

Fourier Transform Infrared (FTIR) spectroscopy is an analytical technique used to determine the molecular structures and chemical bond types of substances.

DLS

Dynamic Light Scattering (DLS) is an analytical technique used to determine the particle size distribution and stability of the extracted carotenoid and anthocyanin pigment particles in solution.

Antimicrobial activity

Antimicrobial activity was conducted to determine the capacity of sample to kill bacteria such as Pseudomonas aeruginosa and Escherichia coli.

Preparation of mordants

The mordant solution was prepared by dissolving the required amount of alum in distilled water. The mordants used are potassium aluminium sulfate, sodium carbonate and sodium sufate.

Dyeing of fabrics

Pretreated fabrics were immersed in the prepared mordants using the dipping method. Mordanted fabrics were dyed under controlled temperature conditions and then dried.

Test for fabrics

The tests done for the fabrics are washability test, sunlight protection test, ironing test and rub fastness test.

III. RESULTS AND DISCUSSION

Confirmatory tests

The confirmatory test for acetonic extract of Musa acuminata and Musa acuminata red dacca peels were performed and reported.

Sulfuric acid test

Added 2-3 drops of sulfuric acid to sample and it resulted in reddish brown colour. Similar reaction was reported by (Morrow et al., 2025) showing the presence of carotenoids with distinct color change indicative of the carotenoids.

Bromine test

Added 2-3 drops of bromine solution is added to sample and it resulted in deep-yellow color. Decolorization indicates the presence of unsaturated compounds, confirming carotenoids in the sample. The same study was conducted by Ajayi et al., (2011), It indicates the presence of carotenoids.

Ferric Chloride test

Added 2-3 drops of Ferric Chloride is added to sample and resulted in formation of blue black colour. The formation of dark color indicates the presence of phenolic compound – anthocyanins in the sample.

Shinoda Test

Added magnesium ribbon and 2-3 drops of hydrochloric acid is added to the sample. It leads to formation of brownish yellow colour. The appearance of brownish colour indicates the presence of anthocyanin.

Test	Acetonic extract of Musa acuminata and Musa acuminata red dacca	Result
Sulfuric acid test	Presence of carotenoids	+
Bromine test	Presence of carotenoids	+
Ferric chloride test	Presence of anthocyanins	+
Shinoda test	Presence of anthocyanins	+

Table 1: Confirmatory tests for carotenoids and anthocyanins

Thin Layer Chromatography

In the present study the result of TLC profiling is summarized. Acetonic extract of Musa acuminata showed the presence of carotenoid and anthocyanin Rf value 0.72 and 0.59 which was similar to the Rf value of the standard which is measured as 0.67 and 0.69 (Table 2) Musa acuminata and Musa acuminata red dacca extract posse's carotenoid and anthocyanin compound. It is reported that it posses yellowish-orange and yellowish red coloured spot on Acetone with Rf value 0.72 and 0.59(Mamatha Chandra Singh et al., 2022)

Compound	Rf value
Standard – Carotenoid	0.67
Standard – Anthocyanin	0.69
Musa acuminata peel – Carotenoid	0.72
Musa acuminata red dacca peel – Anthocyanin	0.59

Table 2: TLC acetonic extract of Musa acuminata and Musa acuminata red dacca

Antimicrobial activity

Antimicrobial activity was performed in acetonic extract of Musa acuminata using 2 microorganisms – Pseudomonas aeruginosa and Escherichia coli. The acetonic extract of Musa acuminata was tested against the bacterial sample with Gentamycin as positive control via agar well diffusion method. The zone of inhibition represents the antibacterial activity measured in millimetre (Table 3) and the zone of inhibition was observed.

S.no	Microorganisms	Concentration of extract – Musa acuminata		Concentration of extract – Musa acuminata red dacca	
		50µl	50µl	100µl	100µl
1	+ve control	21mm	24mm	25mm	23mm
2	E. coli	15mm	19mm	16mm	21mm
3	P. aeruginosa	17mm	18mm	15mm	19mm

Table 3: Antimicrobial activity acetonic extracts

FTIR Analysis

The functional groups present in the extracted carotenoid pigment were characterized using Fourier Transform Infrared (FTIR) spectroscopy. These characteristic peaks validate the polyene chain structure of carotenoids and confirm the successful extraction of carotenoid pigment in the sample.

S. No	Wavenumber (cm^{-1})	Functional Group
1	3510.45	O–H (Hydroxyl)
2	3001.24	Aromatic =C–H
3	1712.79	C=O (Carbonyl)
4	1419.61	C–C / O–H
5	1219.01	C–O
6	1095.57	C–O

Table 4a: FTIR characterization of carotenoids

The presence of these characteristic functional groups confirms the phenolic and flavonoid nature of the extracted pigment, validating the successful extraction of anthocyanin compounds.

S. No	Wavenumber (cm^{-1})	Functional Group
1	3502.73	O–H (Hydroxyl)
2	2978.09	C–H (Aliphatic)
3	1705.07	C=O (Carbonyl)
4	1427.32	C–C / O–H
5	1226.73	C–O
6	1087.85	C–O

Table 4b: FTIR characterization of anthocyanins

DLS Analysis

The particle size distribution of the extracted carotenoid pigment was determined using Dynamic Light Scattering (DLS) analysis. The DLS analysis of Musa acuminata carotenoid pigment exhibited a single

prominent peak with a mean particle size of 572.6 nm and a mode of 559.1 nm, indicating a relatively uniform particle distribution. The sample showed a high polydispersity index (PDI = 0.990), suggesting the presence of some aggregation in the system. The results indicate moderate particle size with partial heterogeneity in the carotenoid extract.

The DLS analysis of Musa acuminata red dacca anthocyanin pigment showed a major particle size distribution peak in the range of approximately 500–900 nm, indicating the presence of moderately sized aggregates. The sharp and narrow peak suggests relatively uniform particle distribution with low polydispersity. This confirms the stability and suitability of the extracted anthocyanin pigment for dyeing applications. These results confirm that the extracted pigment forms nano-sized particles, which may enhance its solubility, stability, and potential application in textile dyeing and bio-functional materials. The same study was conducted by (Stetefeld et al., 2016) for the analysis of carotenoids and anthocyanins.

IV. TESTS DONE FOR THE FABRIC

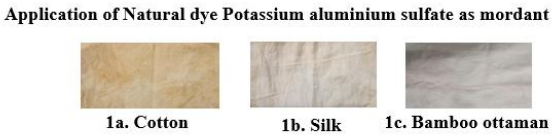

Fig. 1: Application of Carotenoid dye from *Musa acuminata*

Fig 2: Application of Anthocyanin dye from *Musa acuminata red dacca*

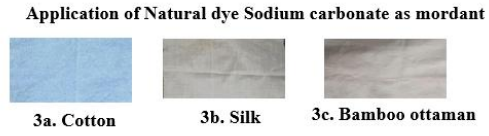

Fig 3: Application of Carotenoid dye from *Musa acuminata*

Fig 4: Application of Anthocyanin dye from *Musa acuminata red dacca*

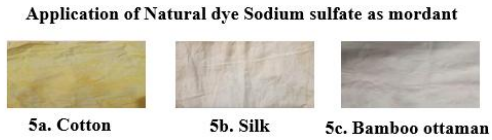

Fig 5: Application of Carotenoid dye from *Musa acuminata*

Fig 6: Application of Anthocyanin dye from *Musa acuminata red dacca*

i. Washability test

The washability test was performed by washing the dyed fabric samples twice using soap detergent to evaluate the durability of the natural dyes on the fabric. After washing, the fabrics dyed with anthocyanins and carotenoids extracted from Musa acuminata and Musa acuminata red dacca peel showed good resistance to fading.

ii. Sunlight protection test

The fabrics coated with natural pigments (anthocyanins and carotenoids) extracted from Musa acuminata and Musa acuminata red dacca peel were exposed to direct sunlight for 7 days to evaluate their photostability and sunlight protection ability. After exposure, the color remains the same. This indicates acceptable light fastness properties of the dye.

iii. Ironing test

The ironing test results indicated that the fabrics dyed with natural pigments such as anthocyanins and carotenoids showed good thermal stability under normal ironing conditions. After ironing at the recommended temperature for cotton (150–180 °C) for 15–20 seconds, no significant colour change, staining on the covering cloth or surface damage was observed. This suggests good thermal stability of the natural dyes on the fabric.

iv. Rub fastness test

The rub fastness of the fabrics dyed with natural pigments (anthocyanins and carotenoids) extracted from Musa acuminata and Musa acuminata red dacca peel was evaluated under wet rubbing conditions. The results indicated moderate to good rubbing fastness for the dyed fabrics showed in the table 5.

Sample	Wet rubbing using croc meter at 9N
Sample 1 Cotton	5 – Excellent
Sample 1 Silk	3 – Moderate
Sample 1 Bamboo ottoman	4 – Good
Sample 2 Cotton	4 - Good
Sample 2 Silk	3 – Moderate
Sample 2 Bamboo ottoman	3 - Moderate

Table 5: Rub fastness of fabric dyed with natural pigments

The dyed fabrics demonstrated moderate to good properties in the washing, sunlight protection, ironing and rub fastness test.

V. CONCLUSION

From the present study we conclude that the acetonic extract of carotenoid and acetonic pigments enriched natural dye provided potential properties and anti-bacterial effect against different pathogens and the confirmatory tests and TLC showed the presence of bio active compounds with the presence of a yellowish orange and yellowish red colour spot. Antimicrobial activity of acetonic extract against E.Coli and Pseudomonas aeruginosa showed clear zones of inhibition. Musa acuminata and Musa acuminata red dacca is excellent source of carotenoid and anthocyanins which provide different shades of colors when mixed with mordants. It is ecofriendly natural dye.

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