COLORATION OF COTTON FABRIC WITH NATURAL COLORANT EXTRACTED FROM WASTE LEAVES OF INDIAN ALMOND (*TERMINALIACATAPPA* L.) *

Wai Wai Phyoe[1], Tin Moe Moe Myint Zaw[2], NguWah Htwe[3], Pyae Phyo San[4]

Abstract

Indian almond (*Terminaliacatappa*L.) leaves are the waste of Indian almondtree and the tannin compound present in the leaves extract can be an alternative colorant for synthetic dyes. Indian almondtrees are abundant and the extraction of colorant from leaves is an effective way to utilize the waste leaves as natural colorant. This research aims to extract the natural colorant from Indian almondleaves and the extracted colorant was utilized in the coloration of cotton fabric. The extraction applied in this study was solvent extraction method in which the leaf samples were extracted using ethanol. The colorant extracted from Indian almondleaves was characterized and identified by using UV-vis Spectrophotometry and FT-IR methods. The physico-chemical properties of extracted colorant were investigated. In this research, extracted colorant was applied in the coloration of cotton fabric with and without mordant. Before coloration, the types of mordant on the absorbance of extracted colorant was examined by using different mordants such as alum, $CuSO_4$, $FeSO_4$, $K_2Cr_2O_7$and CaO, respectively. The effect of mordanting methods on the color development of extract on dyed cotton fabric was determined by using three different methods like pre mordanting, post mordanting and combined mordanting. The analysis of dyeing time on the color development of extracted colorant on dyed cotton fabrics was performed. The high absorbance value (0.928) was observed using alum mordant. Among three different methods, the pre mordanting method was preferable because the color absorption on cotton fabric was great and obvious color change was not occurred. Dyeing time 40 minprovided the better color absorption and color remaining on cotton fabric. For mordanted and unmordanted cotton fabric, the color development of extracted colorant on the cotton fabric such as the color fastness test to sunlight, washing and wet rubbing test were carried out. The results indicated that the colorant extracted from Indian almondleaves could be utilized as natural colorant for the coloration of cotton fabric in the presence of mordant.

Keywords: Extracted Natural Colorant, Solvent Extraction, Coloration to Cotton fabric, Mordant

Introduction

Natural dyes from plant sources have been given much more interest in recent years due to threat raised and the harmfuleffects by synthetic dyes. The main idea of extracting dyes from plant (natural) sources is to avoid the environmental contamination. Natural dyes are hygienic, user friendly, permanentand environmentally friendly than other colorants. For this reason, colorants derived from natural sources have become an important alternative to unsafe synthetic dyes. Natural dyes/colorants derived from plants are believed to be safe because of its non-carcinogenic, biodegradable and nontoxic in nature. Natural dyes are nowadays in demand not only in cosmetics, leather, food and pharmaceutical industries but also in textile industry. Present days with global concern over the use of eco-friendly and biodegradable materials, considerable research work is being undertaken around the world on the application of natural dyes (Yogesh V. and Namrita K., 2017). The advantages of natural dyes compared with synthetic dyes mainly are that(1) the shades produced by natural dyes/colorants are soft and soothing to the human eye, (2) natural dyestuff can produce a wide range of colors by mix and match system including the use of different mordants which can shift the colors to a wide range, (3) natural dyestuff produce rare color ideas and are automatically harmonizing, (4) unlike non-renewable basic raw materials forsynthetic dyes, the natural dyes are renewable, being agro-renewable/vegetable based and at

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[1] Department of Industrial Chemistry, West Yangon University
[2] Department of Industrial Chemistry, West Yangon University
[3] Department of Industrial Chemistry, West Yangon University
[4] Department of Industrial Chemistry, West Yangon University

the same time biodegradable, (5) in some case like indigo, the waste in the process becomes an ideal fertilizer for use in agricultural lands, (6) many dye plants thrive on wastelands, so there is no additional cost or effort required to grow it, and (7) application of natural dyes has potential to earn carbon credit by reducing consumption of petroleum based synthetic dyes (Herry P., et al., 2019). *Terminaliacatappa*L. is one of the sources of natural dye (Menna M.R., et al., 2022). The leaves are large, 15–25 cm (5.9–9.8 inch) long, 10–14 cm (3.9–5.5 inch) broad, ovoid, glossy dark green and leathery. Before falling, they turn pinkish-red or yellow-brown, due to pigments such as violaxanthin, lutein, and zeaxanthin. The leaves contain several flavonoids (like kaempferol or quercetin), several tannins (such as punicalin, punicalagin or tercatin), saponins and phytosterols (Yogesh V. and Namrita K., 2017). The main aim of this workis to studythe effective utilization of waste leaves in extracting natural colorant. The objectives of this research are to extract the natural colorant from Indian almond leaves, to characterize the extracted colorant, to utilize the extracted colorant in dyeing of cotton fabric and to study the color fastness of extracted colorant on the dyed cotton fabric.

Materials and Methods

Sample Collection

Indian almondleaves were collected from Ward 20, HlaingTharYar Township, Yangon Region**.**

Extraction of Natural Colorant from Indian AlmondLeaves

Indian almond leaves were washed with water to remove the dust and they were sun dried for 5 h. The dried leaves were cut into small pieces and ground into fine powder for efficient solvent extraction. 5g of the dried leaf powder sample was extracted using 50 mL of ethanol. The mixture was allowed to stand overnight. Then, the mixture was filtered using Whatman Filter Paper No. (4) to obtain clear colorant solution. Consequently, the filtrate was concentrated using distillation method. The dilute colorant solution was distilledat 60℃ until 10 mL of concentrated colorant extract was obtained.

Figure 1: Indian Almond Leaves

Figure 2: Indian Almond Dried Leaf Powder

Figure3: Extracted Colorant from Indian Almond Leaves

Figure 4: Dyed Cotton Fabric

Coloring Process

The white cotton fabric was cut into 1×1 inch and weighed. The preweighed cotton fabric was mercerized by using 20% (w/v) NaOH solution for 20 min. And then 10% (w/v) of mordant solution (45mL distilled water and 5g alum) was prepared and the white cotton fabric was soaked in mordant solution for 25 min at room temperature. After 25 min, the white cotton fabric was removed from mordant solution and immersed in the extracted colorant solution at 40℃ in a water bath for 40 min. Finally, the dyed cotton fabric was removed from the dye solution and rinsed with water and dried.

Color Fastness to Lighting

The cotton fabric sample (1×1 inch) was soaked in an extracted colorant solution for 60 min and dried at room temperature. After drying, the dyed cotton fabric was exposed to sunlight for 5 h. After exposure to sunlight, the change in color of cotton fabric was studied at oneday interval for one week. Then the color fastness to light of dyed cotton fabric was determined.

Color Fastness to Washing

1×1 inchin length cotton fabric sample was immersed in an extracted colorant solution for 40 min and dried at room temperature. After drying, the dyedfabric was washed with mild detergent solution. Then, dyed cotton fabric was rinsed with water and dried again.The color fastness to washing was determinedevery day for one week.

Color Fastness to Rubbing

The cotton fabric (1×1 inch) was dipped in an extracted colorant solution for 40 min and dried at room temperature. After drying, the dyed fabric wasrubbed by hand and washed with water. Then the color fastness to rubbing test was studied.

Results and Discussion

This study was intended to extract the natural colorant from Indian almond leaves and utilized in the dyeing of cotton fabrics. The identification of extracted colorant was carried out by using UV-vis spectrophotometer and FT-IR analyses. The results are indicated in Tables 1, and 2, and also in Figures 1 and 2. UV-vis spectrophotometry and FT-IR analysis are valuable devices for characterization and identification of compounds or functional groups present in a substance. UV-vis spectra obtained from extracted colorant exhibited that higher absorbance values were observed at wavelength between 400 and 406.5 nm. It confirmed the presence of tannin in extracted colorant from Indian almond leaves. According to the FT-IR results, the functional groups produced from extract of Indian almond leaves showed that the tannin compoundsare present in theIndian almond leaves extract. The results of this analysis are in accordance with the results of FT-IR spectrum analysis of tannin compounds from the previous study conducted by (Muhammadu A.B. et al., 2017). FT-IR spectra showed that -OH group was in the region of wavelength absorption 3387.06 cm^{-1} with a very strong and broad signal. C = C groups were in the area with a wavelength of 1614.45 cm^{-1}. In the region of 1448.57 cm^{-1} indicated the presence of C=C of aromatic group and the absorption band. 1238.32-1054.12 cm^{-1} indicated the presence of C-O groups.

The physico-chemical properties of extracted colorant were determined and the results are presented in Table 3. According to the results, pH of the extract was 5.5 and it was acidic. The color of the extract was reddish brown and the color density of extracted dye was 0.467.

Mordanting process plays an important role in the fabric dyeing using natural dyes. The effect of different mordants such as alum, $CuSO_4$, $FeSO_4$, $K_2Cr_2O_7$and CaO on the absorbance values of extracted colorant were studied and the results are shown in Table 4. The highest

absorbance value was obtained with alum. Moreover, the development of color on dyed cotton fabrics were observed by dyeing the cotton fabric with and without mordant and the results are presented in Table 5. Various colors were observed and the resulting color varied from yellow, reddish brown to brown, dark brown and light yellow.

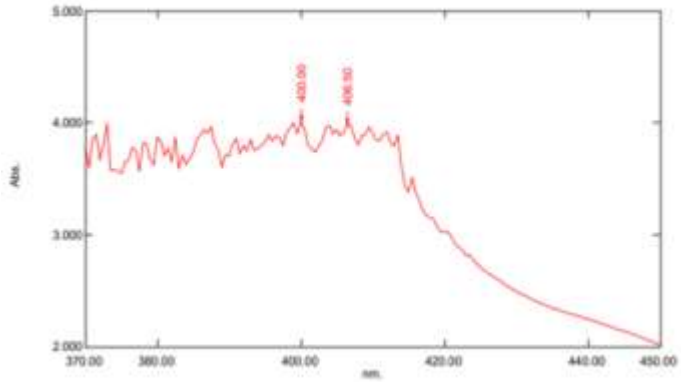


Figure 5: UV-Visible Analysis of Extracted Colorant

Table 1: UV-Visible Analysis Data of Extracted Colorant

Sr. No.	Wavelength (nm)	Absorbance
1.	406.5	3.977
2.	400.00	4.00

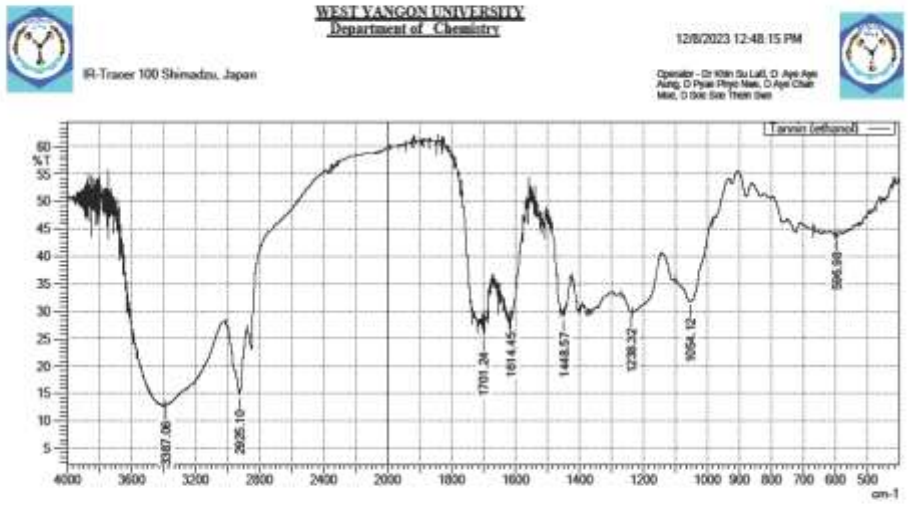


Figure 6: FT-IR Spectral Analysis of Extracted Colorant

Table 2: FT-IR Spectral Data of Extracted Colorant

Wave Number (cm^{-1})			Functional Group	Interpretation
Sr. No.	Observed Value	Literature Value*		
1.	3387.06	3406	ν_{-OH}	-OH bond stretching vibration

Wave Number (cm^{-1})			Functional Group	Interpretation
Sr. No.	**Observed Value**	**Literature Value***		
2.	2925.10	2950	ν_{-CH}	C-H bond extension stretching vibration
3.	1701.24	1713	$\nu_{-C=O}$	C=O bond stretching vibration
4.	1614.45	1613	γ_{-CH} $\nu_{-C=C}$	C-H bending, C=C aromatic stretching vibration
5.	1448.57	1446	γ_{-CH} $\nu_{-C=C}$	C-H bending, C=C alkene and aromatic stretching vibration
6.	1238.32	1227	ν_{-CO}	C-O stretching vibration
7.	1054.12	1066	ν_{-COC}	C-O-C linked symmetric stretching vibration

*****(Jag,2000)

Table 3: Physico-chemical Properties of Extracted Colorant

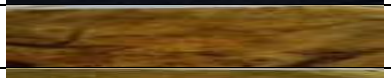
Sr. No.	Properties	Extracted Colorant
1.	pH	5.5
2.	Absorbance value at 405 nm	1.048
3.	Color Density	0.467
4.	Yield % (v/v)	20

Table 4: Effect of Different Mordant on Absorbance of Extracted Colorant

Sr.No.	Types of Mordant	Absorbance Value at 405 nm	pH
1.	Alum*	0.928	4.5
2.	$CuSO_4$	0.852	4.2
3.	$FeSO_4$	0.898	6.3
4.	$K_2Cr_2O_7$	0.905	5.7
5.	CaO	0.846	10.76

* The most suitable mordant

Table 5: Effect of Different Mordant on Color Development on Cotton Fabric

Sr. No.	Mordant	Extracted Colorant	Color Development
1.	Without Mordant	Ethanol	
2.	Alum*		
3.	$CuSO_4$		
4.	$FeSO_4$		
5.	$K_2Cr_2O_7$		
6.	CaO		

*The most favorable mordant for color development after application of color

The effect of dyeing method and dyeing time on the color development of dyed cotton fabrics and percent of dye on cotton fabrics were also investigated and the results are presented in Tables 6, 7 and 8. Different dyeing methods such as pre mordanting, post mordanting and combined mordanting were used to evaluate the color development of extracted colorant on dyed cotton fabric. For cotton fabric mordanted with alum, the pre mordanting method was preferable because the color retention on cotton fabric was acceptable and no obvious color change has occurred. The color obtained from these methods indicated that the pre mordanting method was effective in color absorption and its color retention on cotton fabric was preferable. The percent of dyeing and color development on dyed cotton fabric were determined by using various dyeing time such as 20 min, 40 min and 60 min. Dyeing time did not significantly affect the weight of dyebefore and after dyeing from Indian almond leaves while dyeing with 40 min exhibited better color absorption, uniform color dispersion and color retention on cotton fabric. The percent of dyeing on cotton fabric was 2.6%.

Table 6: Effect of Dyeing Method on Color Development on Cotton Fabric
Extract - Ethanol extract
Mordant - Alum

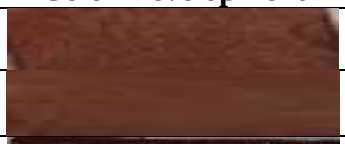
Sr.No.	Dyeing Method	Color Development
1.	Pre Mordanting*	
2.	Post Mordanting	
3.	CombinedMordanting	

*The most favorable method for mordanting

Table 7: Effect of Dyeing Time on Percent of Dyeing on Cotton Fabric
Extract - Ethanol extract
Mordant - Alum

Sr. No.	Dyeing Temp. (°C)	Dyeing Time (min)	Cotton Fabric			
			WeightBefore Dyeing (g)	Weight After Dyeing (g)	Percent of Dyeing (%)	Color
1.	40	20	0.04	0.048	2.5	Reddish brown
2.	40	40*	0.04	0.06	2.6	Reddish brown
3.	40	60	0.04	0.06	2.6	Reddish brown

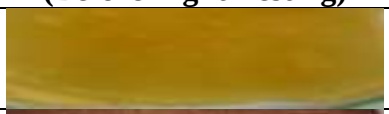
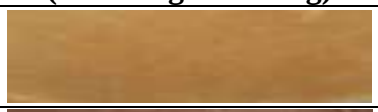
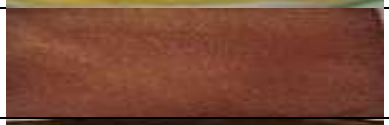
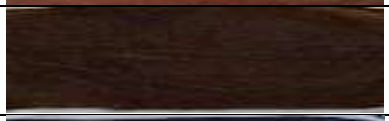
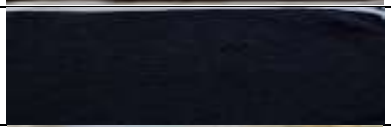
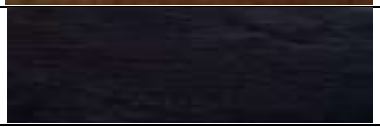
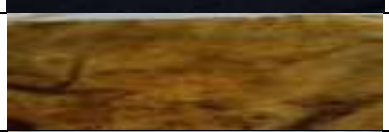
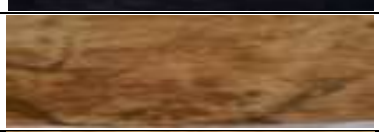
Table 8: Effect of Dyeing Time on Color Development on Cotton Fabric
Extract - Ethanol extract
Mordant - Alum

Sr.No.	Dyeing Time (min)	Color Development
1.	20	
2.	40*	
3.	60	

* The most suitable dyeing time

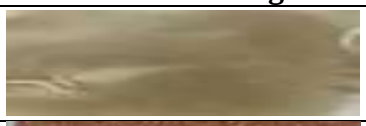
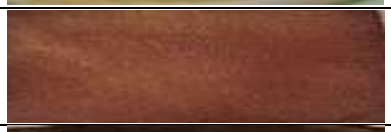
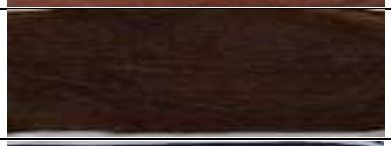
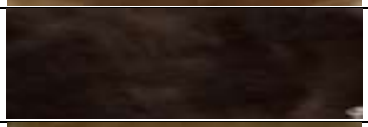
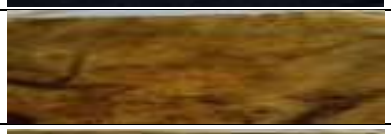
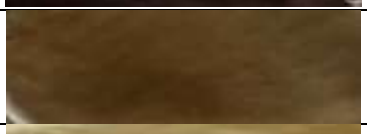
The color fastness test to light, washing with mild detergent and wet rubbing were conducted and the results are presented in Tables 9, 10 and 11, respectively. Sunlight fastness test forunmordanted and mordanted dyed cotton fabric was conducted by exposing the dyed cotton to sunlight for one week. For cotton fabric mordanted with alum, color retention was found to be goodand the original color of extract on the cotton fabric did not obviously change after one week of exposure to sunlight. Washing fastness test of unmordanted and mordanted dyed cotton fabric was carried out by washing dyed fabric with mild detergent. Obvious color changes were observed for all dyed cotton fabric except for fabric mordanted with alum. The results obtained for wet rubbing fastness indicated that the color of dyed fabric before rubbing fastness were totally different from that of dyed fabric after rubbing fastness except mordanted fabric with alum. For unmordanted and mordanted fabrics with $CuSO_4$, $FeSO_4$, $K_2Cr_2O_7$, CaO, the color of the fabric after wet rubbing changed to grey and dark while in the case of mordanted fabric using alum, it was found that there wasno significant color change, and the color retention on the fabric was preferable. Therefore, alum was considered as an effective mordant and the best in color absorption.

Table 9: Color Fastness to Light for Dyed Cotton

Sr.No.	Mordant	Color Stability	
		(Before Light Testing)	(After Light Testing)
1.	Without Mordant		
2.	Alum*		
3.	$CuSO_4$		
4.	$FeSO_4$		
5.	$K_2Cr_2O_7$		
6.	CaO		

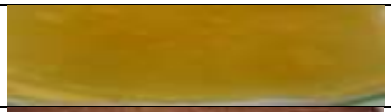
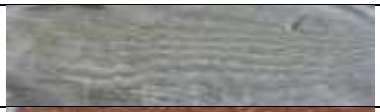
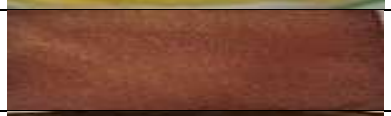
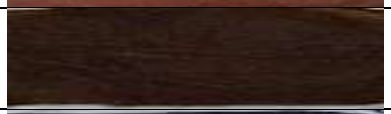
*The most favorable mordant for color stability

Table 10: Color Fastness to Washing for Dyed Cotton

Sr. No.	Mordant	Color of Dyed Cotton	
		Before Washing	After Washing
1.	Without Mordant		
2.	Alum*		
3.	$CuSO_4$		
4.	$FeSO_4$		
5.	$K_2Cr_2O_7$		
6.	CaO		

*The most favorable mordant for color stability

Table 11: Color Fastness to Rubbing for Dyed Cotton

Sr. No.	Mordant	Color of Dyed Cotton	
		Before Rubbing	After Rubbing
1.	Without Mordant		
2.	Alum*		
3.	$CuSO_4$		
4.	$FeSO_4$		
5.	$K_2Cr_2O_7$		
6.	CaO		

*The most favorable mordant for color stability

Conclusion

This research was carried out to extract the natural colorant from Indian almond leaves and its application on cotton fabric. The extracted colorant was characterized and identified by using UV-vis spectrophotometer and FT-IR method. Based on the UV-vis analysis, higher absorbance values were observed at wavelength between 400 and 406.5 nm and it confirmed the presence of tannin in Indian almond leaves extract. According to the FT-IR results, the functional groups produced from extract of Indian almond leaves verified that the tannin compounds were present in the extract of Indian almondleaves. The results of this analysis are in accordance with the results of FT-IR spectrum analysis of tannin compounds from literature value. Indian almondleaves could be utilized as natural dye source in fabric coloration in the presence of mordant. Alum was an effective mordant in color absorption and color retention on cotton fabric. Therefore, the colorant extracted from Indian almond leaves could be used to minimize the usage of synthetic dye and the extraction process in this study can be an effective way to advantageouslyutilize the forest waste in making valuable product.

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