JOURNAL OF SCIENCE TECHNOLOGY AND EDUCATION 13(3), SEPTEMBER, 2025
E-ISSN: 3093-0898, PRINT ISSN: 2277-0011; Journal homepage: www.atbuftejoste.com.ng

Analyzing the Effect of Tannic Acid and Metalic Mordant on the Dyeing Efficiency of Natural Dye Extracted from *Tectona Grandis* Leaf on Chrome-Tanned Leather

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ABSTRACT
Natural dyes have gained renewed interest due to their eco-friendly and sustainable nature. This study investigates the effect of tannic acid and metallic mordants on the dyeing properties of natural dyes extracted from Tectona grandis (teak plant) on chrome-tanned leather. The dye was extracted using aqueous and ethanol-based methods to evaluate yield and color intensity. Pre-mordanting, simultaneous mordanting, and post-mordanting techniques were employed using tannic acid and metallic salts, including Aluminum Sulphate, Ferrous sulfate, and Zinc sulfate. The dyed leather samples were assessed for fastness properties (wash, rub, and light fastness). Results showed that the colour of the dye extract was green and that of the dyed leather ranged from from brown to deep blue (for tannic acid and ferrous sulphate double mordant). The results also showed that tannic acid produced a deeper shade from light green to deep blue and significantly improved fastness properties, particularly when used in combination with metallic mordants. Among the metallic mordants, ferrous sulfate produced enhanced wash and light fastness of 5 on gray scale, while Aluminum sulphate yielded brighter tones. The findings highlight the potential of Tectona grandis as a viable natural dye source and emphasize the role of mordants in modifying dyeing efficiency and durability. This study contributes to the advancement of sustainable textile dyeing practices by optimizing natural dye applications through effective mordanting techniques.

ARTICLE INFO
Article History
Received: March, 2025
Received in revised form: June, 2025
Accepted: July, 2025
Published online: September, 2025

KEYWORDS
Tectona grandis, Mordant, Tannic Acid, Natural Dyes, Fastness Properties, Leather

INTRODUCTION

Natural dyes have been used for textiles for a long time, but their application to leather has been extremely rare. Such an attempt will result in the development of natural leather dyeing process. Leather can be dyed with natural dyes using, either dye alone in acidic or alkaline conditions or with a mordant, which may be applied before or after the dyestuff or simultaneously, Dyes are organic compounds which are widely used for imparting color to textiles. They are produced either chemically or from plants.

An interesting point about them is that unlike paint, they do not build up on the surface of the fiber but are absorbed into the pores of the material. This becomes possible because of two reasons. First, the size of the dye molecules is smaller than the size of the pores in the fiber. The dye molecules have a shape like narrow strips of paper, that is having length and breadth but relatively little thickness. This planar shape assists them to slip into the polymer system when the fiber, yarn or fabric is introduced into the dyebath (Choudhary., *et al,* 2006).

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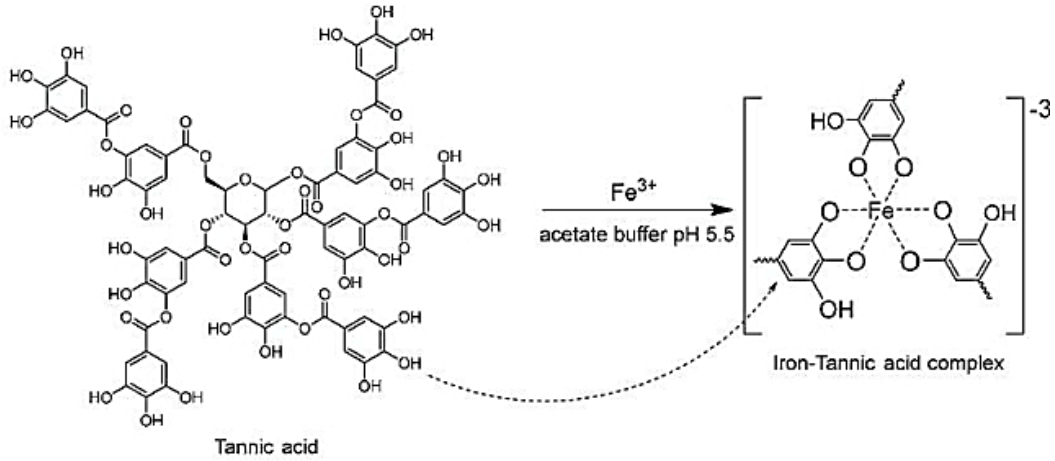

METHODOLOGY

Dye Extraction

An alkaline extract of the dye was prepared by adding 10g of *Tectona grandis* to 125ml 0.3M sodium hydroxide solution in a flask. The mixture was heated, held at boil for 75min, allow to stand for cooling to room temperature and then filtered through a piece of filter paper. The filtrate will then be used for dyeing of leather samples

Dyeing without Mordanting

A control samples of 2g of leather sample was dyed in 100mL of the extract using 50g/dm³ sodium sulphate (Na_2SO_4) without adjusting the pH of the dye bath. The temperature of the dye bath was raised to 80°Cover 25min (2°C min^{-1}) and maintained at this level for 100 min in the exhaust dyeing machine. Then, the leather was removed from the dye bath and rinsed successively in cold, hot and cold water before drying in air

Dyeing after single mordanting

In single-stage mordanting, samples of leather was treated separately with tannic acid, ferrous (II) sulphate heptahydrate, zinc (II) sulphate and aluminum (III) sulphate hexadecahydrate at ratio of 1:1, each at 4% on the weight of leather (o.w.l) concentration using leather to liquor ratio of 1:15 at 60°C for 1h. The mordanted samples will then be rinsed in cold water and allowed to dry in air before dyeing at the same conditions as was used for dyeing the control sample.

Dyeing after double-mordanting

In two -stage mordanting three leather samples, mordanted with tannic acid was mordanted once again separately with ferrous (II) sulphate heptahydrate, zinc (II) sulphate and aluminum (III) sulphate hexadecahydrate, each at 4% o w.l (on the weight of leather) concentration using leather to liquor ratio 1:15 at 60°C for 1h . The double mordanted samples will then be rinsed in cold water and allowed to dry in air before dyeing at the same conditions as was used for dyeing the control sample.

Colour Fastness Test

Washing fastness of the dyed samples was tested according to BS EN ISO 105-C10;2007 at 60°C for 0.5h. Light fastness of the dyed samples was tested according to BS EN ISO 105 -BO2:1999 using Xenon Arc lamp. Rubbing fastness of the dyed samples was tested according to BS EN ISO 105-X12:2002[11].

RESULTS AND DISCUSSION OF FINDINGS

The result of the phytochemical screening of the dye extracted from *Tectona grandis* as presented in Table 1.0 indicated the presence of tannins, alkaloids, terpenoids, steroids, glycosides, phenols, and saponins. The results obtained from the fastness tests as

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presented in table 2.0 also indicated pre-mordanting with tannic acid, ferrous sulphate, zinc sulphate and aluminum sulphate affect the fastness properties of the natural dye with rub fastness (wet and dry), light fastness and wash fastness ranging between 4 and 5. Washing fastness, in terms of colour change, increase from 4 to 5 when ferrous sulphate and zinc sulphate are used in mordanting while washing fastness in terms of staining to cotton increased from 4 to 5 when all mordants are used alone.

The highest fastness property of 5 in terms of rub, light and wash were obtained when tannic acid and ferrous sulphate were used together in double mordanting. This could be attributed to the formation of insoluble colour complex on the leather. This results from the coordinate bond formed between the ferrous ions (Fe^{2+}) from the ferrous-tannate mordanting complex with the oxygen and nitrogen atoms of the collagens amino acid groups or with the phenolic groups of the tannins. In a chrome-tanned leather, the chromium ions (Cr^{3+}) cross-link with the carboxyl groups of collagens, creating a stable network. When ferrous-tannate is applied, the ferrous ions then interact with the remaining reactive sites on the collagen or with the tannins that have been fixed to the leather (Bindia *et al*., 2024).

Furthermore, sample without mordanting also had good washing fastness, because *Tectona grandis* extract contain tannins which also act as mordant. As far as light fastness is concerned, it increases due to mordanting in all cases. All fastness test is improved in most of the cases of the double mordanting with tannic acid and ferrous sulphate, followed by single mordanting with ferrous sulphate. This finding is in line with the result obtained when *Acacia nolitica* plant extract was used as reported by Asif *et al.,* 2010 which shows that tannic acid and ferrous sulphate are perfect for double mordanting as can be seen in the increased fastness property from 3 to 5 due to the formation of ferrous-tannate complex on the dyed substrate.

Table 1.0 Phytochemical Screening of Plant Extract

S/N	Constituent	Availability
01	Tannins	+
02	Alkaloid	+
03	Saponins	+
04	Flavonoid	+
05	Steroid	+
06	Glycoside	+
07	Terpenoid	+
08	Phlabotannin	_
09	Oxalate	_
10	Phenol	+
11	Quinones	_
12	Coumeric	_

KEY: + = Present, - = Absent

Table 2.0 Fastness Properties of Leather Dyed with *Tectona grandis* Leaf Extract

Sample	**Rub Fastness**		**Wash Fastness**	**Light Fastness**
	Dry	**Wet**		
Without Mordant	4-5	4	4-5	3-4
Tannic Acid	4-5	4	4	4
Ferrous Sulphate	5	4-5	4-5	4-5
Zinc Sulphate	5	4-5	4-5	4-5
Aluminium Sulphate	4-5	4-5	4	3-4

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Sample	Rub Fastness		Wash Fastness	Light Fastness
	Dry	Wet		
Tannic Acid + Ferrous Sulphate	5	4-5	5	5
Tannic Acid + Zinc Sulphate	4-5	3	4	4-5
Tannic Acid + Aluminium Sulphate	4-5	4	4	4

KEY: 1= Poor, 2 = Average, 3 = Good, 4 = Very Good, 5 = Excellent

CONCLUSION

Chrome-Tanned Leather was successfully dyed with natural dye extracted from *Tectona grandis*, with and without mordanting, achieving reasonably good overall colour fastness properties. The colour obtained from the dye extract was red while the dyed leather colour gave different shades of purple. Mordanting results not only improve the colour depth and brightness in some cases but also leads to improvement in colour fastness properties due to the mordants ability to penetrate the leather and form complexes with the dye and also with the negatively charged ions in the leather as reported by Bindia *et al*., 2024. Mordanting with ferrous sulphate best results in the improvement of colour fastness properties. Double mordanting with tannic acid and ferrous sulphate gives the best colour fastness results which is 5 with respect to the gray scale.

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