



Analyzing The Effect of Tannic Acid and Metallic Mordant on the Dyeing Efficiency of Natural Dye Extracted from *Tectona Grandis* Leaf

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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). 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 alum, ferrous sulfate, and copper sulfate. The dyed fabric samples were assessed for color strength, fastness properties (wash, rub, and light fastness), and structural interactions using spectrophotometric analysis. Results showed that tannic acid significantly enhanced dye uptake and improved fastness properties, particularly when used in combination with metallic mordants. Among the metallic mordants, ferrous sulfate produced deeper shades with enhanced wash and light fastness, while alum 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.

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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.

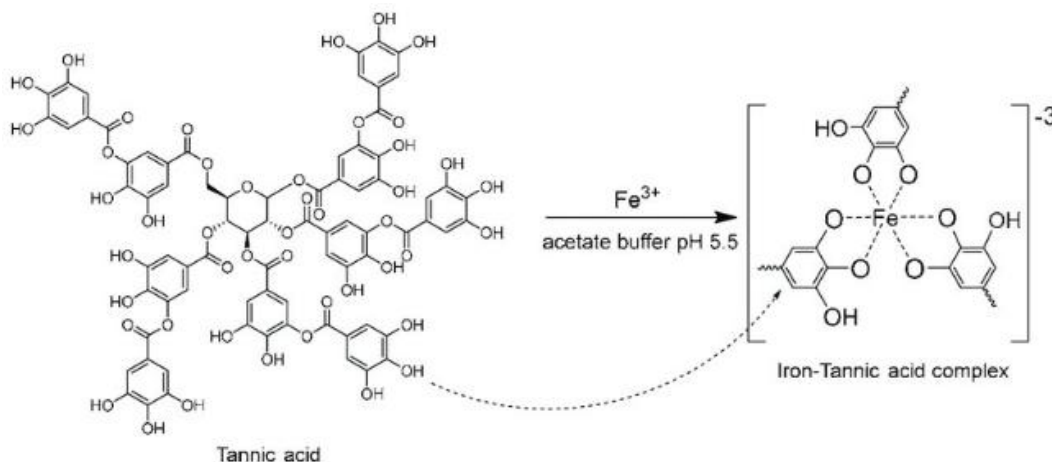
An interesting point about them is that unlike paint, they do not build up on the surface of the fiber but are absorbed into the pores of the material. This becomes possible because of two reasons. First, the size of the dye molecules is smaller than the size of the pores in the fiber. The dye molecules 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 (Na₂SO₄) without adjusting the pH of the dye bath. The temperature of the dye bath was raised to 80°C over 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 were treated separately with tannic acid, ferrous (II) sulphate heptahydrate, zinc (II) sulphate and aluminum (III) sulphate hexadecahydrate, 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-X12:2002¹¹.

RESULTS AND DISCUSSION

Effect of mordanting on colour fastness properties of dyed cotton: Table-1.0 gives fastness properties of chrome-tanned leather dyed with *Tectona grandis*, without and with

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mordanting. Washing fastness, in terms of colour change, increase significantly grade when ferrous sulphate and zinc sulphate are used in mordanting while washing fastness in terms of staining to cotton increases when all mordants are used alone and in case of tannic acid and ferrous sulphate used together. This could be attributed to the formation of insoluble colour complex on fabric.

Furthermore, sample without mordanting also had good washing fastness, because *Tectona grandis* extract containing tannins/polyphenols which also act as mordant. Dry rubbing fastness improves up to 1 grade when mordanting is done with aluminium sulphate alone and tannic acid and ferrous sulphate used together. There is no improvement in wet rubbing fastness properties due to mordanting. It rather decreases in all cases except when tannic acid and zinc sulphate is used together. As far as light fastness is concerned, it increases due to mordanting in all cases. Light fastness is improved

in most of the cases the double mordanting with tannic acid and ferrous sulphate, followed by single mordanting with ferrous sulphate.

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	Phlabetannin	—
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		Light Fastness
	Dry	Wet	
Without Mordant	4-5	4	3-4
Tannic Acid	4-5	4	4
Ferrous Sulphate	5	4-5	4-5
Zinc Sulphate	5	4-5	4-5
Aluminium Sulphate	4-5	4-5	3-4
Tannic Acid + Ferrous Sulphate	5	4-5	5
Tannic Acid + Zinc Sulphate	4-5	3	4-5
Tannic Acid + Aluminium Sulphate	4-5	4	4

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. Mordanting results not only improve the colour depth and brightness in some cases but also leads to improvement in colour fastness properties. While mordanting with tannic acid enhances the colour depth the most, mordanting with ferrous sulphate best results in the improvement of colour fastness properties. Double mordanting with tannic acid and ferrous

sulphate gives the best overall results, both in terms of colour depth and fastness properties.

REFERENCES

- Adeel, S., R. Hanif, M. Zuber, and M. Muneer. (2014). Ecofriendly dyeing of UV-irradiated cotton using extracts of *Acacia nilotica* bark (Kikar) as source of quercetin. *Asian Journal of Chemistry* 26:830.
- Al-Juaid SS, Abdel-Mojib MA. A novel podophyllotoxin lignin from *Justicia heterocarpa*.

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- Batool, F., S. Adeel, M. Azeem, A. A. Khan, I. A. Bhatti, A. Ghaffar, and N. Iqbal. (2013). Gamma radiations induced improvement in dyeing properties and colorfastness of cotton fabrics dyed with chicken gizzard leaves extracts. *Radiation Physics and Chemistry* 89:33–37. doi:10.1016/j.radphyschem.2013.03.045.
- Chemical and Pharmaceutical Bulletin. 2005;52:507-509.
- Choudhary, A. K. R. (2006). *Textile Preparation and Dyeing*. Science Publishers, New Delhi.
- Corrêa GM, Alcântara AFC. (2012). Chemical constituents and biological activities of species of *Justicia* - A review. *Brazilian Journal of Pharmacognosy*;22(1): 220-238.
- Cristea, D., and G. Vilarem. (2006). Improving light fastness of natural dyes on cotton yarn. *Dyes and Pigments* 70:238– 245. doi:10.1016/j.dyepig.2005.03.006.
- El-Nagar, K., S. H. Sanad, A. S. Mohamed, and A. Ramadan. (2005). Mechanical properties and stability to light exposure for dyed Egyptian cotton fabrics with natural and synthetic dyes. *Polymer-plastics Technology Engineering* 44:1269–1279. doi:10.1080/03602550500207816.
- Gulzar, T., S. Adeel, I. Hanif, F. Rehman, R. Hanif, M. Zuber, and N. Akhtar. (2015). Eco-friendly dyeing of gamma ray induced cotton using natural quercetin extracted from acacia bark (*A. nilotica*). *Journal of Natural Fibers* 12:494– 504. doi:10.1080/15440478.2014.964445.
- Iqbal, J., I. A. Bhatti, and S. Adeel. (2008). Effect of UV radiation on dyeing of cotton fabric with extracts of henna leaves. *Indian Journal of Fiber & Textile Research* 33:157–162.
- Islam, S., and F. Mohammad. (2015). High-energy radiation induced sustainable coloration and functional finishing of textile materials. *Industrial & Engineering Chemistry Research* 54:3727–3745. doi:10.1021/acs.iecr.5b00524.
- Kanchanapoom T, Noiarsa P, Ruchirawat S, Kasai R, Otsuka H. (2004). Triterpenoidal glycosides from *Justicia betonica*. *Phytochemistry*;65:2613-2618.
- Khan, A. A., N. Iqbal, S. Adeel, M. Azeem, F. Batool, and I. A. Bhatti. (2014). Extraction of natural dye from red calico leaves: Gamma ray assisted improvements in colour strength and fastness properties. *Dyes and Pigments* 103:50–54. doi:10.1016/j.dyepig.2013.11.024.
- Lee, Y. H., E. K. Hwang, Y. J. Jung, S. K. Do, and H. D. Kim. (2010). The Van der Pauw method for sheet resistance measurements of polypyrrole-coated para-aramide woven fabrics. *Journal of Applied Polymer Science* 115:2246. doi:10.1002/app.31357.
- Melgoza, R. M., A. Cruz, and G. Buitron. (2004). Anaerobic/Aerobic treatment of colorants present in textile effluents. *Water Science and Technology* 5:149–155.
- Nagia, F. A., and R. S. R. EL-Mohamedy. (2007). Dyeing of wool with natural anthraquinone dyes from *Fusarium oxysporum*. *Dyes Pigments* 75:550–555. doi:10.1016/j.dyepig.2006.07.002.
- Orjiakor CA, Uroko RI, Njoku OU, Ezeanyika LUS. (2019). Nutritive properties of aqueous extract of *Justicia carnea* leaves and its effects on haematological and some biochemical indices of anaemia induced male wistar albino rats. *Biomedical Research*;30(4):645-654
- S.A. Verissimo, E.L. Oliveira, R. Ladchumananandasivam, L.P.R. Cruz, G.F. Praxedes and M.S. Aquino, (2001). Department of Chemical

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- Engineering-Centre of Technology, UFRN.
- Shahid, M., A. Ahmad, M. Yusuf, M. I. Khan, S. A. Khan, N. Manzoor, and F. Mohammad. (2012). Dyeing, fastness and antimicrobial properties of woolen yarns dyed with gallnut (*Quercus infectoria* Oliv.) extract. *Dyes and Pigments* 95:53–61. doi:10.1016/j.dyepig.2012.03.029.
- Shahid, M., S. Islam, and F. Mohammad. (2013). Recent advancements in natural dye applications: A review. *Journal of Cleaner Production* 53:310–331. doi:10.1016/j.jclepro.2013.03.031.
- Singh, R., A. Jain, S. Panwar, D. Gupta, and S. K. Khare. (2005). Antimicrobial activity of some natural dyes. *Dyes and Pigments* 66:99–102. doi:10.1016/j.dyepig.2004.09.005.
- Sricharussin, W., C. Sopajaree, T. USDA. *Justicia carnea*. Natural Resources Conservation Service Plants Database. Available: <https://plants.usda.gov/java/ClassificationServlet?source=display&classified=JUCA17> (Retrieved January 2020)
- Yusuf, M., A. Ahmad, M. Shahid, M. I. Khan, S. A. Khan, N. Manzoor, and F. Mohammad. (2012). Assessment of colorimetric, antibacterial and antifungal properties of woollen yarn dyed with the extract of the leaves of henna (*Lawsonia inermis*). *Journal of Cleaner Production* 27:42–50. doi:10.1016/j.jclepro.2012.01.005.
- Yusuf, M., M. Shahid, M. I. Khan, S. A. Khan, N. Manzoor, and F. Mohammad. (2015). Dyeing studies with henna and madder: A research on effect of tin (II) chloride mordant. *Journal of Saudi Chemical Society* 19:64–72. doi:10.1016/j.jscs.2011.12.020.