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Assessment of the Dyeing Properties of Natural Dye Extracted from Lawsonia Inermis Leaves on Chrome-Tanned Leather using Tannic Acid and Metallic Salts as Mordants

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ABSTRACT
Dyeing and coloration of leather are foremost processes in the production of leather material. This study targets to determine the effects of tannic acid and metallic mordants on dyeing properties of natural dye of Henna plant extract, with view to evaluate the phytochemical properties of the extract. The Henna (Lawsonia inermis) plant sample was extracted and used to dye leather using selected synthetic mordants. The extract was subjected to qualitative phytochemical analysis using standard methods. The mordants such as tannic acid, ferrous sulphate, zinc sulphate and aluminum sulphate were used individually and in tannic acid blend combinations. Leather was dyed using each of the selected mordants under conventional mordanting techniques, adopting the recognized dyeing method. The dyed leather samples were washed and dried, after which the color fastness using light fastness and rub fastness were analyzed for assessment of color fastness of leather. Phytochemical compounds such as tannins, alkaloids, steroids, glycosides, terpenoids, phlabotannins and phenols are present, whereas saponins, flavonoids, oxalates and quinones are absent. It was concluded that Henna plant dye with tannic acid-metallic mordant blend as mordant under post-mordanting technique gave the best result of colour fastness of the Henna dye.

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INTRODUCTION

Natural dyes have been recognized since ancient Egyptians. They are obtained from natural resources and renewable, and therefore, their uses will continue to inspire scientists due to their ecological, antimicrobial, and UV protection characteristics (Rather L.J., *et al.*,2019) The revival use of natural dyes, as well as devising new methods of techniques in textile coloration, is of prime ecological interes [(Ahmed N.S.E., *et al.*,2010). However, the use of natural dyes in textile coloration is yet limited due to many reasons such as shades, cost, and fastness properties. The shade and fastness properties of dyed fabrics depend on the mordants used.

Although the use of mordants is necessary for better dyeability and shades, however, their use causes a serious problem for the environment as most of the mordanting process uses toxic metal ions in a large amount that ultimately most of them get discharged into the effluent. Mordants used so far are either metallic or bio-mordant or their combination. Metallic mordant includes copper, chromium, tin, iron, and aluminum (Gedik G., *et al.*,2014). Bio-mordants include Turkey red oil, vegetable oils, and tannin (Gedik G., *et al.*,2014). Tannin is also a coloring matter that can be used by itself for the coloration of textiles after being mixed with metal

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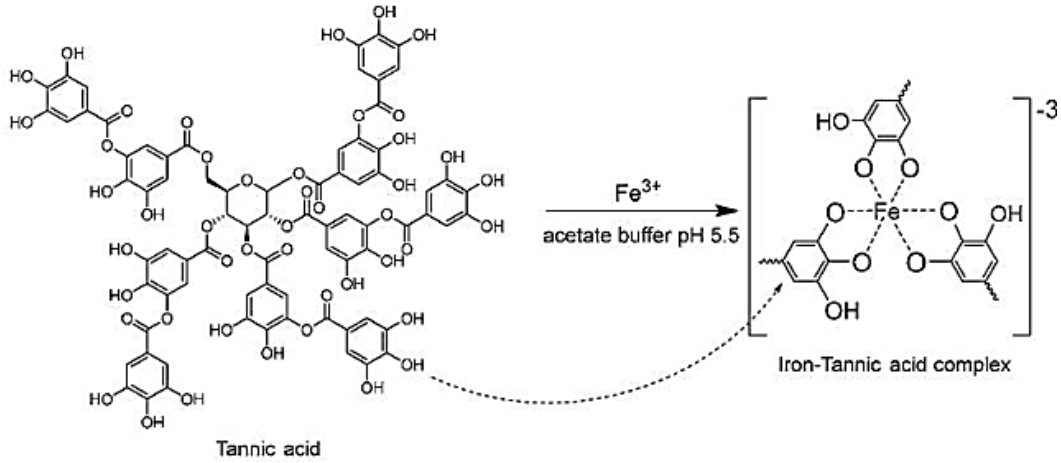
for mordanting (Mongkholrattanasit R.,*et al*.,2011).

The use of mordants metallic or bio-mordant or their combination, although enhanced the color characteristics, yet their uses have been with limited success. Recently, tannin as bio-mordant for the dyeing of wool with Black Plum dye has been reported to improve the washing fastness (Jahangiri A., *et al*.,2018) Also, the combination of tannin and metallic mordant was persuaded for high-temperature dyeing of polyester fabrics, but the results obtained were not satisfied regarding the light fastness (Gedik G., *et al*.,2014).



METHODOLOGY

Dye Extraction

An alkaline extract of the dye was prepared by adding 10g of *Lawsonia inermis* 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°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

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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

Effect of mordanting on colour fastness properties of dyed cotton: Table 1 gives fastness properties of chrome-tanned leather dyed with *Lawsonia inermis,* without and with mordanting. Washing fastness, in terms of colour change, increase 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 *Lawsonia inermis* 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 in 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: 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: Fastness Properties of Leather Dyed with *Lawsonia inermis* Leaf Extract

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

CONCLUSION

Chrome-tanned leather was successfully dyed with natural dye extracted from Henna, 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.

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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.

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.

Gohl, E. P. and Vilensky, L. D. (2005). Textile Science. CBS Publishers & Distributors, New Delhi.

Corrêa GM, Alcântara AFC. Chemical constituents and biological activities of species of Justicia - A review. Brazilian Journal of Pharmacognosy. (2012);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.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.

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doi:10.1016/j.dyepig.2006.07.002.JOU RNAL OF NATURAL FIBERS 11

Orjiakor CA, Uroko RI, Njoku OU, Ezeanyika LUS. 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. 2019;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 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. 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&classid=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.

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