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Effect of Tannic Acid and Metallic Mordants on the Dyeing Properties of Natural Dye Extracted from *Justicea Carnea* Bark

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ABSTRACT
This study is aimed at the production and application of natural dyes extracted from Justicea carnea and also to investigate the effect of tannic acid and metallic mordants on the dyeing properties of the natural dye. A phytochemical screening was carried out on the alkaline extract of the dye after which it was applied on the chrome-tanned leather without and with single and double pre-mordanting. The colour of the dye was red while the colour of the dyed leather was purple. The result of the phytochemical screening indicated the presence of tannins, alkaloids, steroids, glycosides, phenols, oxalates, phlabotannins and coumeric. It was also found that pre-mordanting with tannic acid, ferrous sulphate, zinc sulphate and aluminum sulphate affect both the colour characteristics and fastness properties of the natural dye with rub fastness (wet and dry), light fastness and wash fastness ranging between 4 and 5. Overall, double mordanting with tannic acid and ferrous sulphate gave the best results (which can be interpreted as 5 on the gray scale) in terms of both colour depth and fastness properties.

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INTRODUCTION

Textile industry, at present, almost exclusively uses synthetic dyes and pigments based on non-renewable petrochemicals. The use of natural organic dyes obtained from renewable resources such as plants and trees have the potential for not only preserving the precious petrochemicals but also the all-endangered environment for our coming generations. Inspite of their inferior fastness properties, natural dyes can be employed in the coloration of natural as well as synthetic fibers (Verissimo *et al.,* 2001).

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 results from 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).

METHODOLOGY

Dye Extraction

An alkaline extract of the dye was prepared by adding 10g of *Justicea carnea* 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.

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Dyeing without Mordanting

Exactly 2 g of leather sample (control) was dyed in 100 ml of the extract using 50 g/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 was 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-X12:2002[11].

RESULTS AND DISCUSSION OF FINDINGS

The result of the phytochemical screening as presented in Table 1.0 indicated the presence of tannins, alkaloids, steroids, glycosides, phenols, oxalates, phlabotannins and coumeric. The results obtained from the fastness tests as presented in table 2.0 also indicated pre-mordanting with tannic acid, ferrous sulphate, zinc sulphate and aluminum sulphate affect both the colour characteristics and 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. 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 *Justicea carnea* extract contain tannins/polyphenols which also act as mordant. As far as light fastness in concerned, it increases due to mordanting in all cases.

Light fastness 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

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be seen in the increased colour depth and fastness property from 3 to 5 due to the formation of ferrous-tannate complex on the dyed substrate.

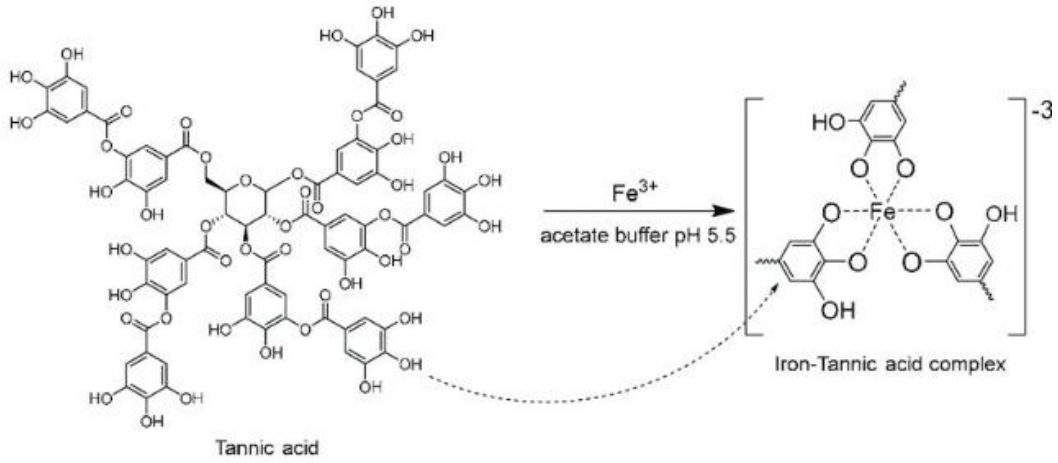

Table 1.0 Phytochemical Screening of Plant Extract

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 *Justicea carnea* Leaf Extract

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

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

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CONCLUSION

Chrome-Tanned Leather was successfully dyed with natural dye extracted from *Justicea cernea*, 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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