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Original Research Article

Evaluation of Dye from *Zebrina Pendula* Plant Species on Cotton and Silk Fabrics

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ABSTRACT

In this study, the phyto- constituents in *Zebrina pendula* plant species for dye compounds was established. The phytochemical screening revealed the presence of flavonoids, anthraquinones (emodols) and tannins (both types) as the potential color compounds. Color fastness of the dye on cotton and silk fabrics were also established *viz*: wash fastness, rub fastness and light fastness. Silk fabrics registered fastness grade of (3) to (4) on a scale of 1 to 5 for both wash and rub fastness with light fastness between (5) and (6) on scale of 1 to 8. Dyed cotton fabrics registered poor wash and rub fastness of (2) with rub and light was of four (4). The toxicological property of plant was studied using the Acute Dermal Toxicity test administered on healthy albino wistar rat models and female Swiss albino mice in accordance with the OECD test guidelines for analysis of chemicals No. 402(1987). The plant extract registered no dermal irritation effects at sites of application even up to the high dose levels of 3200mg/kg bogy weight.

Keywords: Zebrina pendula, Color fastness, phytochemical screening, Acute Dermal Toxicity.

INTRODUCTION

Natural dyes are colorants derived from plants, animals or minerals with majority from plant sources namely; roots, berries, barks, leaves, seeds, woods and other organic sources such as fungi and lichens. [1] Dyeing with natural colorants was one of the oldest techniques practiced during the ancient civilization. This is evident from the Ajanta, Ellora, Sithannavasal, Mithila wall paintings (mural art) and paintings in Egyptian Pyramids which were exclusively done with natural colorants.

The first synthetic dyes were invented by William Henry Perkin in 1856 and they received faster acceptability due to a wide range of applications in various fields like food, cosmetics, photodynamic therapy, non-linear optical activity and more importantly in textile industries due to ease in dyeing, and overall cost factor. [2-6] But, during the last few decades, the use of synthetic dyes is gradually decreasing due to an increased environmental awareness and harmful effects because of either toxicity or their non-biodegradable nature. The synthetic dye stuffs are suspected to cause

allergies, and are carcinogenic and detrimental to human health. [7]

Natural dyes derived from plants have recently gained economic advantage over synthetic dyes because of their non-toxic and biodegradable nature. [8] Due to the current eco-consciousness, researchers' attention has been shifted to the use of natural dyes for dyeing textile materials. [9] However, the natural dyes have their own limitations like availability, color yield, stability, and lack of reproducibility of shades. For these reasons natural dyes cannot yet entirely replace synthetic dyes, but they have their own place in the market.

The interest in the use of natural dyes has been growing rapidly due to the result of stringent environmental standards imposed by environmental board and pollution control board of many countries in response to toxic and allergic reactions associated with synthetic dyes.

In this respect, therefore the study sought for more sources of natural dyes from a locally grown plant species *Zebrina pendula* is one of the selected plants. The plant is classified as a tradescantia from the family of commelinaceae. It originates from Louisiana, Florida and eastern Mexico, but today is found growing all over the world.

MATERIALS AND METHODS

Materials

Fresh samples of *Zebrina Pendula* plants were collected from flower garden at Busitema University. The harvested stems were then properly washed and cut into small pieces and then used for dye extraction. Scoured and bleached 100% woven cotton fabric was purchased from Nyanza Textile Industry Limited (NYTIL) in Jinja district and the silk fabrics from Kawanda sericulture center. Experimental animals: Acute dermal toxicity test was done using Wistar albino adult rats of both sex 10 to 12 weeks old (250g average weight) and female Swiss albino mice of 6 to 8 weeks old (18 ± 4 g). The test animals were fed with a standard diet.

Preparation of reagents

Bleaching solution: was made up of of sodium bi-carbonate (50 g), detergent ®(omo)(150 g), hydrogen peroxide (1 %) and sodium silicate (1.0 g) as a stabilizing agent making a bleaching solution of (2000 cm^3).

Gel formulation of extract: Thirty grams of shear butter oil was thawed by heating in a boiling water bath. To it, bee wax (7.5 g) was added and samples of the dye extract were added to obtain extract-gel concentrations of 0.5, 1.0 and 2.0% w/v basis.

Fabrics pretreatment

Degumming silk fabrics: Degumming of silk involves mainly the removal of Sericin from the fibroin. Knitted silk fabrics (100 %, 250 g) were put into a pan (1500 cm^3) filled with ash water just enough to cover the material and maintained at room temperature and soaked for 24 hours. The mixture was heated and maintained at temperatures between (60°c-70°c) for 1 hour. The fabrics were removed, rinsed ready for bleaching.

Bleaching the silk fabrics: The wet silk fabric (500 g) was transferred in to a bleaching solution and heated to $(60)^0C$ for 30 minutes with continuous stirring. The fabrics were removed and rinsed with luke warm water and immediately used for dyeing.

Extraction of dye from *Zebrina Pendula*

This was done by aqueous method with slight modifications. [10] The fresh leaves were freshly sampled (1000 g) and separately soaked in pans containing distilled water (1000 cm^3) for 30 minutes. The soaked samples were gently heated at 70°C for 30 minutes and temperature gradually increased to between 90°C and

maintained for one hour to yield a dye extract. The dye extract was filtered and used for dyeing and phytochemical screening.

Phytochemical screening of the crude dye extracts

Qualitative determination of phytochemical components was carried out on the extract as per the standard procedure. [11]

Test for Flavonoids: Extract sample (3.0 cm^3) was evaporated to dryness. The residue was dissolved in methanol (2.0 cm^3). A piece of magnesium ribbon was then added to the solution followed by 5 drops of concentrated hydrochloric acid.

Test for Anthraquinones (emodols): To the extract (3.0 cm^3) was transferred in a test tube and sodium hydroxide solution (10%, 1.0 cm^3) was added.

Test for Tannins: The extract (1.0 cm^3) was diluted with distilled water (2.0 cm^3) to which 3 drops of iron (III) chloride were added.

Dyeing Fabrics

Dyeing silk fabrics: The knitted fabric samples measuring (8x8 cm, 6 pieces) were weighed and added to a dye bath containing mordant at 10% on weight of fabric (o.w.f) preheated to 80°c. The mixture was maintained at that temperature while stirring intermittently for 20 minutes. The fabrics were removed from dye-bath, rinsed and made to dry at room temperature. This was done for each mordants used.

Dyeing cotton fabrics: Premordanting method was used for dyeing cotton fabrics. Samples of cotton fabrics each approximately weighing (1.4 g) and measuring (8 x 8cm) were soaked in a solution of mordant at 10% on weight of fabric (o.w.f) separately for each mordant. The fabrics were removed and transferred to a dye-bath with a material to liquor ration (LR) of 1: 200 and the temperature was slowly raised to 80°C and made to simmer for 30 minutes while gently turning the fabrics regularly. The pH of the mixture was maintained between 6.5 and 7.5 using dilute acetic acid. The material was removed from heat source and then allowed to cool in the bath for about 40 minutes, after which they were removed from the dyeing pan and washed with cold water and dried at room temperature.

Determination of color fastness

Wash fastness: The color fastness test to washing was assessed according to standard method using a standard grey scale. [12] Dyed samples were cut to suitable sizes, and each sample was attached to bleached white cotton fabric of similar dimensions. There after the composite specimen was treated in a stainless steel beaker (100 ml), containing 2g/l industrial soap as a detergent and rotated in a washing machine at 40°C for 30 minutes. The samples were washed with tap water, squeezed to remove excess water and made to dry. The color change was evaluated on a 1-5 standard grey scale.

Light Fastness Test: This was done on a TEXLAB Light Fastness Tester where each sample was cut into small pieces and placed in a sample holder then exposed to MBTL (Mercury Blinded Tungsten Lamp) inside chamber for 24 hours. The change in color shades were graded against standard blue dyed wool on a scale of (1-8).

Fastness to rubbing: This was determined according to the BS 1006 No. X12: 1978 standard methods. [13] Dry and wet rubbing fastness properties were determined using a manual crockmeter (James H. Heal and Co.Ltd, United Kingdom). In the dry-rubbing test, the finger covered with the bleached fabric was rubbed with finger 10 times. In the wet-rubbing test, the same procedure was used, with a fresh dry specimen and bleached cloth which had been wetted with distilled water and squeezed to remove excess water. Staining of bleached white cotton fabric by dyed

fabrics was assessed on a standard grey scale (1-5).

Acute Dermal Toxicity Test of crude dye extract

Administration of the extract: A single dose dermal toxicity test was conducted according to the OECD guidelines of toxicity studies. [14] Furs were clipped from dorsal area of the trunk of the test animals prior to the application of the test substance. The rats were divided into one control and five treated groups (each group consisted of ten animals including 5 males and 5 females). The control group received extract gel (3200mg/kg) while each treated group received the extract gel at 200mg/ kg, 400 mg/Kg, 800mg/kg, 1600mg/ kg and 3200mg/kg body weight by dermal application. The test substances were held in contact with the skin with a porous gauze dressing and nonirritating tape throughout the exposure period and to ensure that the animals could not ingest the test materials. Cage side observations of the test animals were done frequently, at least once per day, for changes in behavioral patterns, adverse skin reactions or corrosion to the test samples, body weight, food and water intake and death if any. The observations were done alongside the control animal for each dose level to compare and assess the extent of toxic effects if any for 14 days.

RESULTS AND DISCUSSIONS

Phytoconstituents of *Zebrina Pendula* dye extract

The phytochemical screening of the extract was done for those compounds which are known to be dye yielding. The following compounds were found present in the crude dye extract *viz*: flavonoids, anthraquinones, and tannins. Both the condensed and hydrolysable tannins were found in the extract. Tannins have been reported to be the most important ingredients which are necessary for dyeing with natural dyes, especially to brown shades of color. [15] However, the presence of anthraquinones and flavanoids may suggest that the formation of color shades may be due to synergies of these compounds.

Color shades developed on fabrics with different mordants

Color shades produced had a color trend of purple irrespective of mordanting. The use of iron water mordant produced deeper shades on both cotton and silk. Alum mordant produced lighter shades on both fabrics as can be seen in Table 1 below.

Color fastness of the dye

The dyed material was tested for light fastness, wash fastness and rub fastness. The color fastness is usually rated either by loss of depth of color in original sample or is expressed by staining scale.

Dry and wet rubbing fastness ratings were good with grades above four (4) on both cotton and silk fabrics for all the mordants. Good rubbing fastness indicates that there are no unfixed dyes left on the fiber surface after soaping and washing. Dyes from plants with good fastness penetrate well into the amorphous regions of the fibers, associated with ionic interactions or hydrogen bonding or by complexation with mordant or with functional groups of dyes (Anna and Christian, 2003). The dyed silk fabrics registered better wash fastness than cotton fabrics. Dye from this plant species therefore have poor washing characteristics on cotton fabrics and are likely to be easily washed out of the dyed textile material after repeated washing. This could be resulting from lack of strong metal coordination complexes formed inside the internal fiber structure between the mordant and dye fiber. However, there was no

significant staining observed on the adjacent bleached white cotton fabrics.

Good light fastness was exhibited by both fabrics dyed using the dye extracted. Notably, the presence of a mordant did improve the light fastness of dyes from this plant on cotton and silk fabrics making them more stable under the influence of light radiation.

Table 1: Shades formed on silk and cotton fabrics using different mordant

Dyed fabrics	Color description	Fabric type, and mordant used
	Red, accent 2,lighter 60%	silk fabric with alum
	Purple, accent 4, lighter 40%	Silk fabric with common salt.
	Tan, background 2, darker 50%	Silk fabric with Iron water
	Purple	Cotton with iron water
	Red, accent 2,lighter 40%	Cotton with alum

Table 2: Fastness grades registered on cotton and silk using different mordants

Fabric	Mordant	Rank of fastness			
		Wash (5)	Rub(crocked dry)	Rub(Crocked wet)	Light (8)
Silk	Iron water	4/5	5	4	6
	Alum	4	4/5	4	4
	Common salt	3/4	4	5	4
Cotton	Iron water	2-3	4	4	5
	Alum	2-3	4	4	4

Acute dermal toxicity

There were no observable signs of toxicity including dermal irritation to the sample at sites of administration in all the animals used in the test. There were no signs of corrosion or skin irritation observed at the areas of application within the two weeks of exposure. No signs of tremors, convulsions

and salivation that differed from the control animals were recorded. No abnormalities were observed in any of the animals at every stage of the study including respiratory dysfunction. No deaths was registered resulting from the topical application of the test samples in all the animals used in this study even up to the highest dose of 3200mg/kg of body weight. No adverse skin reactions were noted at all dose levels in all the animals used in the test.

The test samples were not irritating to the animals and were not likely to cause allergic reactions. The natural dye from this plant is not therefore likely to cause injury to human epithelium during periods of contact or exposure that are realistic for acute toxicity. The test sample materials gave negative toxicity test results with no adverse effects of contact allergies observed during each experiment. The overall results showed that there was no dermal irritation at site of application and the test substances should not be considered skin sensitizers and can be classified as not harmful in normal use and therefore of no significant lethal potential following dermal exposure.

CONCLUSION

The dyes from *Zebrina Pendula* exhibited good color absorption on silk and cotton fabrics and therefore met the maximum performance standards for color fastness to light, rubbing and washing. The dye samples were also not irritating to the animals and did not cause allergic reactions. Thus they are not likely to cause injury to human epithelium during periods of contact or exposure that are realistic for acute toxicity.

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