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WASH FASTNESS PROPERTIES OF PRE-MORDANTED TIE-DYED COTTON FABRICS DYED WITH MUUKU BARK AND MAROGOLD FLOWERS NATURAL DYES.

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Abstract: *There is a global quest for consumer eco-friendly and sustainable products fashioned with natural dyes through either printing or dyeing. However, research on imparting white patterns on textile substrates with natural dye has concentrated on dyeing and printing techniques rather than on tie-dyeing technique. Tie-dying an ancient craft used for traditional/local identification has been executed at room temperatures with synthetic dyes. This paper thus investigates the effect of mordants on wash fastness of pre-mordanted tie-dyed cotton fabrics using natural dyes. Colourants from two plants acquired from Kenya namely marigold flower and muuku bark plant were extracted using aqueous extraction method. Before dyeing, the fabrics were scoured and bleached. Saltless dyeing preceded by first pre-mordanting tie-dyed cotton fabrics with copper sulphate and anhydrous Iron sulphate mordant for 30 minutes at 100^{0}C. After pre-mordanting, fabrics were dyed with extracted colourants at 100^{0}C for 45minutes. Colour change and staining to wash on the tie-dyed fabric was analyzed. Tie-dyed cotton fabrics tied using binding and tying technique dyed with muuku natural dye gave intricate brighter lines and shades respectively than those dyed with marigold flowers. Fastness properties of the tie-dyed fabrics were acceptable ranging from 3/4 (fairly good) to 4/5 (very good). Anhydrous Iron sulphate as an inducer gave the best fastness grades. The results suggest tie-dyeing as a possible technique for pattern creation of environmental friendly fabrics.*

Key words: *Natural dyes, Tie-dyed, sustainable, fastness, eco-friendly.*

1. INTRODUCTION

Sustainable eco-friendly goods produced from natural dyes is the current global need of textile consumers. This is attributed to the affirmed environmental pollution, carcinogenic and unhealthy usage of synthetic dyes and salts from the textile industry [1]. Therefore, emphasis on clean & sustainable environment and healthy living can be achieved through responsible production, application and consumption of eco-friendly dyes. Application techniques of dyes such as dyeing and printing with little accent on tie-dyeing have been employed to accomplish eco-friendly patterned products. It's argued that tie-dyeing is similar to dyeing and printing [2]. However, unlike printing where creation of white patterns in cloths requires modelling patterns using software, skilled personnel [3], lengthy periods & large capital investments for screen development; tie-dyeing fabric preparation on the other hand, requires human wisdom (intellectual development of patterns) and binding (tight tying) of fabric with strings or rubber bands. This art of dyeing dating back to pre-historical times [4], is plausive for creation of unique attractive patterns and colours. The fundamental procedures

embedded into five major techniques [5], principally are: folding, tying and sowing/stitching of fabrics done to inhibit absorption of colourant in individualized cloth fragments.

Natural dyes have been employed for dyeing, printing [6], and tie-dye with reactive dyes [4]; but meagerly been applied in tie-dyeing with natural dyes [7]; either through cold dyeing or at elevated temperatures advocated for [8], because higher temperatures enhance exhaustion and penetration of dye into textile substrates. Therefore, the objective of this study is to evaluate the wash fastness of pre-mordanted and dye tie-dyed cotton fabrics via saltless dyeing at elevated temperatures using marigold flowers and muuku bark natural dye. Marigold flowers botanically termed as *Tagetes erectal* is a weed (with yellow flowers) found in plantation and has been used as a dye [9], but not exploited for tie-dyeing. Muuku tree on the other hand an indigenous tree found in semi-arid areas of Kenya, likewise has various applications such as ornamental, medicinal (leaves and barks) and dye. Regardless of the plant part used for dyeing, it's imperative to determine the wash fastness properties of dyed fabrics since the elegance of natural tie-dyed fabrics lies in the beautiful shades associated with age. Furthermore, traditional aesthetics instigate the existence of universal and timeless criteria of artistic value.

2. MATERIALS AND METHODS

2.1 Material

These included: 4 meters of grey cotton fabric, sodium hydroxide, Hydrogen peroxide, copper sulphate (Cu_2So_4), Anhydrous Iron sulphate (Fe_2SO_4), marigold flowers and muuku bark natural dye, Narcolab/Multase detergent, grey scales, and wetting agent.

2.2 Method of extraction of natural dye

Marigold flowers and Muuku bark were collected, washed, dried and grinded into powder using a grinding machine. With a ratio of 1:10; 600g of respective powder dissolved in water was extracted for 30 minutes at 95-97^{0}C. After extraction, colourants were left to cool, sieved and stored for dyeing.

2.3 Dyeing Process

Before dyeing, cotton fabric was divided into four sections (each measuring 1 meter) and prepared. The preparation process entailed combined scouring (5g/l) and bleaching (8ml/litre) with 2m/l of wetting agent. After preparation, the fabrics were washed and dried. Subsequent process was tie-dyeing of each meter of substrate using different procedures namely sandwiching, binding & tying, sew-twisting (shown in **Fig. 1** and **Fig. 2**) and pre-mordanting of two meters of substrate with 50g of copper sulphate and anhydrous Iron sulphate respectively for 30 minutes at 100^{0}C.

Wet on wet dyeing process was conducted through dyeing with muuku dye (fabric pre-mordanted with Cu_2So_4) and marigold flower (fabrics pre-mordanted with Fe_2SO_4) at 100^{0}C for 45 minutes using 2 liters of extracted colourant. After dyeing, fabrics were washed with detergent, rinsed, shade dried and analyzed for wash fastness using ISO105-C-06:2010(E). Fastness to wash was repeated twice, and the average grade recorded.

Fig. 1*: Tied for Copper Sulphate mordanting*

Fig. 2*: Tied for hydrous Iron sulphate mordanting*

3. RESULTS AND DISCUSSION

3.1. Techniques of tying

Dyeing with copper sulphate and anhydrous Iron Sulphate created beautiful shades of orange-brown and lighter black shades as shown in **Fig. 3**, **Fig. 4, Fig. 5** and **Fig. 6** respectively.

Fig. 3: *Dyed with Muuku bark Dye*

Fig. 4: *Tie-dyed with Muuku dyes*

The dyeing process was executed under the same conditions of temperature, time, same dye (muuku dye), colour inducer and fabric but with different tying techniques. Sample A (**Fig. 3)** that embraced binding & tying technique while sample B (**Fig. 4) which** exploited sew-twisting method, resulted into the production of spiral and rectangular patterns respectively. Both techniques produced bright shades. However, sample A showed distinct spirals than sample B.

Fig. 5*: Tie-dyed with marigold flower*

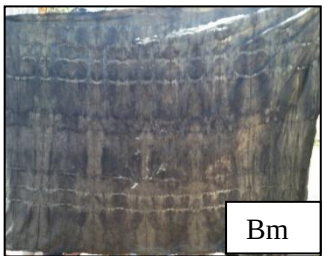

Fig. 6*: Dyed with marigold flowers*

Sample Bm was tie-dyed using sew-twisting techniques while sample Am entailed sandwiching technique; where parts tied are characterized by umbrella like shapes. As can be seen, sample Am gave intricate brighter lines than sample Bm. owing to the tightness during tying. However, for all samples dyed, the shades were dull as affirmed in natural dyeing of cotton substrates. Nonetheless cotton fabrics dyed with mukku natural dye gave brighter shades than fabrics dyed with marigold dye.

3.2. Wash fastness

Colour fastness is considered acceptably if the dye has ablity to retain or withstand colour change when washed. Fastness properties of dyed fabrics in reference to **Fig. 3 - Fig. 6**; colour change (CC) and colour staining (CS) are displayed in Table 1. For assessment, gray scale with nine gauges ranging from 1, 1/2, 2, 2/3, 3, 3/4, 4, 4/5 to 5 where 1 signifies very poor, fairly very poor, poor, fairly poor, fair, fairly good, good, very good and excellent respectively was used.

Table 1: Fastness Properties of tie-dyed Cotton Fabrics

Fastness to wash						
Particular dye and mordant	CC_1	CC_2	**Average**	CS_1	CS_2	**Average**
Dyed with muuku & copper sulphate						
1. Sample A	4	3/4	**4**	4	3/4	**4**
2. Sample B	3	4	**3/4**	4	3/4	**4**
Dyed with marigold flowers & anhydrous Iron Suilphate						
1. Sample A_m	4/5	4/5	**4/5**	4/5	4/5	**4/5**
2. Sample B_m	4/5	4	**4**	4/5	4	**4**

The fastness grade of the control fabric (fabric unmordanted) dyed with marigold dyed was 1 (very poor) for both colour staining and colour change; and 2 (poor) for control fabric dyed with muuku bark natural dye

3.2.1. Colour Staining

As can be seen from Table 1, colour staining grades ranged from good (4) signifying the lowest grade to very good (4/5) denoting the highest grade. This is ascribed to the elevated temperature of 100^0C used during the dyeing process [4]; which enhanced sorption of dye into the fabric hence through bonding with mordant formed complex coordination [10]. Sample Am tied via sandwiching technique and mordanted with Iron sulphate using marigold dye had the highest grade of 4/5. Generally all the fabrics exhibited acceptable similar fastness properties.

3.2.2. Colour Change

Wash fastness grades in Table 1 indicate that fabrics dyed with marigold flowers and muuku dye similarly exhibited acceptable fastness properties levels ranging from 3/4 (fairly good) to 4/5 (very good). This implies that, when fabrics were washed, there was a negligible change in colour. This can be ascribed to the crosslinking of hydroxyl groups of the dye molecules with cotton fabric and hydrogen bonding between dye, fabric & mordant that formed metal dye complexes. Fabrics tied via sandwiching technique and pre-mordanted with anhydrous Iron sulphate exhibited better fastness levels than those mordanted with copper sulphate.

In summary, a comparative analysis of the two mordants recomends sandwiching technique and pre-mordanting with anhydrous ferrous sulphate as the suitable mordant for dyeing cotton fabrics using marigold flower natural dye.

5. CONCLUSIONS

The purpose of this paper was to evaluate the wash fastness properties of pre-mordanted tie-dyed cotton fabrics tied using different techniques. The findings demonstrate that it's possible to tie-dye cotton fabrics with marigold flower and muuku bark natural dyes. Fabrics dyed with muuku bark natural dye gave brighter shades and distinct lines than fabrics dyed with marigold tie. The wash fastness levels of dyed cotton fabrics were acceptable ranging from fairly good (3/4) to very good (4/5). Fabrics that were first pre-mordanted with anhydrous Iron sulphate then dyed with marigold dye gave the best fastness properties ranging from 4 (good) to 4/5 (very good). Samples dyed with copper sulphate had the lowest grade of 3/4 (fairly good). The best mordant was therefore hydrous Iron sulphate. For this dyeing, binding and tying techniques of pattern designing achieved intricate line/spirals than sew-twisting and sandwiching technique. However, sandwiching technique enabled better sorption of dyes as observed by the best fastness grades. Despite this exploratory nature of the study, the results offers awareness on the opportunities of using unexploited natural dyes in tie-dyeing and hence accords us the information on attaining sustainable eco-friendly tie-dyed cotton fabrics created with low environmental impact. The study thus provide the following insights for future research: use of natural mordants, dyeing under various conditions and optimization of extractions conditions of natural dye.

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