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Suitability of Dyes from Mulberry and Coffee Leaves on Silk Fabrics using Eco-Friendly Mordants

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Abstract- Natural dyes from leaves of mulberry and coffee was extracted by aqueous method and used for dyeing silk using different mordants. The selected eco-friendly mordants used include; iron water, ash water, cow dung and lemon juice. Silk yarn which was not bleached was knitter into small fabrics (8 x 10 cm). The knitted fabric pieces were degummed and bleached by soaking in ash water for 24 hours and heating in a solution containing hydrogen peroxide respectively. Sodium bi-carbonate was used as a catalyst, powder detergent and sodium silicate were used as stabilizing agents. Post-mordanting method was used during the dyeing of the pretreated silk fabrics.

It is evident that natural dyes from the leaves of coffee and mulberry can effectively be used for dyeing silk fabrics. This is because good color shades were recorded which varied with the mordant used. More importantly the dyes registered suitable color fastness to washing, heat and light in the range of grades (3) to (4/5) for wash and heat fastness and grade of (4) and (5) for light fastness. The mordant that exhibited the best fastness characteristic is iron water with fastness grades of (4) to (4/5) for wash and heat fastness and grades of (4) and (5) for light fastness. The fastness property of ash water follows that of iron water in the range of (3/4) to (4) for wash and heat with light fastness in range of (4) to (5). Cow dung and lemon juice had inferior fastness property in the range of (3/4) and (3) however the light fastness recorded is between (4) and (5). Iron water and ash water also registered visibly more intense colors on silk fabrics therefore most mordants for dyeing of silk fabrics using these dyes.

Index Terms- color fastness, eco-friendly, mordants, , post-mordanting,.

I. INTRODUCTION

Natural dyes comprise colorants that are obtained from animal, minerals and vegetable matter without and chemical processing. A renewed international interest has arisen in natural dyes due to increased awareness of the environmental and health hazard associated with the synthesis, processing and use of synthetic dyes. Natural dyes derived from plants have recently gained economic advantage over synthetic dyes because of their non-toxic and biodegradable nature (Bhuyan and Saikia, 2008; Samanta and Agarwal, 2009). However, studies have shown that certain natural dyes may have detectable mutagenic effects e.g. elderberry color and safflower yellow; others like carmine, can cause asthma by continuous inhalation, but it can be said that most of the natural dyes are safe and some even have curative effect e.g. curcumin in turmeric has antibacterial properties (Han and Yang, 2005; Hill, 1997).

The problem associated with the use of natural dyes is the, poor color fastness, lack of reproducibility and lack of brilliance in color produced. They therefore need chemical species called mordants for binding the dye to fabrics to improve color fastness. Mordants help in binding of dyes to fabric by forming a chemical bridge from dye to fiber thus improving the staining ability of a dye with increasing its fastness properties (Padma, 2000).

In Uganda, silk farming also known as Sericulture is a practice commonly embraced by the local farmers in the Central, Western and Eastern parts of the country. Silk is a natural protein fiber produced by silk worms. The silk is produced by feeding of silk worms on mulberry leaves to produce cocoons and the cocoons are eventually processed into the silk threads which are a source of high quality textile fiber. In the agronomic practice of mulberry cultivation, there is extensive pruning of side stems and old leaves. As far as silk marketing is concerned, the methods of value addition to silk threads and its products include; twisting, doubling, sizing, singeing, bleaching, dyeing, weaving, knitting, finishing (Kasozi, 2011). The cultivation of coffee is a practice carried out in all parts of the country contributing around 50% of Uganda's export earnings (Seaman *et al.*, 2004). Careful and regular pruning of coffee trees is one of the most important practices aimed at maintaining the tree in a young and productive condition. Pruning of coffee plant involves the removal of; the Suckers, secondary branches and weak branches (Ibero Uganda Ltd, 2005). In both plants, this practice yields a large quantity of leaves which are not gainfully utilized by farmers.

This study harnessed the abundant leaves from the pruning of these plants as a source of natural dyes for silk fabrics coloration with the use of available eco-friendly mordants for the purpose of value addition on silk yarn.

II. MATERIALS AND METHODS

Materials

The fresh aged leaves of 'Thailand' mulberry (500 g) were randomly picked from the mulberry gardens in Kawanda, whereas coffee leaves chosen were the 'Robusta' type; being the most commonly grown type in Uganda. Just like the mulberry leaves, (500 g) of the aged fresh leaves of coffee were also randomly picked for dye extraction, all these were handled in the Busitema University Textile Laboratory. Silk yarn (not degummed) was bought from Kawanda research station. Distilled water was used for dye extractions. Mordants; wood ash and iron nail for processing ash water and iron water respectively.

Standard grey scale and standard dyed wool were used for matching degree of fading.

Solutions preparation

Ash water was prepared by putting wood ash powder (250 g) into a clay pot and distilled water (5000 cm^3) added to it and made to stand for three weeks. The mixture was decanted and filtered. The filtrate is the ash water used for silk degumming and a mordant in dyeing.

Iron water was made by soaking rusted iron nails (250 g) in distilled water (500mls) and made to stand for one week. The nails were removed and the liquor filtered.

Lemon juice was produced from fresh lemon fruits bought from Tororo town market. These fruits were squeezed and juice (200 cm^3) screened with a kitchen strainer to separate the seeds from the juice. The liquid was diluted with distilled water to (500 cm^3).

Fresh cow-dung (250 g) was collected from the grazing field near Busitema University campus. Distilled water (500 cm^3) was added and the mixture stirred. The mixture was filtered and the filtrate stocked for use.

The bleaching solution (2000 cm^3) was prepared by mixing sodium bicarbonate (500 g), dilute hydrogen peroxide solution (250 cm^3, pH 8) and sodium silicate (1 g) in distilled water.

Degumming and bleaching of silk fabrics

Degumming was done by soaking the hand knitted silk fabrics in ash water for 24 hours. The fabrics were later removed and rinsed with distilled water and dried at room temperature thereafter.

Bleaching was done by oxidation using an oxidizing bleaching agent. Fabrics (500 g) were soaked in a solution of detergent *omo* (250 gpl) for 30 minutes removed and rinsed twice with distilled water at room temperature. The fabrics were then placed in the bleaching solution and heated to a temperature of (60^0C) for (90) minutes. During this process, the fabrics were agitated by stirring continuously. They were removed from bleaching bath and washed with soap and distilled water at 30^0C, rinsed repeatedly and air dried.

Extraction of dyes

Fresh mulberry and coffee leaves (500 g) were separately weighed and washed. Aqueous extraction method as described by Deo and Roshan (2004) with slight modifications was used. Fresh mulberry and coffee leaves (500 g) each were washed. The leaves were then placed in a steel pan containing distilled water (750 cm^3) and heated to a temperature of 60^0C for 60 minutes. The leaves were removed and the liquor filtered and used immediately for dyeing the fabrics. This was done separately for both the mulberry and coffee leaves.

Dyeing of silk fabrics

Dyeing was done according to the method described by Katty (1997) with slight modifications. Pieces of degummed and bleached silk fabrics measuring (8x5 cm) were soaked in distilled water and transferred to dye bath liquor (700 cm^3) and the mixture heated gradually to 60^0C while stirring for 30 minutes. The fabrics were removed from the dye bath and immediately soaked in solution of a mordant. Different fabrics were soaked separately in; iron water, ash water and cow dung solution each made to stand for 15 minutes. A ratio of 35 g of fabrics to 100 cm^3 of a mordant solution was used in all cases.

Evaluation of color fastness

The wash fastness was done according to standard method as described by Foulds (1995). A slight modification was made by using knitted fabrics of (4x3 cm). The wash fastness rating was assessed using standard grey scale as per ISO-05-A02 (loss of shade depth). The heat fastness was conducted by pressing the fabric with a hot iron plate at 90 ^{0}C for 30 seconds on patterned dyed and un-dyed silk fabrics. The color change and degree of staining were later observed and assessed on a scale of (1-8).

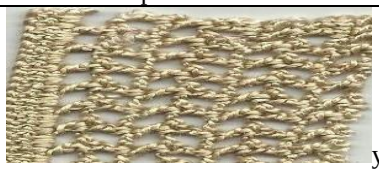
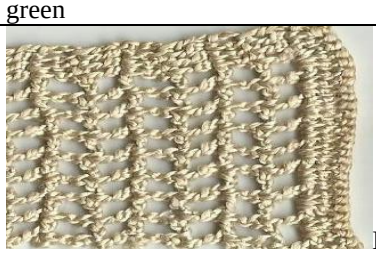
Light fastness was determined according to the standard method describe by Trotman (1993) with slight modifications by using knitted fabrics of dimensions 4x3 cm. The exposure to light per day was 8 hours for a total of 20 days. The change in color shades were evaluated against standard blue dyed wool in the range of 1 to 8.

III. RESULTS AND DISCUSSION

Color shades developed on silk fabrics on application of the dyes

Dyes from the leaves of coffee and mulberry plants produced colors on cotton fabrics without the application of any mordant in the dyeing process. Coffee and mulberry leaves gave yellow green and buff brown colors respectively as shown in **Table 1**. below.

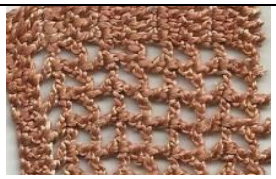
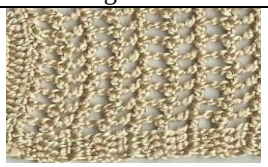
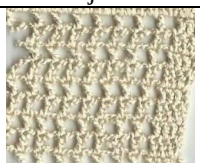
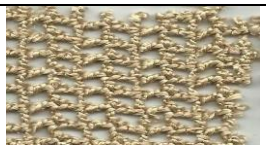
Table 1. Colors produced on cotton fabrics on application of mulberry and coffee dyes without mordants.

Plant used	Color shade produced
Coffee leaves	 yellow green
Mulberry leaves	 Buff brown

Colors of multiple shades were produced on the application of dyes from coffee and mulberry leaves on cotton fabrics with the use of mordants. The variation in shades was with respect to the applied mordants as shown in **Table 2**. below. Iron water produced colors of deeper shades than the other mordants for dyes from both plants namely; grey and olive green for coffee and mulberry respectively. Ash water produced a brilliant tawny brown with coffee leaves and buff brown with mulberry leaves. The lightest shades were produced from the use of lemon juice

mordant, this may be a result of the bleaching property of citric acid which is a component of lemon juice. For dyes from both plants, cow dung produce yellow shades viz; arylide yellow and lemon yellow for coffee and mulberry in that respect.

Table 2. Color produced on cotton fabrics from mulberry and coffee dyes with different mordants

Plant used	Mordant used and color produced			
	Iron water	Ash water	Cow dung	Lemon juice
Coffee leaves	 grey	 Tawny brown	 Arylide yellow	 Buff
Mulberry leaves	 Olive green	 Buff brown	 Lemon yellow	 Khaki

Color fastness of shades produced on silk fabrics

The fastness was determined with respect to washing, heat and light. As can be noticed in table 3 below, iron water mordant gave a very good wash fastness of (4), a good heat fastness of (3/4) and a good light fastness of (5). Ash water recorded a good wash and heat fastness of (3/4) and an average light fastness of (4). A weak was and heat fastness of (3) was recorded for both lemon juice and cow dung with cow dung exhibiting a good light fastness of (5) better than that for lemon juice of with moderate light fastness of (4). Generally for dyes from coffee leaves, iron water gave the best fastness followed by ash water; they also exhibited deeper shades on silk fabrics. Cow dung and lemon juice gave inferior fastness results in comparison to iron water and ash water.

Table 3. The color fastness of coffee and mulberry dyes on silk fabrics

Plant used	Mordant used	Fastness grade		
		Wash	Heat	Light
Coffee	Iron water	4	¾	5
	Ash water	3/4	¾	4
	Cow-dung	3	3	5
	Lemon juice	3	3	4
Mulberry	Iron water	4/5	4	5
	Ash water	4	4	4
	Cow-dung	¾	3	4
	Lemon juice	¾	3	4

In the case of dyes from mulberry leaves, iron water registered an excellent wash fastness of grade (4/5), a very good heat fastness of (4) and a good light fastness of grade (5). With ash water, very good wash and heat fastness of grade (4) were recorded and a moderate light fastness of (4). Cow dung and lemon juice registered equal grades of fastness in all cases where a good wash fastness of (3/4), moderate heat fastness of (3) and moderate fastness of light (4) were recorded. From these results, iron water exhibited the most superior fastness properties followed by ash water. Cow dung and lemon juice registered less desirable fastness properties with relatively deeper color shades.

IV. CONCLUSIONS

From the study, it is evident that natural dyes from the leaves of coffee and mulberry can effectively be used for dyeing silk fabrics. This is because good color shades were recorded which varied with the mordant used. More importantly the dyes registered suitable color fastness to washing, heat and light in the range of grades (3) to (4/5) for wash and heat fastness and grade of (4) and (5) for light fastness. The mordant that exhibited the best fastness characteristic is iron water with fastness grades of (4) to (4/5) for wash and heat fastness and grades of (4) and (5) for light fastness. The fastness property of ash water follows that of iron water in the range of (3/4) to (4). Cow dung and lemon juice had inferior fastness property in the range of (3/4) and (3) however the light fastness recorded is between (4) and (5). Iron water and ash water registered good color fastness and they also exhibited visibly intense color shades on silk fabrics therefore most suitable mordants for dyeing of silk fabrics using natural these dyes.

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