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Potential of Henna Leaves as Dye and Its Fastness Properties on Fabric

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***Abstract*—**Despite the wide spread use of synthetic dyes, natural dyes are still exploited and used to enhance its inherent aesthetic qualities as a major material for beautification of the body. Centuries before the discovery of synthetic dyes, natural dyes were the only source of dye open to mankind. Dyes are extracted from plant - leaves, roots and barks, insect secretions, and minerals. However, research findings have made it clear that of all, plants- leaves, roots, barks or flowers are the most explored and exploited in which henna (*Lawsonia innermis* L.) is one of those plants. Experiment has also shown that henna is used in body painting in conjunction with an alkaline (Ammonium Sulphate) as a fixing agent. This of course gives a clue that if colour derived from henna is properly investigated, it may not only be used for body decoration but possibly, may have affinity to fiber substrate. This paper investigates the dyeing potentials – dye ability and fastness qualities of henna dye extracts on cotton and linen fibers using mordants like ammonium sulphate and other alkalis (hydrosulphate and caustic soda, potash, common salt, potassium alum). Hot and cold water and ethanol solvent were used in the extraction of the dye to investigate the most effective method, dye ability, and fastness qualities of these extracts under room temperature. The results of the experiment show that cotton have a high rate of dye intake than other fiber. On a similar note, the colours obtained depend most on the solvent used. In conclusion, hot water extraction appears more effective. While the colours obtained from ethanol and both cold hot methods of extraction range from light to dark yellow, light green to army green and to some extent shades of brown hues.

***Keywords*—**Dye, fabrics, henna leaves, potential.

I. Introduction

THE use of dye stuffs is as old as textiles themselves and pre-dates written history. Dyes are obtained from two main sources; the natural dyes and synthetic dyes. Natural dyes can be defined as those organic materials that have the ability to impart colour to any substrates which they must have had affinity for. Natural dyes are biodegradable and very compatible with the environment [1]. They have beauty and depth of colour that cannot quite be obtained with synthetics [2]. These dyes can be obtained either from plants, animals, and minerals. Until the mid19th century, all dyestuffs were made from natural materials, mainly vegetables matter. Research findings have reported that synthetic dyes are harmful to the body as in [1], [3], [4] and thus the increased search into the arrays of plants for natural dyes which is more environmental friendly. Most of these dyes are substantive and therefore do not require mordant to fix the molecules on fibers but mordant are sometimes used to increase the colour and shade range of the natural dye plant [5]. Some of these dyes are useful as indicators, stains, or solvent dyes and the fact that textile fibers especially cellulosic, do not have much affinity for the majority of the natural dyes [4], makes it more imperative for addition of mordants which acts as a link between the fiber and the dyestuff. This creates an enabling environment for the dye molecules, especially from the fugitive plants, to be transferred into the amorphous parts of the fiber.

Henna is a household name in decoration especially the body painting. Henna, also known as hina, the henna tree, mignonette tree, and the Egyptian privet is scientifically known as *Lawsonia innermis* L. [6]. It is a flowering plant and the sole species of the Lawsonia genus. The name henna also refers to the dye prepared from the plant and the art of body painting referred to as tattoo based on these dyes. In Nigeria, henna is known as *"lalle"* and it has been used since antiquity to dye skin, hair, and fingernails. Although research has shown that henna has been used to dye animal fibers such as silk, wool, and leather, not much was said about the dye ability and fastness properties of henna on plant fibers such as cotton and linen.

Historically, henna, a small desert plant, was used for cosmetic purposes in Ancient Egypt, as well as other parts of North Africa, the Horn of Africa, the Arabian Peninsula, the Near East and South Asia [7]. It is most especially used for tattooing in the Muslim dominated areas of Africa including Northern Nigeria where brides cannot be complete in their bridal outfit without a full decoration with the *"lalle"* dye. Bridal henna nights remain an important custom in Northern Nigeria, particularly among traditional families [8]. In the past, due to its importance among the traditional families of the Northern states of Nigeria, henna was cultivated at home as domestic and ornamented plant as well as in farms in a wide range for sale. However, presently, growing of henna is a thing of the past as the imported henna paste has taken over. Henna only grow in the wild. These plants are commonly found in Sokoto, Kano, Katsina, Borno, Adamawa, Taraba, Yobe, Bauchi, Plateau, Kwara, Kebbi, and Niger States.

Henna has been used since antiquity. Like *"uli"* (a body painting of the Igbos of Eastern Nigeria), it is a material and a method of making design. As Dye, it has been used in staining and sticking on various substrates which it penetrates either by itself or through a mordant. Dyes are different from paints, because they bind with the fiber and have no hand (the feel when touched with your hand) unlike the paints which lay on top of the fiber and do have hand. There are many substances which can be coloured with dyes, such as textiles, paper,

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leather, etc. During the dyeing process, dye molecules are deposited from solution onto the material in such a way that they cannot be subsequently removed by the solvent in which they were dissolved. This retentiveness is referred to as colour fastness. Fastness is then defined as the ability of a pigment or dye or the leather, cloth, paper, ink to retain its original hue, without fading, running or changing when wetted, washed, cleaned or stored under normal conditions of exposure to light, heart or other influences. Dyes have different levels of fastness on different materials.

Dye application is either in a molecular or colloidal state of dispersion as opposed to pigments, which are applied, in the form of insoluble particles [9]. Therefore, the dye is defined as water soluble, a transparent coloring agent that saturates and binds with the fiber. The nature of henna as a desert shrub enables the production of the most soluble dye especially when grown in temperatures between 35 and 45°C (95 and 113°F) due to the high concentration of the dye content. [10], [11].

A. Description of Henna Plant

Bailey and Bailey [6] made a concise description of henna plant as a tall shrub or small tree, standing 1.8 to 7.6 m tall (6 to 25 ft.). It is glabrous (hairless and smooth) and multi-branched, with spine-tipped branchlets. The leaves grow opposite each other on the stem. They are glabrous, sub-sessile, elliptical, and lanceolate (long and wider in the middle; average dimensions are 1.5–5.0 cm x 0.5–2 cm or 0.6–2 in x 0.2–0.8 in), acuminate (tapering to a long point), and have depressed veins on the dorsal surface. Kumar, Singh and Singh [12] also gave a concise study on henna ecology and distribution. In their research, it was reported that henna flowers have four sepals and a 2 mm (0.079 in) calyx tube, with 3 mm (0.12 in) spread lobes. Its petals are obvate, with white or red stamens found in pairs on the rim of the calyx tube. The ovary is four-celled, 5 mm (0.20 in) long, and erect. Henna fruits are small, brownish capsules, 4–8 mm (0.16–0.31 in) in diameter, with 32–49 seeds per fruit, and open irregularly into four splits

B. Henna as Dye

Research reports have shown that henna extracts have been used in the art of tattooing and general body decoration due to the staining marks it leaves on the skin which lasts for a certain period (two weeks – two months). Unlike the *"uli"*, used in place of *'lalle'* (henna) in the eastern part of Nigeria, henna dye must go with additives in form of mordants for the staining on the skin to be intensified. Various researches show that different colours can be obtained from henna dye, but these depend more on the use of different mordants meant mainly for body adornment. To prepare henna as a body dye, it is commonly traded as a powder made by drying, milling and sifting the leaves. The dry powder is mixed with lemon juice, strong tea, or other mildly acidic liquids to make a preparation with toothpaste-like consistency, which can be used to make finely detailed body art as in [6].

The plant Henna exists in different varying species. The encyclopedia Britannica [10] ascertained that *Lawsonia innermis* of the family *Lythraceae* and native to north east Africa, is the henna of commerce, yielding an orange – red dye that has been in use for centuries in the Middle East and east of Asia for colouring the hair, finger nails, and soles of the feet. They contain a substance that reacts directly with the keratin of human hair and skin to form the bright pigment. Henna extracts, sometimes, are chemically altered and used as the base for a wide array of hair colourants [13]. It added that the dye obtained from henna is also used to stain leather, hides and to colour the hooves and manes of horses. Henna can produce various shades, generally in the red family, but without peroxide or developers. The shades it produces depend upon the basic color of the hair and how long the henna is left on as in [13].

Nkeonye [14] states that for a dye to be a textile dye it must have intense colour, an attraction or affinity for fibers, be capable of being retained by fiber after application and/ or fixation and have a sufficient degree of resistance (fastness) to common agencies encountered during use of the coloured material e.g. light, water etc. Henna therefore can be acclaimed as dye as all these attributes are inherent in the plant extract. Research report has indicated of dyeing silk and wool with henna dye extract as in [1]

Dye fastness refers to the fading or unfading quality that is the ability of a dye to be retained in the substrates which it has penetrated without fading or running. Gohl and Vilensky [15] stated that dye is a colorant that penetrates the actual fiber and appears to become part of it. They further explained by stating that the best colour fastness is attributed to those dyes which most successfully colour the total fiber. All dyes are not equally fast; not even all dyes within one dye group are equally fast. Fastness can be described in relation to the ability of the dye to withstand the light, washing, water, perspiration, chlorine, crocking. Within each of these are degrees of fastness made possible by dye fiber or the combination of both. Dyes as a coloring agent vary from one to the other due to the method of application and its origin [16].

Eicher [17] added that other domestic dyes are gotten from the leaves and barks of many plants and trees that are utilized in producing other colours of dyes. He also mentioned that shades of red can be obtained from leaves of guinea corn (*Sorgum vulagre*), leaves of teak (*Lawsonia innermis*), barks and roots of African rose wood (*Pterocarpus erinaceous*), wood of the cam wood (*Baphia nitida*). She explained further that the sap of old physic nut tree (*Jatropha curcas*) produces a black dye.

II. Materials and Methods

The plants *Lawsonia innermis* L. were located in Mr. Degry's country farm in Dakri about 18 kilometers away from the researcher's residential home in Yola North local government area of Adamawa State, Nigeria. The plant was harvested or collected by hand from the farm and was identified by a taxonomist in the Department of Plant science, School of Agric. and Agricultural Technology, Modibbo Adama University of Technology Yola, Nigeria.

A. Preparation of Henna Leave for Experiment

The henna leaves were cut from the plant, spread in a shade for several day under room temperature to dry out the water content in the leaves. It is then pounded with mortar or grinded mechanically into powdered form for effective extraction. The powdered sample was sieved with a sieve to remove some stalk that is not well pounded or grinded.

B. Dye Extraction from Henna Leaves

The methods used in extracting dye from henna leaves were hot and cold water and ethanol solvent extraction. The hot and cold method was used to ascertain which of the two can give a better solution. The crushed powdered leaves of *Lawsonia* L. were used for this experiment.

1.Hot and Cold Water Extracts

The extraction was conducted using 100gs of *Lawsonia* L. mixed in 2litters of water in 2 different containers. One was boiled for 45minutes at boiling point and allowed to stay overnight (Specimen 1). The other was soaked for 48hrs (Specimen 2). It was observed that the hot aqueous extraction showed slightly deeper– red-orange colour while the cold extract exhibits deep red-orange colour.

2.Ethanol Solvent Extraction

Different degrees of sample were developed for the extraction of henna dye using ethanol solvent (Specimen 3). The sample was weighed in 5%, 10%, 15%, and 20% being equivalent to 10g, 20g, 30g, and 40g respectively. Each set was soaked in 200mls of ethanol solvent as in Table I.

TABLE I
PREPARATION OF ETHANOL EXTRACT SAMPLES

Powder (g)	Solvent (ml)	Concentration (%)	Set
10g	200ml	5%	3a
20g	200ml	10%	3b
30g	200ml	15%	3c
40g	200ml	20%	3d

Each of the sets (3a, 3b, 3c, and 3d) was allowed to stand for 24hours and the colours observed after extraction ranges from dark green to very deep dark green.

Both the aqueous and ethanol experiments were carried out based on individual alkalis (table salt, hydrosulphate and caustic soda, alum, ammonium sulphate- *"gishirinlalle,"* and potash- *"kawa")* which forms the fixing or binding agent. The gishirinlalle was subjected to laboratory test and confirmed to be ammonium sulphate.

C. Fabric Used for the Experiment (Cotton and Linen)

The fabrics used for this experiment were picked from natural cellulosic fiber group (cotton and linen). Cotton is the most common and most widely used textile fabric. It is the cheapest natural fiber used in cloth application. The plant is indigenous to many sub-tropical countries (especially Nigeria). Cotton is chosen for this experiment because it has high affinity to dye, readily available and equally easily affordable. Linen, also a cellulosic fiber is derived from the stem of flax plant and ranks second in usage and availability. It is comfortable, hand washable and light weight. Linen also absorbs dye. These fibers were selected for their ergonomity, availability and affinity to dye. These fibers were washed with detergent to remove impurities like starch and other additives used during weaving and dried in an open air drying line. After dyeing, a part of these fibers was washed with soap to ascertain the fastness of the dye on fibers – cotton and linen. Fabric is prepared by washing with detergent to remove impurities.

D. Other Materials and Tools

The following are the tools and materials used for the experiment: hand glove, dye bath, water, henna leave, heat source, pot, measuring spoon and scale. Alkalis used are table salt, alum, hydrosulphate and caustic soda (sodium hydroxide), ammonium sulphate (*"gishirinlalle")*, and potash.

III. PREPARATION OF DYE SOLUTION

Each of these alkalis was used individually to form a separate solution for this experiment. Alkalis were mixed directly with the aqueous extracts. To make it soluble to alum, the required quantity of alum in its solid state can either be dissolved in water before adding to dye bath or it can be dropped into the dye bath containing henna dye extract.

A. Dyeing Procedure

The following procedures were used in the experiment of dye ability of henna leaves- as dye using textile materials of cotton and linen:-

Hot Water Extract

1. Without Mordant (Direct Dyeing)

- 100ml of sample 1 extract
- 2pieces of 11cm x 14 cm of cotton and linen fabrics.
- Soaking Time – 30minutes.

Procedure

Immerse sample fabrics into a dye bath container (beaker) of 100mls of specimen 1 (henna leave dye) extract. Allow for 30minutes and turn at intervals. Remove from the dye bath and allow to drip dry. When dried, cut 1/3 of the material and wash with soap to determine their fastness qualities.

2. With Mordant

The mordants for these experiments are Potash ("kawa"), Table salt, Ammonium sulphate ("gishirinlalle"), Alum, Hydrosulphate and caustic soda.

- 100mls of aqueous extracted henna dye solution.
- 9g of table salt.
- 4g of hydrosulphate and 4g of caustic soda respectively.
- 5g of alum.
- 10g of ammonium sulphate (*"gishirinlalle*").
- 6g of potash (*"kawa*").
- 2 Pieces of 11cm X 14 cm cotton and linen fabrics for each of the experiment.

Procedure

Pour 100ml of henna leave dye extract into a dye bath

container (beaker). Add the required measure of any of the mordants (hydrosulphate and caustic soda is 2:1). Steer thoroughly to ensure complete mixture of the solution. Immerse the sample materials (cotton and linen). Allow for 30 minutes with interval steering. Remove from solution. Allow for some minutes to air and rinse.

Cold Water Extract

1. Without Mordant (Direct Dyeing)

- 100ml of specimen 2 extract
- 2pieces of 11cm x 14 cm of cotton and linen fabrics.
- Soaking Time – 30minutes.

Procedure

Immense sample fabrics into a dye bath (beaker) containing 100mls of specimen 2 (henna leave dye) extract. Allow for 30minutes and turn at intervals. Remove from the dye bath and allow to drip dry. When dried, cut 1/3 of the material and wash with soap to determine their fastness qualities.

2.With Mordant

The mordants for these experiments are Potash (*"kawa"*), Table salt, Ammonium sulphate (*"gishirinlalle"*), Potassium Alum, Hydrosulphate and caustic soda.

- 100mls of aqueous extracted henna dye solution
- 9g of table salt.
- 4g of hydrosulphate and 4g of caustic soda respectively.
- 5g of potassium alum
- 10g of ammonium sulphate (*"gishirinlalle")*
- 6g of potash (*"kawa*").
- 2 Pieces of 11cm X 14 cm cotton and linen fabric.

Procedure

Pour 100ml of henna leave dye extract into a dye bath container (beaker). Add the appropriate measure of any of the mordants (hydrosulphate and caustic soda is 2:1). Steer thoroughly to ensure complete mixture of the solution. Immerse the sample materials (cotton and linen). Allow for 30 minutes with interval steering. Remove from solution. Allow for some minutes to air and rinse.

Ethanol Solvent Extract

1.Without mordant (Direct dyeing)

- 100ml of specimen 3 extract
- 2pieces of 11cm x 14 cm of cotton and linen fabrics.
- Soaking Time – 30minutes.

Procedure

Immense sample fabrics into a dye bath (beaker) containing 100mls of specimen 3 (henna leave dye) extract. Allow for 30minutes and turn at intervals. Remove from the dye bath and allow to drip dry. When dried, cut 1/3 of the material and wash with soap to determine their fastness qualities.

2. With Mordant

The mordants for these experiments are Potash (*"kawa"*), Table salt, Ammonium sulphate (*"gishirinlalle"*), Alum, Hydrosulphate and caustic soda.

- 40mls of ethanol henna dye extract.
- 3g of table salt.
- 2g of hydrosulphate and 1.5g of caustic soda.
- 2g of potassium alum.
- 3g of ammonium sulphate (*"gishirinlalle*").
- 2g of potash (kawa).
- 2pieces of 11cm x 14cm cotton and linen.

Procedure

Due to the non-dissolution of the alkalis in ethanol solvent, the pre mordant method was adopted. Required measurement of the mordant was dissolved in 20ml water. The sample materials (cotton and linen) were soaked in the solution for 2minutes steering at intervals. Remove sample and immerse in dye bath containing 40ml of ethanol solvent. Allow for 30 minutes with interval steering. Remove from solution. Allow for some minutes to air and rinse.

IV. Results And Discussions

A. Results after Dyeing With Hot Water Extracts

Table II shows the results of the experiment carried out with hot water dye extract from henna leaves using direct dyeing and different mordants.

B. Results after Dyeing with Cold Water Extract

Table III shows the results of the experiment carried out with cold water dye extract from henna leaves using direct dyeing and different mordants.

C. Results of Direct Dyeing Using Ethanol Solvent Only

Tables IV shows the result of the experiment carried out with ethanol solvent extract from henna leaves only (direct dyeing).

D. Results after Dyeing With Ethanol Solvent Solution with Different Mordants

Tables V-XI show the results of the experiment carried out with ethanol solvent extract from henna leaves using different mordants.

D. Discussion

The discoveries made in this experiment has shown that colours of varying degrees can be obtained from one dye colour yielding plant through the use of different mordants as well as the method of extraction of the dye liqueur (Tables III-VI) as supported by [1], [18], [19]. The methods used in extracting dye for this experiment are aqueous extraction in which hot and cold water method was adopted for this exercise and ethanol solvent. The investigation on the aqueous extraction revealed hot water method as more effective in dye extraction [7], [20]. This was noticed from the colour of the liquid extract, reddish orange, and the intensity of colour exhibited by the sample fabrics after dyeing.

TABLE II
HOT WATER EXTRACT

S/N	Test	Observation			Inference	
		SOLUTION	**COTTON**	**LINEN**	**COTTON**	**LINEN**
1.	Without mordant (Direct).	The solution colour showed deeper red-orange and therefore good for the extraction.	Showed a stain of light yellow that turned slight red -orange after desizing.	Showed the same colour as cotton but gave a little slightly stronger red-orange after washing.	Have little affinity to henna dye. Tannin in aqueous extract. A little fast.	Have little affinity. Low tannin in aqueous extract. A little fast.
2.	Table Salt	There was no change in colour	The henna dye gave a deep brown colour after oxidation but became lighter- carton colour- after desizing.	Gave a deeper brown colour but shows lighter brown colour after desizing.	Can be used. The table salt seems to be a fairly good binder for the natural henna dye.	Have a better affinity to henna extracted dye.
3.	Caustic soda (Sodium Hydroxide) and Hydrosulphate	The mixture formed a slight precipitate but no change in colour.	Gave brownish stain on the fabric but washed off almost completely when rinsed leaving light carton colour.	Gave brownish stain that washed off completely after desizing	Not a favorable fixing agent for henna dye.	Does not have affinity
4.	Potassium Alum	No Change in solution colour	The sample shows a deep dark grayish brown colour stain but lost some amount of the colour in desizing.	Gave the same result as in cotton	Can be used when lighter carton colour is desired. Fairly good fast	Can be used when lighter carton colour is desired. Fairly good fast
5.	Ammonium sulphate (“*Gishirinlalle*”)	No Change in solution colour	This fixing agent gave a dark brown colour. It allows high absorption of the henna dye to the cotton fabric. Though there was dye loss during desizing that reduce the dark brown to carton colour.	Showed dark brown colour which became a little lighter after desizing.	Allows for higher dye absorption. Good fast	Allows for higher dye absorption. Fairly good fast
6.	Potash (“*Kawa”*)	The mixture became foamy and very dark solution with uncomfortable odour	The staining colour was autumn orange but all colour was lost during desizing.	Gave the same result as cotton	Not a good binder for cotton	Not a good binder for linen

TABLE III
COLD WATER EXTRACT

S/N	TEST	OBSERVATION			INFERENCE	
		SOLUTION	**COTTON**	**LINEN**	**COTTON**	**LINEN**
1.	Without Mordant	Red – orange in colour	The solution gave a yellow – orange colour. Most of the colour was lost during desizing leaving a light peach colour.	The solution gave a stronger yellow – orange but lost almost all the colour in washing	Does not have strong affinity to henna dye. Low tannin in aqueous extract but fairly fast	Does not have attraction to henna dye. Low tannin in aqueous extract.
2.	Table Salt	No change in solution colour	Walnut/burnt umber colour was resulted which was reduced to lighter colour after washing	Same as observed in cotton	Can be used if the colour realized is desired.	Can be used if the colour realized is desired.
3.	Caustic Soda and Hydrosulphate	No change in solution colour	There was a slight stain of light yellow ochre which washed off completely.	Very light tint of what is observed in cotton which washed of completely	Not a good binder for Henna dye.	No affinity for Henna dye.
4.	Potassium Alum	No change in solution colour	Showed a good brown (burnt umber) colour which became a little lighter (carton) after desizing.	Good brown (burnt umber), was obtained, little of which was lost in a washed off.	Can fix henna dye to an extent.	Good binder of henna
5.	Ammonium Sulphate (“*gishirinlalle”)*	No change in solution colour	A Much darker than Alum stain but that turns light after rinsing due to colour loss.	Slightly darker shade.	Fairly strong fixer for henna dye.	A Moderately good fixer for henna dye.
6.	Potash *(“Kawa”)*	The mixture became foamy and very dark solution with uncomfortable odour	Obtained very strong brick Red colour but lost much in desizing.	Obtained strong brick red but lost the colour completely in desizing.	Not a strong fixer for henna dye.	Not a fixer for henna dye

TABLE IV
ETHANOL SOLVENT ONLY

Test	Colour	Fastness Quality				
		Cotton		Linen		
	Colour After extraction	After dyeing	After desizing	After dyeing	After desizing	
3a (5%/10g)	Dark Green	Yellow	light yellow	Yellowish brown	Light yellowish brown	Excellent
3b (10%/20g)	Dark Green	Yellowish brown	Army green	Yellowish brown	faint army green	Excellent
3c (15%/30g)	Deep Dark Green	Yellowish green	patches of orange and army green	Yellowish green	light stain	Excellent
3d (20%/40g)	Very Dark Green	Army green	Light Army green	Light army green	Very Light army green stain	Excellent

TABLE V
ETHANOL WITH HYDROSULPHATE AND CAUSTIC SODA

	OBSERVATIONS							
	COTTON				LINEN			
Sets	5% (10g)	10% (20g)	15% (30g)	20% (40g)	5% (10g)	10% (20g)	15% (30g)	20% (40g)
Colour after dyeing	Yellow ochre	Yellow ochre	Raw umber	Deeper Yellow ochre	Yellow ochre	Yellow ochre	Yellow ochre	Deeper Yellow ochre
Fastness after desizing	Loss of colour leaving high light yellow ochre	Little or no colour loss, Excellent fast	Not fast. Complete loss of colour	Left patches of lemon yellow. Moderately fast	Loss of colour leaving high light yellow ochre	Moderate fast. Left some stains of the colour	Not fast. Complete loss of colour	Left patches of lemon yellow. Moderately fast

TABLE V
ETHANOL WITH AMMONIUM SULPHATE ["*GISHIRINLALLE*"]

	OBSERVATIONS							
	COTTON				LINEN			
Sets	5% (10g)	10% (20g)	15% (30g)	20% (40g)	5% (10g)	10% (20g)	15% (30g)	20% (40g)
Colour after dyeing	Patches of olive green and Raw umber	Olive green	Olive green	Yellow ochre	Patches of olive green and Raw umber	Olive green	Light Olive green	Yellow ochre
Fastness after desizing	Light olive green. Fairly good fastness quality	Colour loss Light patches of olive green	Poor fast. Lost most colour leaving patches.	Little colour loss. Good fast	Light olive green. Fairly good fastness quality	Colour loss Light patches of olive green	Poor fast. Lost most colour leaving patches.	Lost some colour but maintained a fairly good fast.

TABLE VII
ETHANOL WITH POTASH ["*KAWA*"]

	COTTON				LINEN			
Sets	5% (10g)	10% (20g)	15% (30g)	20% (40g)	5% (10g)	10% (20g)	15% (30g)	20% (40g)
Colour after dyeing	Light gold ochre	Raw sienna	Raw sienna	Raw sienna	Light Gold ochre	Light burnt umber	Gold ochre	Light burnt umber
Fastness after desizing	Light olive green. Poor fast	Lemon yellow. Fairly good fast	Complete loss of colour. Poor fast	Lemon yellow. Fairly good fast	Light olive green. Poor fast	Lemon yellow. Fairly good fast	Complete loss of colour. Poor fast	Lemon yellow. Fairly good fast

TABLE VIII
ETHANOL WITH COMMON SALT

	OBSERVATIONS							
	COTTON				LINEN			
Sets	5% (10g)	10% (20g)	15% (30g)	20% (40g)	5% (10g)	10% (20g)	15% (30g)	20% (40g)
Colour after dyeing	Light olive green	Mid olive green	Mid olive green	Mid olive green	Lighter than 10%	Light raw umber	Mid raw umber	Mid raw umber
Fastness after desizing	Very High tint of olive green. Not a strong fixer for henna dye.	High tint of olive green. Not a strong fixer for henna dye.	Light olive green. Fairly good fixer for henna dye.	High tint of olive green. Not a strong fixer for henna dye.	Very high tint olive green. Not a strong fixer for henna dye.	High tint of olive green. Not a strong fixer for henna dye.	Light olive green. Not a strong fixer for henna dye.	Washed off completely. Poor fast

TABLE XI
ETHANOL WITH POTASSIUM ALUM

	OBSERVATIONS							
	COTTON				LINEN			
SETS	5% (10g)	10% (20g)	15% (30g)	20% (40g)	5% (10g)	10% (20g)	15% (30g)	20% (40g)
Colour after Dyeing	Light olive green	A little darker than 5% olive green	Olive green	Olive green	High light olive green	Light olive green	Light olive green	Olive green
Fastness after Desizing	Lost a little colour. Fair good fast	Little loss of colour Good fast	Little loss of colour. Good fast	Little loss of colour. Good fast	High light olive green. Fair fast	Light olive green. Fair fast	Little loss of colour. Good fast	Little loss of colour. Good fast

Based on the discovery of this experiment, it has been found that cotton fabric ordinarily absorbs dye more than linen fabric as in [19], [21]. This showed in the intensity of the colour obtained after the dyeing.

A direct dyeing carried out to investigate on the level of natural mordant in the henna dye extract showed low level of tannins as the colours were almost lost during desizing. In general, the aqueous consideration has among the fixing agents ammonium sulphate and potassium alum (Table II) that show high tendency of fixing agent while salt, and potash show low tendency. The fixing level of caustic soda and hydrosulphate is so insignificant and thereby cannot be rated as fixing agent for aqueous extract of natural henna dye. Also it was discovered that in using dry henna leave some mordant show a high fixing rate in cold water while others retain more of the dye in hot water. In cold water, Ammonium Sulphate

(*"gishirinlalle"*) and potassium alum show high retentive tendency, while salt, and potash show low rate of fixing. Potash showed the least fixing agent in the experiment. It give good reaction with dye extract and exhibits to an extent excellent colour which is released at a contact with water or any liquid. This, it seems, is because of the large potassium content in plant [22]. Caustic soda and hydrosulphate still has nothing to show as a fixing agent of this natural dye under this condition. Under high temperature (hot water) only ammonium sulphate and potassium alum show high fixing rate followed by salt while others did not show any tendency of fastness to this dye. The colours obtained using aqueous extracts are all tints and shades of brown. This is in agreement with the investigation of [19] that henna hot and cold extracts stained in shades of brownish colour.

The ethanol investigation for colour yielded positively as different colours (majorly brilliant colours) were obtained with the use of different mordants. Better colour strength and considerable fastness quality rating from fairly good to excellent. Hydrosulphate and caustic soda proved an excellent binder for henna dye rather than in aqueous extracts. This is followed by the direct dyeing of the sample materials so as to ascertain the strength of tannin in the plant. This proved to be excellent fast but with slow up take of dye, as a result of which mordants are added to improve this condition. Ammonium sulphate at 20% showed fairly good fast followed by Potash 10% which yielded light lemon yellow after wash. Others did not show good tendency of fastness to henna dye extract. The investigation with ethanol solvent at 5%, 10%, 15%, and 20% of henna dye extraction concentration reveals the effect of dyes at different concentration levels with respect to their colour strength. The result is shown in Tables V-IX. The tables show the colour intensity of the dyed sample fabrics from different dye concentrations. It then reveals that dye up take decreases with the increase of dye concentration and increases with the decrease of dye concentration as proved by [1]. Also, in agreement with [1], that the maximum dye absorption happens at 10% concentration.

Finally, the dye ability and fastness qualities of dye from henna on cotton and linen (cellulose fibers) are not as excellent as wool or silk (protein fiber). Burch [3] stated that cotton is less suitable for many natural dyes. Also in agreement to this fact is the concluding result of [1] investigation on extraction and effects of henna leave dye on textile fabrics, that "Considering dyeability and colour fastness, dye from henna matured leaves was highly applicable on dyeing of silk fiber as well as other protein fiber." In other words, dye from henna leave was highly not applicable on dyeing of cotton or other cellulose fibers. This study then reveals that to an extent cotton is less suitable for many natural dyes and henna leave dye is one of the many natural dyes. Although numerous different colours were obtained, a good number are colour fast to the level of moderately good to excellence rating. However dyeing cotton or any other cellulose fiber with ethanol extracts of henna leaves dye is encouraging as different bright colours of good strength are obtained. Nonetheless, a number of mordants showed good fastness to henna dye on either cotton or linen or even to both, a good number also exhibited weak and poor fastness quality. However they cannot be ruled out completely as dye fixers due to the colour change left on the sample fabrics [23].

V. Conclusion

The result of this study has revealed that natural henna extracted dye is not meant for only decorating finger nails, dyeing hair or as ingredients in the cosmetic industry, but can also be used to impart colours to textile which include, to an extent, cotton and other cellulose fibers as demonstrated in Tables II-IX. In addition, the result of this experiment will add a bust to environmentally conscious consumers with growing need for organic clothing.

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