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The Efficacy of Dyes Extracted from Henna (Masrasdi) Leaves for Colouring Cotton Fabric

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ABSTRACT

The increasing environmental concerns associated with synthetic dyes have renewed interest in natural dyes as sustainable alternatives for textile coloration. Specifically, the study extracted dyes from henna (masrasdi) leaves for colouring cotton fabric. The study adopted experimental research design/cum observational techniques using two different extraction techniques which include: Boiling and acetone organic solvent with particular attention to colour strength, shade quality, colour fastness, dye uptake, environmental sustainability and economic implications. Natural dyes obtained from plants, agricultural residues, fruits, leaves, roots, bark, flowers and other biological resources possess considerable potential for textile coloration. However, cotton, being a cellulosic fibre, presents particular challenges because many natural dyes have low affinity for cellulose and consequently produce inadequate colour fastness without appropriate pretreatment or mordanting. Recent literature indicates that mordants, bio-mordants, surface modification, improved extraction methods and innovative dyeing technologies can significantly improve the performance of natural dyes on cotton. The paper stated that natural dyes should be viewed as components of a broader sustainable textile system capable of promoting waste valorization, environmental protection, local resource utilization and entrepreneurship. It concludes that the efficacy of natural dyes especially, henna (masrasdi) leaves on cotton is promising but depends strongly on the source of the dye, extraction procedure, mordant, dyeing conditions and method of fixation. Greater standardization and scientific optimization are therefore necessary to facilitate their wider adoption.

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KEYWORDS: *Colour fastness, Cotton, Dye extraction, Natural dyes, Mordant and Sustainability.*

INTRODUCTION

Various phenomena and contradictions in our world today beg for exploration and explanation. Researchers, textile manufacturers, sustainability advocates and Artisans have responded to these situations with the experiments on dye extraction from natural sources. They are experimenting with natural materials in good response to the environment especially those in the area of clothing and textiles (Nwanna, 2024). Textile dyeing is one of the most important stages in the production of aesthetically appealing fabrics. Colour contributes significantly to the attractiveness, functionality, cultural identity and commercial value of textile materials. Colour in textiles is one of the most significant factors in the appeal and marketability of textile products mainly because consumers generally expect aesthetically pleasing colors, prints, and colour permanence (Owoade, Lowe, Khalid, 2015). Colour in textiles is produced by dyeing, printing or painting (Harris, 2017). Dyeing processes may be used either to colour fibers and yarns before they are made into cloth or to colour and decorate the fabric itself (World Book Incorporated, 2018). Torture and Collier (2017) posit that a dye must be highly coloured, colourfast or resistant to colour change or loss during use and care; and be soluble or capable of being made soluble in water or other medium in which they are applied, or they must themselves be molecularly dispersible into the fibers of the fabric.

For several decades, synthetic dyes have dominated textile coloration because they provide a wide range of colours, relatively consistent shades, good application properties and, in many cases, high levels of fastness. However, the environmental consequences associated with textile wet processing have increased interest in more sustainable alternatives such as natural dyes from natural sources (Obenewaa, 2020). Ironically, nature most times presents itself as the resource base especially, plants leave from which dye can be obtain and used to beautify our homes as well as transform our environment. Leave is one of the world's most economically important plant products. Many generations have benefited immensely from its great potential especially for medicinal purposes and in the production of dyes. Dyes are coloured chemical substances which can be bound to a fiber to alter the colour of that fiber (Earth Guild, 2016). Dyes are also an organic chemical component which imparts colors to other materials by saturating them in an aqueous solution (Madichie, 2013). For the sake of our environment natural dye were extracted from plant leave.

Natural dyes are colouring substances obtained from naturally occurring sources. Natural dyes are colour-producing substances obtained from renewable biological and geological sources, particularly plants, animals, microorganisms and minerals (Gordon, 2021). Plant-based sources include leaves, flowers, roots, fruits, bark, seeds, wood and agricultural residues. For this study leaves from henna *(Masrasdi)* were used. Unlike most conventional synthetic dyes, which are manufactured through chemical processes, natural dyes can be extracted from biological materials. Natural dyes are extracted from animals, plants, and minerals (Madichie, in Arinze, 2025). Plants dyes are usually extracted by mechanical processes such as pounding or squeezing, boiling, grinding, crushing, steeping among others (Aimson, 2020). Boiling and acetone organic solvent extraction techniques were adopted for this study to determine their effects on the type of dyes extracted for clothing and textiles.

Henna also known as Menendi, is shrub or small tree with dense branches. It is a flowering plant from which dye is derived. Henna is cultivated for its various parts (stem bark, roots, flowers, and seeds) that are used in traditional medicine and its dye effects. It grows in tropical and subtropical areas. The benefits of Henna are mentioned in abundance in the history of India Ayurvedic, Siddha, and Chinese medicine. Henna has been an essential part of people's traditions and it symbolizes fertility. Its popularity in India is due to the cooling effect of the herb which is useful for people in summers. Henna plant consists of a range of compounds that play a vital role in several human conditions such as, it may have heart protective benefits, beneficial properties for leprosy, blood sugar lowering activity, has the potentials of dye pigment for both hair and finger nails (Douglas, 2021). The dye pigment may also be beneficial to dyeing of cotton fabrics. Natural dyes often have relatively low affinity for cotton. This is one of the principal reasons why natural dyeing of cotton requires special attention. Researchers have investigated mordanting, cationization, plasma treatment, microwave treatment, ultraviolet treatment, ultrasonic treatment and bio-enzyme treatment to improve the interaction between cotton and natural colourants. In addition, Madichie, in Arinze (2025) classified dyes according to their application and they include acid, azoic, vat, sulphur, direct, disperse, organic and mordant dye. Hence, mordant application was used in the study.

Mordant is a chemical element that fastens the rate of chemical reaction taking place between a natural dye and a fibre (Arinze, 2015). Mordants are substances used to improve the fixation of dyes to textile fibres (Saeed *etal,* 2023). They may form a bridge between the dye molecule and the fibre, thereby improving colour development and fastness (Repon, *etal* 2024). Common mordants include alum, iron, salts, zinc, tin and other metallic compounds. However, the environmental implications of mordants must be considered carefully. Potassium aluminum sulfate (Alum), copper sulfate and Tannins were mordants used also cotton material was used for the study. Cotton is a natural cellulosic fibre widely used for clothing, household textiles and industrial textile applications. Its popularity associated with properties such as comfort, softness, moisture absorption and breathability (Zhang, 2022). Therefore, the efficacy of a natural dye for cotton must be assessed using several performance indicators rather than colour appearance alone. The efficacy of natural dyes refers to their ability to produce desirable, durable and reproducible colour on cotton material under specified dyeing conditions. Aanya (2024) review reported that bio-mordants can improve the bonding of natural dyes to textile materials and may enhance washing fastness.

Presently, the interest in natural dyes is increasing worldwide mainly because natural dyes are less polluting, non- carcinogenic and non-toxic unlike the synthetic counterparts (Apparel Search Company, 2024). No fabric dyeing in clothing and Textiles industries can be successfully carried out without one

form of dye or the other. However, in Nigeria, funding for many schools is a great challenge and the inability of the schools to provide instructional materials and consumables such as dyes in sustainable supply poses threats to practical work, practical exercises are often skipped or stalled and students will not acquire the needed skills that will promote entrepreneurship in Home Economic especially, clothing and textiles. This is a problem. It then becomes necessary to evolve workable ways of sourcing dyes locally which students, artisans, and clothing and textiles can use for their practical work. This present study therefore extracts dyes from indigenous plants henna *(Masrasdi)* for dye extraction.

The purpose of this study is to improve the pedagogical methods in clothing and textile arts through dye extraction to support the development of creative skills and foster an entrepreneurship development in the institution and it will also expose the students to learning the science involved in cloth dyeing production. The following steps were utilized in achieving the set objectives; collection or sourcing of dye yielding plants from the study area which were done by the researchers.

Materials and Methods

Materials used for this research include Potassium aluminum sulfate (Alum), copper sulfate, Tannins, sal soda, Acetone, Cotton (100%), distilled water, heater, thermometer, hand gloves, stainless steel with plenty room for the fabric to move freely to avoid uneven dying, dying pots, scales and plastic bowels, spoons, laboratory blender, buckets, towels, mixing bowls, water, goggles, aprons, caps (protective). Their uses will be explained below alongside the procedure of the work.

Methods: the methods were done in different stages such as:

Stage 1, Scouring and collection of dye yielding plants (henna *(Masrasdi))* from the study area which was done by the researchers.

Primary source



Sample of henna leave (after milling)



Sample of Henna (*Mehndi)* leave

Extraction of dyes from the identified leaves/plants was done using boiling and acetone organic solvent extraction techniques of Saha & Datta in Arinze (2025). Extraction of henna leave dyes by boiling and acetone organic solvent, equal quantities (4kg) of fresh henna *(Masrasdi)* leaves were dried under room temperature for 96 hours and warm to enhance quick and smooth milling for 5 minutes only. After drying, henna leaves were milled into fine flour (powder) and stored for dye extraction by boiling and acetone organic solvent techniques and for dyeing the fabric samples.

Dye extraction by boiling: 80g of henna flour was dissolved in 80ml water in the ratio 1:2 (w/v 40g henna flour: 160ml water) and boiled at the temperature of 80^{oC} – 90^{oC} for 20 minutes. The dye bath was then allowed to cool and then sieved with .05 sieves to get the dye liquor which were labeled and use to dye the fabric samples.

Dye extraction by organic solvent Technique: 80g of henna leave flour (powder) was measured and weighed out in the ratio of 1:2 of Acetone organic solvent in to plastic containers with tight lid. The acetone organic solvent (99% absolute) were poured into containers containing the flour and shook properly after covering and left for 48hours for dye extraction to take place. The mixtures were filtered off to remove the impurity. The dyes were then poured into plastic containers roomy enough to enhance quick evaporation of the Acetone. After I week, the dye paste was ready for dyeing and labeled.

Stage 2, Treatment of substrate: The cotton fabric (white cotton) samples of 320g by mass (3yards by 45") was scoured or washed in warm water with detergent thoroughly three times to remove all sizing that might interfere with dye adhering to the fiber.

Modanting the substrate: In order to change the substrate to dye, Potassium aluminum sulphate which is locally known as alum, Tannin and copper sulfate at this ratio Alum = 80.8.g, Sal Soda = 5.5g, Copper =30g, Tannin = 80g, Water =10 liters. was used for the treatment. Water was heated and the alum, sal soda, Tannin and copper sulfate were thoroughly dissolved in it. The wet scoured cotton fabric was immersed gently and thoroughly stirred so that it is opened out in the solution in this order Tannin → Alum → Copper sulfate. It was then heated at 40-60^{oC} for 1 hour and allowed to cool overnight in the solution.

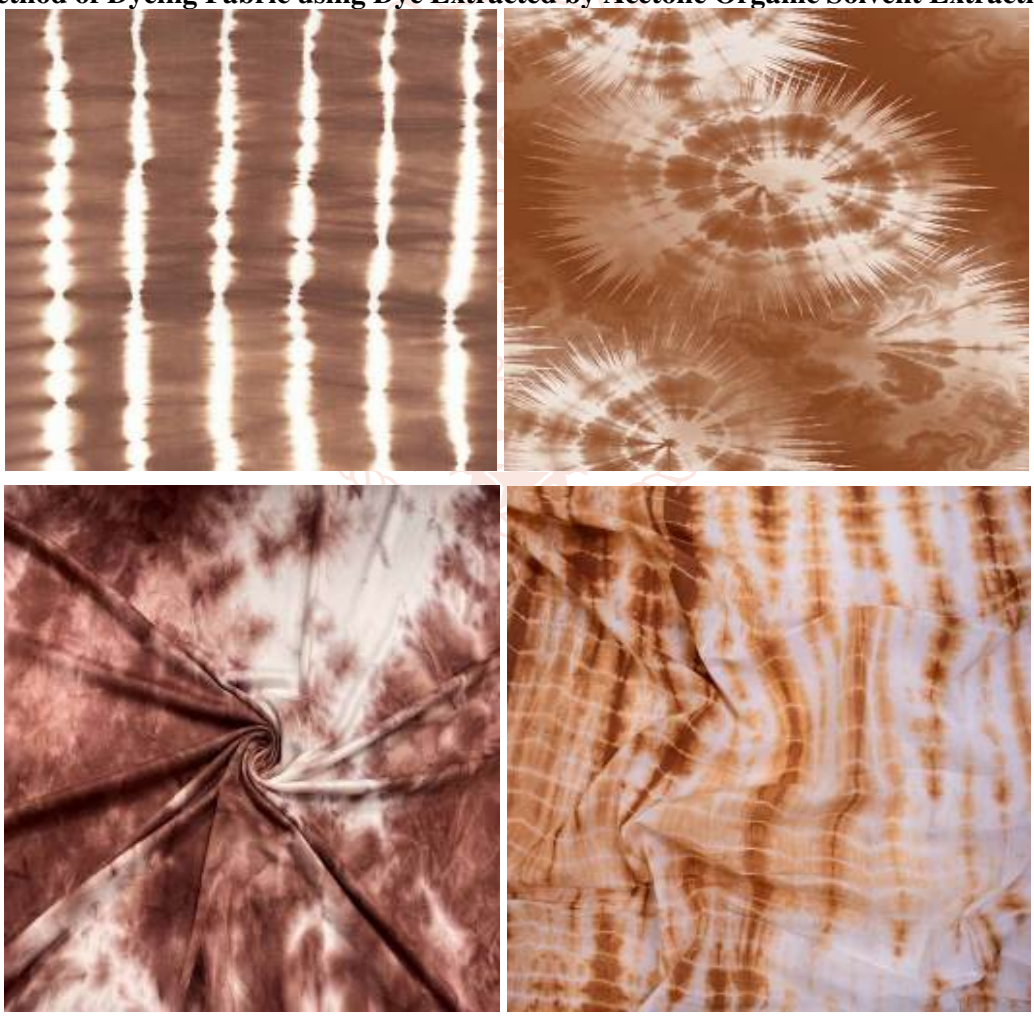
Extraction yield percentage

The extraction yield was measured. This was done by measuring the solvent's efficiency to specific components from the original material (Murugan and parimelahagan, 2021). This was identified as the amount of extract recovered in mass compared to the initial amount of whole plant. This was presented in percentage (%).

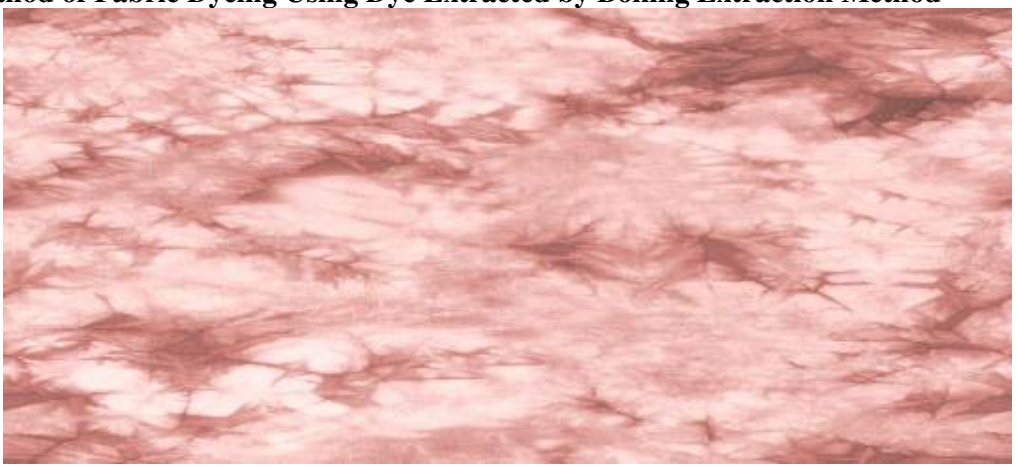
Dyeing procedure: Procedure for dyeing of fabrics with the extracted henna dye (HD) for colour fastness. The mordanted samples of cotton were immersed in the respective extracted dye baths for 1hour at a temperature of 80^{oc} and after completion of dying, the samples were taken out to dry under a shade. Enough additional water was added where necessary to the solution so that fabric could move freely in the dye bath.

SAMPLES OF DYED FABRIC

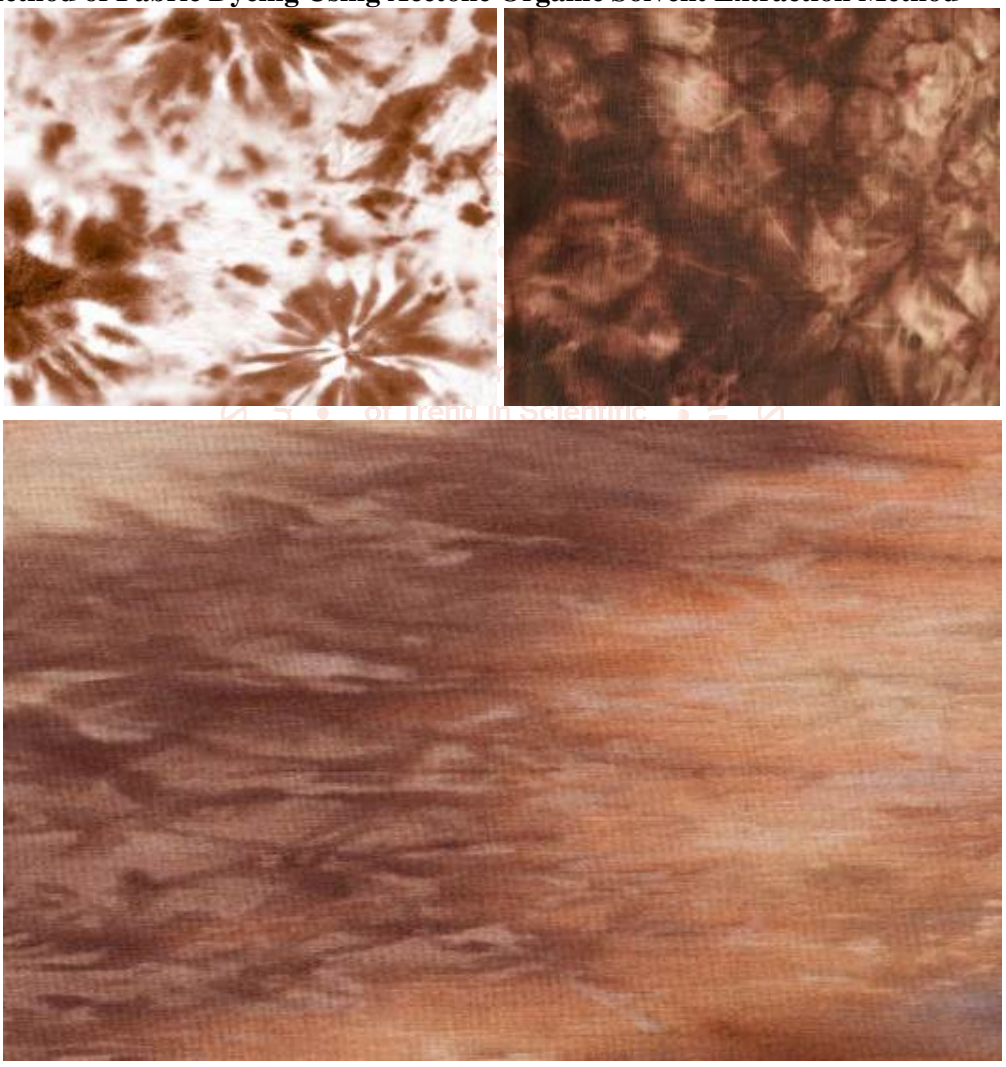
Tie Dye Method of Dyeing Fabric using Dye Extracted by Acetone Organic Solvent Extraction Method



Marble Method of Fabric Dyeing Using Dye Extracted by Boiling Extraction Method



Marbling Method of Fabric Dyeing Using Acetone Organic Solvent Extraction Method



RESULT

Table 1: Boiling Extraction of 100g of Material

Material	Technique	Temperature	P^h	Time	Yield
Henna leave	Boiling extraction	$80^{oC} – 90^{oC}$	5	48 hours	48.7%
Henna leave	Acetone extraction	32^{0c}	5	48 hours	52.8%

Table 1: Revealed that, in boiling extraction the dye yield was 48.7% under 80 – 90oc with P^h 5 and time observed was 48 hours. For acetone extraction the yield was 52.8% under 32^{oc} with P^h 5 and time observed was 48 hours.

Table 2: Colour obtained with different solvent and method of extraction

Material	Technique	Type of textile	Ph	Temperature	Colour observed after extraction	Colour observed after dyeing
Henna leave	Boiling extraction	White cotton	5	$80^{oC} - 90^{oC}$	Brown	Brown
Henna leave	Acetone extraction	White cotton	5	32^{0}c	Reddish brown	Dark-brown

Table 2: showed the colours obtained from different solvents and methods. For water (boiling) extraction, the colours observed after filtration and dyeing were Brown and brown. In acetone extraction it was Reddish brown and Dark-brown

DISCUSSION

The dye sample from the henna leave was found soluble in distilled water and acetone. It was observed that dye concentration was high in acetone extraction. This supports the fact that acetone extraction is a very efficient form of extracting colour from materials (Vankar, 2016). It may also be as a result of the temperature as the heat of the solvent comes in contact with plant the extracting power was more efficient (Nwonye, & Ezema, 2017). Temperature is the main factor which affects the extraction efficiency of dye from natural plants (Murugan, & Parimelahagan, 2021). At higher temperature, acetone was able to extract larger yield of natural dyes. The hue obtained by acetone extraction gave Reddish-brown and Dark-brown compared with extraction by boiling (water) which gave brown and brown It also supports the fact that acetone extraction is preferably used with volatile solvents (Ekong, 2020).

Conclusion

The work showed that different hues of dye can be extracted from the henna leave. The process of extraction was eco-friendly. The hue obtained has the dyeing potentials which can be used as a sources of textile dyeing. The colour shade can be obtained using different methods and different solvent. The research work unveiled that their properties are preferable to synthetic dye as they are not toxic. The use of modant in textile application is found to be fruitful to improving colour adherence and shades of dyes. Henna leave is a very good plant part that serves as a source of raw material for obtaining shades of brown, and dark-brown dye that can be used for fabric dyeing in future. Natural dyes represent an important opportunity for developing more sustainable approaches to textile coloration. Their renewable origins, potential biodegradability and compatibility with circular-resource approaches make them attractive alternatives to conventional colourants.

However, their application to cotton remains technically challenging because of low fibre affinity and variation in shade reproducibility. The efficacy of natural dyes should therefore be understood as a function of dye source, extraction technique, dye concentration, mordant, cotton pretreatment, dyeing conditions and post-dyeing treatment.

Recommendations

The advantages of researching natural dyes and their application on textiles will improve the art of creativity in the field of clothing and textiles. In view of the results of study the following recommendations are made:

1. Instructors should use the study to educate the students on the use of dye that is eco-friendly.
2. Natural dyes should be evaluated using standardized colour-fastness tests rather than relying solely on visual assessment.
3. Greater attention should be given to bio-mordants and environmentally safer fixation methods and Researchers should optimize extraction procedures to obtain maximum dye yield using minimum resources.
4. Emerging technologies such as ultrasound, microwave processing, enzyme treatment and surface modification should be explored.

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