Determination of Dyeing Efficiency of Natural Dye from Teak (*Tectona grandis*) Leaves by Home Economics Students of Michael Okpara University of Agriculture, Umudike.

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Abstract

The study investigated the dyeing efficiency of dye extracted from teak (*Tectona grandis*) leaves. Specifically, the study determined the fastness of teak dye to repeated washing and the use of different detergents, it also ascertained the acceptability of the dyed fabric samples. The study adopted an experimental research design. It was conducted in five phases: treatment of teak leaves; mordanting cotton fabric with alum; extraction of dye from teak leaves, dyeing of the cotton fabric; testing for the fastness of the dyed cotton fabric to repeated washing and different detergents. Alum-mordanted cotton fabric was dyed with teak dye, which gave red shades to the fabrics. The dyed fabric was cut into three parts, each for the different treatments of determination of colour fastness as follows; part of the samples were exposed to washing with bar soap. The other part was subjected to washing with soapless detergent. The remaining part served as control. Each of the treatments was carried out twice. A 32-man panel assessed the samples (DB1, DB2, DS1, DS2) using a 4-point rating scale. Data were analyzed using mean. Major findings reveal, among others, colour of the fabric remained fast (dark red) after first treatments for sample DB1 ($\bar{X}$=3.87) and sample DB2 ($\bar{X}$=3.03), these are samples from first and second Bar soap washing. Samples DS1 and DS2, from soapless detergent washing, exhibited slight colour change, with acceptability mean of $\bar{X}$=2.78 and $\bar{X}$=1.96 respectively. It was recommended that further research be conducted on light and perspiration fastness of teak dye.

Keywords: Teak, Natural dye, Dye efficiency, Colour fastness, Acceptability.

Introduction

Textile dyeing is the art and process of applying colour (s) to textiles, fabrics, or fibres to achieve the intended aesthetic. Dyeing is a essential step in the textile manufacturing process, as it determines the final colour and often improves the overall quality and value of the textile. It is a creative and technical process of creating and manipulating designs and patterns on textiles (Ezeokonkwo et al., 2018). Textile designers are tasked with developing the visual aesthetics and

functional aspects of textiles, and their works play an important role in the fashion and textile industries (Etuk & Asuamah, 2022).

Contemporarily, the environmental concerns and health risks linked to synthetic dyes have rekindled interest in natural dyes, which are eco-friendly and sustainable alternatives. Natural dyes are sourced from plants (roots, leaves, barks, trunks, seeds, fruits, flowers, and nuts), insects, microbials, and other natural sources, obtained even from our own immediate environment and used to colour fabrics, foods and other household items, when processed. According to Mazharul (2022), natural dyes are substances extracted from renewable natural sources, including plants, animals, and minerals, characterized by their sustainable and environmentally friendly properties. In support, Akubugwu et al., (2017), highlighted the eco-friendly benefits of natural dyes, emphasizing their; biodegradability, environmental compatibility, non-toxicity, and renewability. They offer a sustainable colouring solution, minimizing environmental harm while providing a better alternative to synthetic dyes.

In traditional textile dyeing, various plants, roots, and leaves have been used to produce varieties of colours. Teak leaves among other notable plants like indigo, madder, weld, turmeric, and teak, are preferred for their colouring capabilities. Teak leaves (*Tectona grandis*) are obtained from a tropical hardwood tree native to South and Southeast Asia. It has an alternate leaf arrangement, large, oval-elliptical shape with pointed tips, having simple, single leaf blade with smooth margins. The leaves range from 15-30 cm (6-12 inches) in length, with widths half of their length. The leaves have smooth, glossy, and deep green upper surface, and lighter green with fine hairs or slightly rough texture underside. They have prominent, parallel veins running from the base to tip. Teak leaves are aromatic, emitting an earthy fragrance when crushed. The main colouring agent in teak leaves is anthocyanins, responsible for the red color in teak dye extract (Kusumawati, 2021). Despite the benefits of natural dyes, several challenges persist in their use in textile dyeing, including low colour yield, limited shade range, blending issues, inadequate fastness properties (Kulkarni et al., 2017). However, mordanting, a process in textile dyeing, can overcome some of these issues. Mordanting involves applying a substance called mordant, typically a metal salt, to the fabric before or during dyeing, common mordants include; Aluminium sulphate (Alum), cream of tartar, salt, vinegar, salt, baking soda. The process enhances dye adherence and permanence on

fabrics, forms chemical bonds between dye molecules and fibers, and improves dye binding efficiency (Nwonye et al., 2017). The choice of mordant used and techniques employed, significantly influence the final colour and quality of the dyed fabric (Kusumawati, 2017). Mordanting contributes to the efficiency of natural dyes.

Dye efficiency is the measure of the effectiveness of a dyeing process in achieving its intended goals, including colouring a material, ensuring colour fastness, minimizing waste, optimizing water and dye usage (Dissanayanka et al. 2019). It is the effectiveness of a dye in colouring or staining a materiel. Achieving high dye efficiency often involves reducing water and energy consumption, minimizing chemical waste, and adopting eco-friendly dyeing methods to ensure sustainable and cost-effective practices (Nizamuddin et al., 2021). Colour fastness as one of the measures of dye efficiency, measures the ability of a fabric to retain its colour under various conditions and treatments. It is vital in textiles, especially clothing products, as fading or bleeding can affect appearance and durability (Adeyemi, Ogunkeyede & Jolayemi, 2017). Ezema (2023), defined colour fastness as the degree of change in colour of a dyed fabric either through washing, exposure to sunlight, perspiration, and rubbing. This aligns with the statement of Leverette (2022) that colour fastness is the ability of a fabric to maintain the same colour without running off even if washed, exposed to perspiration or treated with certain chemicals. Colour fastness is typically tested under conditions like washing, exposure to light, and friction to ensure that the colour remains stable over time.

However, the type and nature of washing agents usually affect colour fastness. Detergent is a type of washing agent, or surfactant that is used to remove dirt, stains, grease, and other impurities from various surfaces, including fabrics, dishes, and household items (Ali et al., 2015). Deng et al. (2017), stated that detergents work by lowering the surface tension of water, which helps it penetrate and break down the dirt and oils, allowing them to be washed away more effectively. Laundry detergents are designed for washing clothes and textiles. They come in various forms, such as powders, liquids, bars or sticks, gels, and pods, and are formulated to remove stains and dirt while preserving the fabric's colour and quality. They play a significant role in the colour fastness of textiles, using appropriate detergents and following care instructions can help preserve the vibrant colours of clothing and fabrics over time.

The reliance on synthetic dyes has led to significant environmental degradation, including water pollution, chemical waste, and health risks. Despite the benefits of synthetic dyes, their widespread use poses significant environmental and health challenges. Tackling these challenges is hinged on minimizing the dependency on synthetic dyes, embracing environment-friendly alternatives, and promoting the use of natural dyes in diverse applications, of which this study advocates. Given the benefits of natural dyes, efforts should be made on promoting the extraction of plant-based dyes for textile applications. This approach will help minimize the textile industry's ecological footprint and promote environment-friendly dyeing processes. This study was therefore based on determining the dyeing efficiency of a natural dye extracted from teak leaves in dyeing cotton fabric.

Purpose of the Study:

This study investigated the dyeing efficiency of natural dye extracted from Teak leaves (*Tectona grandis*) leaves.

Specifically, the study aimed at:

1. determining the fabric affinity to dye stuff of teak.
2. testing the fastness of teak dye to washing with different detergents and its fastness to repeated washing.
3. ascertaining the acceptability level of the different fabrics dyed with teak.

Materials and Methods

Design of the study: the study design was experimental design which was conducted in the clothing and textile laboratory of Michael Okpara University of Agriculture, Umudike. The study was carried out in the following five phases.

• Treatment of teak leaves.

• Mordanting 100 percent cotton fabric with alum (potassium aluminum sulphate).

• Extraction of dye from teak leaves.

• Dyeing of the mordanted cotton fabric with the teak dye.

• Testing for the fastness of the dye to repeated washing and use of two different detergents.

Procurement of Materials: Teak leaves were collected from Forestry Research Institute of Nigeria, Okwuta Isieke Ibeku, along Ikot-ekpene road in umuahia Abia state. One and half yard of 100% cotton fabric which is the substrate and alum (potassium aluminum sulphate), the

mordanting agent, were purchased from a local market called Ahia-Ndioru situated in Ikwuano Local Government Area, of Umuahaia, Abia State of Nigeria. The detergents, Viva plus (powdered/soapless) and premier soap (bar/stick) were purchased from the same market.

Preparation of Materials:

The following processes were involved in the preparation of materials;

Treatment of Teak leaves: Fresh and tender teak leaves were thoroughly washed under running water to remove dirts and dust particles, drained, and shredded.

Treatment of substrate (Scouring the substrate): The fabric material was simmered for 5 minutes in a solution of dish soap. This was done to desize it of starch, wax, oil, or dirt that might inhibit dye penetration and adhesion to the material. After the fabric was scrubbed and rinsed properly under running water.

Mordanting the substrate: A solution of potassium aluminum sulphate, commonly known as alum was used to charge the substrate to be dyed (pre-mordanting). It was used for the treatment of the fabric. Three liters of water was filled in a pot, 30g of alum was added to it and it was continuously stirred to properly dissolve the fixating agents, the fabric was submerged in the solution. This was brought to a boil at 100°C and stirred at intervals for one hour. After 1 hour, the fabric was removed from the pot and allowed to cool and dry.

Extraction of dye from Teak Leaves

The extraction process was done by preparing 500kg of young teak leaves. The leaves were washed using running water and shredded into smaller sizes, transferred to a sizeable pot, then a litre of water was added and boiled for 1 hour. The solution was left to cool and strained to an extract.

Fabric dyeing Procedure

The concentrated extract was obtained in aqueous form. The dyeing process was done in a sizeable pot. The extract solution of teak leaves was transferred to a pot. After that, the cotton fabric was submerged into the pot and was simmered between 30-35°C. The dyeing process was done for 60 minutes. The coloured fabric was then squeezed and fixated in the mordant solution for 15 minutes (post-mordanting). Then it was removed and aired for oxidation to take place for five minutes. After which, it was rinsed in cold water to remove excess dye and dried under a shade.

Determination of Colour Fastness of Teak Dyed Cotton Fabric: Two samples of the dyed fabric were subjected to two different treatments and resulted in four samples altogether, two samples (DB1 and DB2) of fabric washed with bar soap. And two samples (DS1 and DS2), were washed with soapless detergent, and the samples were exposed to sunlight after washing. The remaining sample D served as control. After the treatments, data were collected and analyzed.

Treatment A- Washing with bar soap and water:

Parts of sample D were cut, washed with bar soap and dried under sunlight two different times, resulting in DB1 and DB2. After each washing and drying, data on fastness were collected.

Treatment B- Washing with soapless detergent and water

Parts of sample D were cut, washed with soapless detergent and dried under sunlight two different times, resulting in DS1 and DS2. After each washing and drying appropriate data were collected.

Population for the Study

The population for the study comprised of 32 students made of six 300 level students and twenty-six 400 level students of Home Economics Education of Michael Okpara University of Agriculture, Umudike. The choice of 300 and 400 level students, is as a reason of their theoretical and practical knowledge of fabric dyeing, because they have been taught and exposed to practical on dyeing in these study levels.

Instrument: A 4-point rating scale was developed and validated for data collection. The response options are;
Highly deep red/ No Colour Change /Highly acceptable /excellent adhesion = 4

Deep red/Slight Colour Change/acceptable/good adhesion = 3

Slightly deep red/Obvious Colour Change /unacceptable/fair adhesion = 2

Red/Extreme Colour Change/Highly unacceptable/poor adhesion = 1

Method of Data Collection: The dyed fabric samples labelled, DB1 = Decoction first Bar soap washing, DB2 = Decoction second Bar soap washing, DS1 = Decoction first soapless detergent washing, and DS2 = Decoction second soapless detergent washing, were subjected to physical examination and rated at the end of the treatments, with sample D as control.

Method of Data Analysis: Data were analyzed using mean. Mean score of 2.5 was regarded as fairly-colour fast, acceptable and good adhesion. While > 2.5 was regarded as non-colour-fast, unacceptable or poor adhesion.

Results

Table 1: Extraction and application on mordanted cotton fabric

Material	Temperature	Time	Coloured observed after extraction	Coloured observed after dyeing with mordanted cotton fabric
Young teak leaves	100°C	1 hour	Reddish purple	Deep reddish brown

Table 1 reveals the colour obtained from the different extraction methods and that obtained after applying the dye on mordanted cotton fabric. The extraction which was done for 1 hour under

100°C, yielded a reddish purple colour at extraction, on application on a mordanted cotton fabric, the colour obtained was deep reddish brown.

Therefore, Table 1 reveals that the cotton fabric exhibited good affinity to the dye stuff as it absorbed the dye well, changing from white to deep reddish brown.

Table 2 : Mean Scores of Colour Fastness of Teak Dyed Cotton Fabric to Washing with bar soap.

Samples	Number of washing	Colour of Control	Colour after Treatment	Mean score ( )	Remark
DB1	Once	Deep reddish purple	NCC	3.87	Highly acceptable
DB2	Twice	Deep reddish purple	SCC	3.03	Highly acceptable

SCC = Slight colour change; OCC = Obvious colour change; NCC = No colour Change

Table 2 reveals that teak dyed fabrics exhibit good colour fastness to washing with bar soap, as first washing with bar soap, showed no colour change ($\bar{X}$= 3.87). While second washing showed slight colour change ($\bar{X}$= 3.03).

Table 3: Mean Scores of Colour Fastness of Teak Dyed Cotton Fabric to Washing with soapless detergent.

Samples	Number of washing	Colour of Control	Colour after Treatment	Mean score ( )	Remark
DS1	Once	Deep reddish purple	SCC	2.78	Acceptable
DS2	Twice	Deep reddish purple	OCC	1.96	Unacceptable

OCC = Obvious colour change; ECC = Extreme colour change; SCC = Slight colour Change

Table 3 reveals that teak dyed fabric on first washing with soapless detergent showed slight colour change ($\bar{X}$= 2.78), second washing with soapless detergent showed obvious change ($\bar{X}$= 1.96). These indicate that teak dye is not fast to repeated washing with soapless detergent.

Discussion

It was revealed that the dye extract from teak leaves was found to be soluble in water, and contributed to shades of red colour on cotton fabric, showing the dye's affinity to alum mordanted fabric. It was observed that the dye concentration was high on decoction extraction. A similar result was reported by Jeelene et al. (2017). It may also be as a result of the temperature, as the

heat of the solvent comes in contact with the leaves the extracting power was more efficient. Temperature which is one of the operational conditions, is the main factor which affects the extraction efficiency of dye from natural plants. At higher temperature, the water was able to extract a larger yield of natural dyes.

The results show that there was no change in the colour of the dyed cotton fabric from decoction after washing for the first time with bar soap ($\bar{X}$= 3.87), this is consistent with the report of Khan et al., (2020), that colour fastness is usually rated either by loss of depth of colour in an original sample or expressed by staining scale. Washing of the dyed fabric twice revealed a change in the colour of the dyed fabric, indicating that repeated washing with different detergents and exposure to sunlight of fabric dyed with teak dye results in fading. Fading of colour when naturally dyed fabric is repeatedly washed and exposed to sunlight may be attributed to constant friction and agitation during washing and the composition of the detergent. The friction from agitation during washing causes the dye to come loose from the clothes.

This result is supported by the statement of (Mazharul, 2022) that colour fastness of natural dyes to washing and light are generally inferior to well selected and applied synthetic dyes, and tend to fade easily. Running of the colour of the fabric into the wash water means that the dye is not fast, but when there is no colour change in the original dyed fabric, the dye colour is fast. Nwonye and Ezema (2019) also noted that colour fastness is the resistance of a material to change in any of its colour characteristics through washing, light, dry cleaning and rubbing.

The result of the experiment shows that there was an obvious change in the colour of the dyed fabric when subjected to washing with soapless detergent ($\bar{X}$= 2.78 & 1.96, respectively for the first & second treatments). The colour change may be attributed to the reaction between the dye and the ingredients used in preparing the detergent. The findings are consistent with those of Andrea (2020), who pointed out that ingredients used in most powdered detergents; bleaching agents like sodium bisulfite or sodium percarbonate usually result in observable colour changes in fabrics. Also, the finding by Laundry Chef (2017), aligns with the observation that some dyes will exhibit a colour change when exposed to acidic or alkaline substances contained in powdered detergents.

Conclusion

This study investigated the colour fastness properties of fabrics dyed using natural dye from teak leaves. Cotton fabric was used as substrate for the natural dyeing process, to assess its affinity to the dye stuff. Decoction extraction methods was used to extract dye from the teak leaves, which was applied on samples of mordanted cotton fabric. Colour fastness tests were conducted to evaluate the durability of the dyed fabrics under different conditions. These tests included exposure to repeated washing and the use of different types of detergents. The research findings revealed variations in colour fastness properties among different fabric samples. Generally, samples from bar soap washing were more colour fast and more acceptable, than fabric samples from soapless detergent washing. Specifically, DB1- first bar soap washing, exhibited excellent colour fastness, while sample DS2- Second soapless detergent washing, gave the poorest colour fastness and unacceptable. The study contributed to the understanding of the colour fastness of fabrics dyed with teak dyes, highlighting the need for minimal and gentle washing of the fabrics, and careful selection of suitable detergents in laundering clothes to achieve the desired durability and appearance in naturally dyed fabrics.

The research study has shown that shades of red natural dye can be extracted from teak leaves. This process of extraction is eco-friendly. The red colour obtained from teak leaves has the ability to dye fabrics. The utilization of mordant on the fabric helped in improving colour fixation. It reveals that teak leaves are good source of dye extraction for fabric dyeing. Dye from teak leaves was found to be fast to initial washing but sparingly fast on subsequent washing with different detergents. It is therefore concluded that dye extracted from teak leaves could be used for dyeing fabrics that should be subjected to minimal washing.

Recommendations

Based on the findings and conclusion drawn from this study, the following recommendations for further studies are made;

1. Teak dyed fabric should be subjected to fastness to light and perspiration to determine further the dye's efficiency in colour fastness tests.

2. Dye extracted from teak should be applied to different fabric types or blends to ascertain their fastness to washing, light and perspiration.
3. Textile craft sections in secondary schools and higher institutions can use the findings of the study as a resource material for teaching creative skills in natural fabric dyeing.

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