

Extraction, Application and Determination of the Fastness Properties of Natural Dyes Extracted from Allium Cepa (Onion Peels) and Zobo (Hibiscus Sabdariffa) Leaf Plant Applied on Cotton Fabrics Using Alum and Cream of Tartar as Mordant Made into Array of Products for Household Usage

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Abstract- The utilization of natural dyes in textile production has gained significant attention due to the ecofriendly characteristics and minimal environmental impact. This research focuses on the application of mixture of natural dyes (Zoboleaf, onion peels) on cotton fabric. The objectives of the study are to produce color from the red calyxes of Zobo and onion peels and to dye a cotton fabric with the mixture of these natural dyes and to assess the color characteristics of the dye on cotton fabric. The research design adopted in this study is an experimental method. Cotton fabrics used was mordanted using aluminum potassium and cream of tartar. the dyed sample of Zobo leaves on cotton fabric gives a light pink on a grey scale of wash fastness evaluation of 1-2. Onion peels dyed sample gave a green color with an evaluation of 3-4 wash fastness using a grey scale., findings revealed that onion peel dye extract has the ability to retain the dye on cotton fabric after washing at 80-90% while Zobo leaves dye extract is quick to fading after washing at 60-70%. Result of fastness test shows that cotton fabric has a good affinity for dye, conclusively, Plant leaves are potential sources of natural dyes because of their easy availability and abundant nature. These dyes are safe for humans, are not environmentally harmful also have some medicinal properties for health. But natural dyes have poor color fastness compared to synthetic dyes, meaning they fade quickly when exposed to light, washing or wear. It was recommended that Standard application of mordanting or fixing agents on textile fabrics (cotton, silk, polyester, wool) should be set to enhance resistance to fading during washing. complexity to specific mordants or chemicals for proper fixation on dye absorption, also, due to the increasing demand in the use of natural materials for environmental sustainability across the globe as well as the need to search for ways of sustainability, Entrepreneurs,

students, and homemakers, clothing and fashion designers, interior decorators should be encouraged to produce and commercialize household clothing articles using natural tie and dye fabrics as a source of income.

Keywords: *Natural Dyes, Dye Techniques, Extraction, Mordants, Fastness Test*

I. INTRODUCTION

This shift toward eco-conscious practices has propelled the revival of natural dyes, emphasizing their sustainability and biodegradability. Natural dyes are very well known for their consumption in the coloring of food substrate, leather as well as natural fibers such as silk, cotton, and wool from the prehistoric era. However, comparing the experience of the past, the usage of natural dyes has not changed or evolved completely. The methods are currently in use in various parts of the globe. Thus, different natural dyes fabrics and leather are further developed especially in the sector that has particularly crossed the province's products of the provinces without the usage of synthetic dyes for a broader scale in general fabrics and clothing. (Salaudinn, Mia and Haque, 2021) Recently, the majority of retailers and textile companies have begun to look the other way great opportunities to use natural dyes to dye and print various fabrics for niche market identification. (Sharma, Gupta, Aggarwal, and Nagpal,2022)

The renewed global interest has come into view in natural dyes because of the increased surrounding consciousness as well as health risks that came hand in hand with the integration, processing, and use of synthetic dyes. (Tarikul, Kazi, Rashedul, Shahin., Jalil and Bashar (2024). A growing global awareness of sustainable living has revived interest in the use of natural dyes, which are derived from renewable and biodegradable plant and animal sources. Unlike synthetic dyes that often contain hazardous chemicals, natural dyes extracted from turmeric roots, onion peels, hibiscus petals, kolanut, walnut, henna leaves and indigo leaves are safe, eco-friendly, and culturally resonant. Their use not only enhances environmental sustainability but also promotes healthier production practices for artisans and consumers alike (Bello and Adeyemi, 2018; Fadairo and Aremu, 2020). When natural dyes are used alone, they have a limit of speed as well as brightness. Although, when consumed in combination with metallic mordants bright and fast colors are used. Hence, the unsustainable technology of color production can be replaced by gentle chemistry where one can achieve almost similar results. Our nation's biodiversity has given us many resources, Natural dyes have minimal environmental impact, renewable, safe, and also free from carcinogenic components. Natural dyes are mostly employed for dyeing of natural fibers textiles to enhance their eco-friendly characteristics. They are usually applied to textiles by dyeing. (Kaur and Chopra 2023). Natural tie and dye support ecological sustainability by reducing reliance on chemical dyes that harm ecosystems. Environmentally, it promotes biodegradable processes and supports local agriculture through the use of plant-based materials (Nwafor and Adedayo, 2022). Economically, it empowers homemakers, creates job opportunities, and strengthens local textile industries. Government and NGOs increasingly integrate tie and dye into empowerment schemes as part of poverty alleviation and cultural preservation programs (Nwachukwu and Ogunlade, 2021).

Textile crafts have for centuries played a central role in human life, serving functional, cultural, and economic purposes (Adetoro, 2019) In Africa, the art of tie and dye has remained one of the most celebrated indigenous crafts because it embodies creativity, cultural symbolism, and economic resilience. Tie and

dye, commonly known as *adire* in southwestern Nigeria, involves various resist dyeing techniques in which fabric is manipulated through tying, folding, pleating, or compressing before immersion in dye solutions. The outcome is a unique fabric design that often carries both artistic and symbolic meaning (Akinola and Yusuf, 2021). Among the numerous techniques employed in tie and dye, the folding method has gained wide acceptance due to its accessibility, repeatability, and aesthetic versatility. In this method, fabrics are carefully folded into geometric shapes such as triangles, squares, or accordion pleats, then tied or compressed before dyeing. The covered portions resist dye penetration, creating distinct symmetrical motifs. This method is particularly useful for beginners and homemakers, as it requires minimal technical skill yet produces high-quality outcomes (Oladipo et al., 2021).

Since the earliest days of cotton cultivation, the fabric has been prized for its exceptional breathability and lightness. Cotton fabric is also incredibly soft. While cotton is more durable than silk, it is less durable than wool, and this fabric is relatively prone to pilling, rips, and tears. Nonetheless, cotton remains one of the most popular and highly produced fabrics in the world.

(Samanta, Agarwal and Datta 2020). This textile has relatively high tensile strength, and its natural coloring is white or slightly yellowish. Cotton is very water absorbent, but it also dries quickly, which makes it highly moisture wicking. However, cotton fabric is relatively prone to wrinkling, and it will shrink when washed unless it is exposed to a pre-treatment (Ojo and Adeniran 2019).

The extraction process plays a pivotal role in isolating the desired color components from plants by breaking down their cell walls and facilitating their separation into the solvent medium (Sharma et al., 2022). Within textile manufacturing and other industries such as cosmetics, medicine, and food, natural dyes and colors have emerged as favored alternatives to synthetic counterparts. However, extracting natural dyes presents a unique challenge due to the complex nature of plant matrices, which contain various non-dyed constituents alongside coloring materials. Therefore, understanding the characteristics and solubility of these coloring materials is crucial before the extraction

process. A variety of extraction methods are employed for natural coloring materials, including aqueous extraction, solvent extraction, enzymatic extraction, fermentation, alkaline or acid extraction, supercritical fluid extraction, as well as extraction utilizing ultrasonic energy or microwave technology. Each method offers distinct advantages and is selected based on factors such as the nature of the plant material and the desired outcome of the extraction process. (Tarikul et al.,2024)

The aqueous extraction method, a traditional approach for extracting colors from plants and other materials, involves soaking the colored materials in water, sometimes with the addition of salt, acid, alkali, or alcohol to enhance extraction efficiency. Typically, the materials are first crushed into a powder form and left to steep overnight in a steel container to facilitate the breakdown of cell structures. Upon boiling, the compounds are carried away with steam due to their insolubility or slight solubility in water, with a vapor pressure of 100°C. Upon condensation, the extracted components are separated using an oil-water separator, followed by filtration using a trickling filter to isolate the dye from plant residues. It is important to note that maintaining a low temperature during extraction is advisable, especially for temperature-sensitive dyes, as excessive heat can adversely affect color yield. The resulting dye can then be utilized in various textile applications

Mordants are auxiliary dyeing substances that are able to form complexes with molecules of dyes. This results in increased exhaustion or low-affine dye from the bath and thus improving the colour-fastness. This particularly improves the wet fastness and sometimes the light fastness. Mordant may be applied before dyeing or as additional stabiliser of dye after dyeing or may be applied directly to the bath during dyeing. The type of mordant used can change the colour of both the dye plus mordant solution and influence the shade of the final product. Some mordant darken the color while some brighten the color. They improve light and wash fastness properties. Mordants that are regularly used are alum, tin, copper sulphate, tannic acid, cream of tartar, among all the types of alum, potash alum is cheap, easily available and safe to use. It usually produces pale version of the prevailing dye color in the plant. It does not affect color. It is usually used with

cream of tartar and other compounds which helps evenness and brightens slightly.

Fastness properties are influenced by the dyes chemical structure, its binding force to the fiber, and the manufacturing process, they are measured through standardized testing procedures often using a grey scale. Standard grey scale measures color fastness of textile dyes. Gray scale for color change indicates the amount of fading or color alteration with environmental exposure or washing. The loss of color using the grey scale is evaluated by comparison of five pairs of grey standard rating 1-5. Color fastness refers to the resistance of a dyed material, such as fabrics or fibres, to maintain its color when subjected to various environmental factors like sunlight, washing, and other external agents. Achieving optimal color fastness with natural dyes involves considering several factors, including the type of dye used, the substrate (material being dyed), and the dyeing method employed. It is crucial to understand these factors to ensure that natural dyes retain their vibrancy and integrity over time, even when exposed to challenging conditions. By addressing these considerations, we can enhance the durability and longevity of dyed materials, providing both esthetic appeal and practical functionality.

II. STATEMENT OF THE PROBLEM

In the past, researchers have investigated and used synthetic dyes or commercially produced dyes where as we are blessed with many natural resources that are abundant in our environment which can be obtained at no cost or at cheaper rate. The overdependence on imported and commercially produced dyes is also a matter of concern for our indigenous dyes.

A number of plants are found to exhibit a major role in the common people advanced life. Although it's a cause of concern that the cognitive content of transforming and usage of natural dyes has greatly reduced among the genesis of the appropriate ethnological groups because many practitioners feel that natural dyes do not work because of quality. Some of the challenges of natural dyes in terms of fastness in comparison to synthetic dyes their limited fastness properties, often falling short of modern textile requirements. natural dyes pose challenges due to the

restrictions imposed by eco-standards on certain metal salts as mordants, such as chromium, copper, and tin, have further compounded the issue, narrowed the color range of natural dyes, and complicated the production of shades with adequate fastness qualities. Additionally, incorrect application procedures can lead to poor fastness properties, underscoring the need for optimized mordanting and dyeing techniques (Tarikul et al., 2024).

It has been a problem to the researcher to know why fabrics dyed with natural dye extract fade or worn out rapidly, is it possible for naturally dyed fabrics to withstand wash? and color test when mordant are used to help fix the dye into the fabrics? In view of this situation, the researcher deems it necessary to carry out research into the methods of extraction, application of dye and determination of wash fastness of local plant source *allium cepa peel* (a kitchen waste) and onion peels which are not harmful to the eco- system and man. The dye extract will be used to produce some arrays of household articles such as duvets, curtains, bedsheets, handbags, backpack, laptop bags and slippers.

Objective of the Study: The broad objective of the research was to evaluate the Extraction, Application and Determination of the Fastness Properties of Natural Dyes Extracted from *Allium Cepa* (Onion peels), and Zobo (*hibiscus sabdariffa*) leaf plant applied on Cotton Fabrics using Alum and Cream of Tartar as Mordant made into Array of Products for Household Usage such as Curtains, bedspreads, duvets, hand bags, sandals and laptop bags.

Specifically, the research seeks to:

1. Extract color from Onion peels (*allium cepa*) and red calyxes of Zobo (*Hibiscus Sabdariffa*)
2. Application of dye on the cotton fabrics with the dye extracts
3. Determination of wash and color fastness test on the dyed fabrics
4. Produce clothing items such as Curtains, bedspreads, duvets, hand bags, sandals and laptop bags using the dyed fabrics.

III. METHODOLOGY

Research Design: The research adopted an Experimental research design. Experimental research design is the process of carrying out research in an objective and controlled conditions.

Area of Study: The research was carried out in the dept of laundry and dry cleaning and fashion design and clothing technology, college of agriculture, science and technology, Lafia, Nasarawa State. The need to be innovative on nature to produce array of household item. The school has facilities that enhances dyeing and fashion techniques.

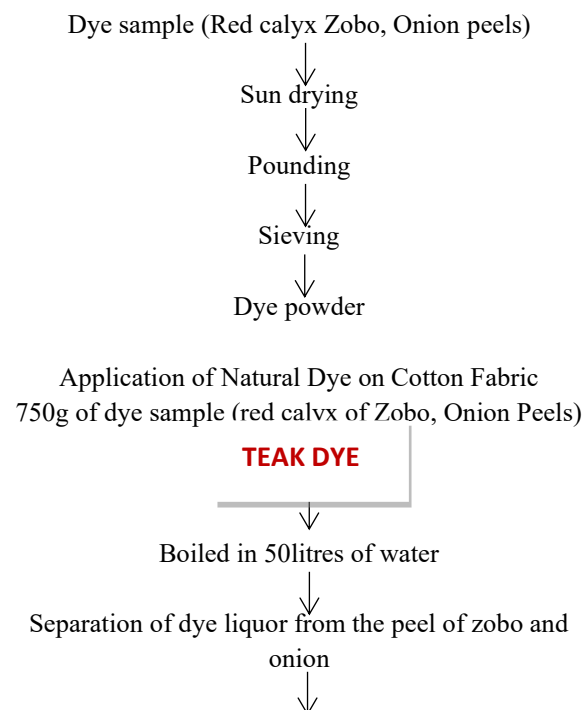
IV. MATERIALS AND METHOD

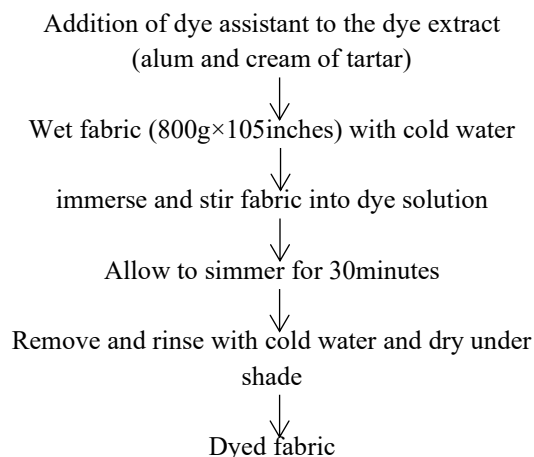
Materials

Hibiscus sabdariffa (Red calyxes of Zobo), *Onion peels* (*allium cepa*), Water, Test tables, Beakers, Cooking pot, stove, Hand gloves, Wooden spoon, Cotton fabric, Lab coat, Spatula, Bowl,

Preparatory process of Dye Extraction

The Zobo and onion peels were bought from Alami's market in Lafia. These samples were sundried to obtain the dye stuff. Flow chart 1: Extraction of dye powder





Flow chart 2: Dyeing of cotton fabric with natural dye stuffs (Red calyx of Zobo, Onion peels)



Fig 1:Zobo Leaves



Fig. 2: Onion peels

V. RESULTS

Samples of the dyed fabric



Fig. 3: fabric dyed with zobo extract



fig.4: fabric dyed with Onion peels extract

Fig,5: Household clothing articles produced using dye extract from zobo and onion peels on cotton fabrics

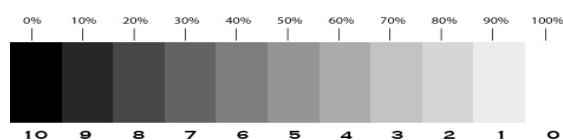


Determination of Test for Wash Fastness

To test for wash fastness, a dyed sample was washed in a beaker of soapy solution under controlled conditions (temperature and time). After drying. The color was evaluated using a grey scale. This process assesses how well the dye remains fixed to the fabric indicating its resistance to fading when washed.

Color fastness to wash	Change in colour (zobo)	Change in color (onion peels)
1-5	1-2	3-4

Standard Grey Scale



The results of the fastness test are typically given a grade from 1 to 5, where grade 1 indicates very poor fastness and grade 5 indicates excellent fastness. The rating is based on the colour change from the original fabrics.

Test (Samples)	Observation of dye solution	Color when removed from dye solution	Color when washed after removing from dye
A (Zobo)	The solution color showed a deeper pink color	It showed a stain of deep pink color	It showed a light pink color
B (Onion)	The solution color showed green color	It showed a green color	Showed a green color

Discussion of results

The commitment to harnessing the full potential of natural dye sources has fueled ongoing research and exploration, leading to the discovery of newer sources

and expanding the color palette available for textile dyeing. In recent years, there has been a resurgence of interest in natural dyes, particularly for dyeing cotton and silk fabrics. The result of this experiment shows that the dye extracted from these natural dyes is very rich in color pigment, and has the ability to impact color on cotton fabric. It also has been found out that fabrics ordinarily absorb dye, this shows the intensity of color obtained from the different samples. Based on the experiment for each of the dye sample, a deep pink color was obtained from the red calyxes of zobo. When dyed the cotton fabrics color remained pink, but when washed it became light pink which indicate a fast affinity to fading, a deep green color was obtained from onion peels extract and after washing, it still maintains the greenish color though not deep. Dyed cotton fabrics with zobo dye which was rated 1-2 showed a significant difference from the immersion to wash fastness. This indicates that cotton dyed in Zobo color and mordanted with Alum has a poor fastness to washing and it may require another fixing agent to enhance resistance to fading during washing. Dyed cotton fabrics with onion peels showed a remarkable change in color and rated 3-4 under a standard wash condition. Like cotton, it displayed a fair resistance to fading when washed. Onion peels dye extract also needs a fixing agent to enhance resistance to fading. Natural dyes extracted from the roots, leaves, stems or barriers, and flowers of various plants have various exceptions and possess no substantive to textile fiber, have little or no coloring power when used alone, but in conjunction with mordants they produce shades of good to excellent properties (Sharma et al., 2022). The beautiful color that are obtained from natural dyes would initially appear bright, but soon fade. The poor fastness produced mainly by natural dyes, resulted in the discovery of mordants substance which aid in the absorption of dyes (Eze and Okafor, 2022). However, the natural dyestuffs extracted from roselle petals are known as subjective dyes require some mordants to attach the color on the fibres and form strong chemical bonds. The mordant enters deeply into the fibre and combines with dyestuff to form the color (Chumsri et al., 2018). Mordant help the fibre receives the dyestuff well and form bonding. Compounds of potassium alum, tannic acid, and ferrous sulphate are the safest choices, they combine with the dyestuff and are then permanently fixed onto the fiber. Intensity of the hue

and the fastness of the resultant color can be improved (Okeke and Nwachukwu, 2020).

VI. CONCLUSION

Synthetic dyes have been implicated in being non-biodegradable and producing harmful waste to the environment which is toxic to man. The resources of synthetic dyes are non-renewable. The requirement of a professional in preparing synthetic dyes due to the specificity of accuracy in measure has led to its unavailability when needed unlike natural dyes which are easy to prepare. The use of available material for dyeing by conventional dyeing reduces the cost of natural dyeing and increases the productivity of resources and reduces the amount of waste. This makes onion peels and Zobo leaf one of the easily accessible materials for the natural dyeing industry. These dyes are safe for humans, are not environmentally harmful also have some medicinal properties for health. But natural dyes have poor color fastness compared to synthetic dyes, meaning they fade quickly when exposed to light, washing or wear.

VII. RECOMMENDATION

1. The use of natural dyes in laboratories should be more encouraged to facilitate possibilities for obtaining types of natural dyes and opens up good prospects for alternatives to synthetic dyes for the textile industry both for students and researchers. Since the applications of these natural dyes are found to be cheap, easy and more reliable. The extraction and application do not require specialized training. The dyes are also eco-friendly and biodegradable.
2. With the increasing demand in the use of natural materials for environmental sustainability across the globe as well as the need to search for ways of sustainability, Entrepreneurs, students, and homemakers, clothing and fashion designers, interior decorators should be encouraged to produce and commercialize household clothing articles using natural tie and dye fabrics as a source of income.
3. Standard application of mordanting or fixing agents on textile fabrics (cotton, silk, polyester, wool) should be set to enhance resistance to fading

during washing. complexity to specific mordants or chemicals for proper fixation on dye absorption

4. More of natural dye should be extracted and applied on different textile fabric and more research should be carried on how to properly fix the fastness properties of some natural dyes and also access to specific technical information on the process of extracting, and dyeing methods.

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