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Dyeing Efficiency of Natural Dye from "Insulina" (*Justica secenda)* Leaves.

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Abstract.
The study investigated the dyeing efficiency of dye extracted from 'insulina' *(Justica secenda)* leaves. Specifically, the study determined the fastness of dye extracted from insulina leaves, to washing, sunlight and perspiration. The study adopted experimental research design. It was conducted in five phases: treatment of insulina leaves; mordanting 100 percent cotton fabric with alum (potassium aluminium sulphate); extraction of dye from insulina leaves, dyeing of the mordanted cotton fabric with the insulina dye; testing for the fastness of the dyed cotton fabric to washing, sunlight, and perspiration. Alum mordanted cotton fabric was dyed with dye extracted from insulina leaves. This gave a light yellow colour to the dried fabric. The dried dyed fabric was cut into samples (A, B, C and D) for three different treatments of determination of colour fastness of insuluna dyed fabric as follows: Samples A– boiling, Sample B – exposure to sunlight; and sample C exposure to perspiration; Sample D was control. Each of the three treatments was carried out three times. A panel of five assessed the samples (A, B, and C) using a 3-point rating scale. Data were analyzed using mean. Major findings reveal, among others, colour of fabric remained fast (light yellow) after first treatments for samples A ($\overline{X}$ = 3.00) and sample B ($\overline{X}$ = 3.0); subsequent treatments showed slight colour changes ($\overline{X}$ =1.00). Sample C (exposed to perspiration) showed obvious change in exposeure ($\overline{X}$ = 2.00) and second showed "very obvious change of colour" on the third treatment ($\overline{X}$ = 0.5). It was recommended that further study be carried on more fastness of insulina dye to washing with different types of detergents.

Keywords: Insulina, Natural Dyes, Mordant, Fastness, Creativity, Innovations, Efficiency.

Introduction.

The continent of Africa according to (Wanyama, Kireme & Murumu, 2014) is rich in different plant species that have potential to produce novel natural products. One of such plant is insulina (*Justicia secenda*) plant. Insulina (*Justicia secenda*) is an evergreen, perennial plant that is a member of Acanthaceae family as well as *Justicia pectorals*. (Daniel, 2011). They thrive well in tropical and warm temperate regions. Insulina plant which grows in a wide range of soil produces flowers and seeds. The flowers come in various colours of white, cream, yellow, orange or pink. This plant is found in many parts of Latin America, India and Africa.

Bernhardic (2016) stated that parts of insulina plant are used for colds, flu, sedative, inflammation reduction and elimination of kidney stones. The medicinal properties of this plant have been explored by many researchers. Insulina leaves are also used in the treatment of anemia, cough, fever, malaria, measles and whooping cough.

In Nigeria, Insulina plants are planted in family gardens. The leaves are used as vegetables for preparing yam porridge. Also the leaves when boiled, produce red colour extract which is drank for enhancing blood level (blood tonic). The red colour extract from insulina leaves, attracted the attention of the authors to research on its efficiency in dyeing fabric, since there is no available evidence that the leaves have been investigated as potential source of dye for fabrics.

Dye can be obtained from natural sources such as plant, animal and mineral resources. Dyes got from these natural sources are referred to as natural dyes. Osobohien (2009) defined natural dyes as substances from plants and animals that impart colour to foods, cosmetics, drugs, hair, fibre, fur and polymers. Mazharul (2022), explained natural dye as any dye, pigment or oher substance derived from natural sources such as plant, animals and minerals which are renewable and sustainable bioresources products with minimum environmental impact. These dyes are introduced to various items to enhance their aesthetic properties, thus awaking consumers' interest in their purchase.

The application of natural dyes in colouring of items has been in existence since time immemorial. In support of this, Ibrahim, Mohammed & Wong (2013) pointed out that the use of natural colour for dyeing fabrics has been in practice since ancient times. These natural dyes can be extracted from plant leaves, flowers, roots, fruits and bark of plants. Natural dyes from animal origin can be got from Mollusks, shell fish, lichen etc.

In extracting dyes from natural sources such as plant, requires the use of different techniques ranging from very simple one like boiling in water to complex ones such as maceration and soxhlet extraction. For proper , technical extraction and application of natural dyes, efficient methods of extraction and adequate use of solvents that will be able to extract the dye from the plant has to be employed (Nwonye & Ezema, 2017).

Due to the difficulty in extracting dye from natural sources and the limited number of colours got from natural dye, interest in the use of natural dyes declined. This lead to the invention of synthetic dye when in 1856, a British scientist named W.H .Perkin produced a dye stuff called *mauve* (Ezema, 1996).

From that time of invention by Perkin, chemists started working on synthetic dyes which were inexpensive and have different colour range. Samanta & Konar, (2012) also affirmed that synthetic dyes appear in variety of colours and have good fastness quality. These synthetic dyes, though cheap and fast are not environmental friendly because of their source of extraction/production. Ekong, (2016) reiterated that synthetic dyes are synthesized from petro chemical sources through hazardous chemical processes which pose a threat to the environment. Mansour, (2013) in his own write up noted that researches have shown that synthetic dyes are suspected to release harmful chemicals that are allergic, carcinogenic and detrimental to human health.

Based on these problems posed by the use of synthetic dyes, interest or crave for going back to the use of natural dyes was re-awaken. Natural dyes were found to have better bio-degradability with the environment. They are non-toxic, non-allergic to the skin, non-carcinogenic, easily available and renewable (Thlyaparajan, Balakrislin & Tarnilaras, 2015).

The positive attributes of natural dyes lend themselves to scholars researching on extraction and utilization of dyes from various parts of plants. Acguah & Oduro (2012) pointed out that many research works have been carried out across the world on the application of natural dyes as important alternatives to synthetic dyes. It is this curiosity that led the authors to research on the efficiency of dye extracted from Insulina leaves in dyeing pre-mordanted cotton fabric. Dyes extracted from plant have little or no colour power by themselves except when used in conjunction with a mordant. Osabohein (2009) reiterated that many of the natural dyes have poor affinity to textile materials unless they are treated with Mordant.

Mordant are chemical agents which allows a reaction to occur between the dye and the fabric thereby aiding in fixing the colour to the fabric. Mordant fixed the dye to a substrate by combining with the dye pigment to form an insoluble compound (Wipperlinger, 2004). Obenewaa (2010) also, commented that mordant is an essential part in the dyeing process. Continuing, he noted that it is very essential except for plants which contains a lot of tannin such plants like Lichens and walnuts. Mostly used mordants are Alum (Potassium aluminum sulphate), iron (fereous sulphalte) etc. Locally in Nigeria, alum, salt and ash from charred palm florescence or cocoa pod are most widely used mordant.

Mordanting cotton fabric before dyeing increases its affinity to the plant dye. Cotton fabric is mostly used because of its high absorbent property, thus the most preferred fabric for dyeing.

Since dye can be extracted from different parts of plant, the need to ascertain the fastness qualities of such extracted dye becomes necessary.

Colour fastness is the degree of change in colour of a dyed fabric either through washing, exposure to sunlight, perspiration and by rubbing. This is in line with the statement of Nayak and Padhye (2015) that some coloured or printed garment fabrics change colour significantly during use due to abrasion, rubbing, atmospheric condition as light, acid or alkaline substances, laundry or dry cleaning, perspiration, ironing to mention but these few. Leverette (2022) explained colour fast as the ability of of a fabric or other substances to keep the same colour without fading or running even if washed, placed in harsh light, exposed to perspiration or treated with certain chemicals.

This study was therefore based on determining the dyeing efficiency of dye extracted from insulina leaves in dyeing a 100% white cotton in terms of its fastness to washing, sunlight and perspiration.

Purpose of the Study:

This study investigated the dyeing efficiency of natural dye extracted from insulina leaves (*Justicia secenda*). Specifically, the study determined the fastness of extracted dye from insulina leaves to:

1. washing.
2. exposure to sunlight.
3. exposure to perspiration.

Materials and Methods.

Design of 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 insulina leaves.
- Mordanting 100 percent cotton fabric with alum (potassium aluminium sulphate).
- Extraction of dye from insulina leaves.
- Dyeing of the mordanted cotton fabric with the insulina dye.
- Testing for the fastness of the dye to washing, sunlight and perspiration.

Procurement of Materials**:** Insulina (*Justicia secenda*) leaves were collected from garden in Umudike environment. The cotton fabric and alum (potassium aluminum sulphate) were purchased from a local market called "Nkwo Ndiro" situated in Ikwuano Local Government Area, of Umuahaia, Abia State of Nigeria.

Preparation of Materials: The following processes were involved in the preparation of materials.

Treatment of Insulina leaves: Fresh and tender insulina leaves were washed, drained, shredded and fermented for three (3) days. The fermentation was carried out by wrapping it in a cellophane bag.

Mordanting of white Cotton fabric: One and half ($1^1/_2$) yards100 percent cotton fabric was first washed with soap to remove oil, wax or dirt so as to prevent any interference with the dyeing process. It was finally rinsed and sun-dried. To make the white fabric receptive to insulina dye, one and half ($1^1/^2$) yards of the white cotton fabric was treated with 30g of alum (potassium aluminum sulphate) to which was added to six liters of water in a pot. The cotton fabric was soaked in the solution. The pot containing the fabric, water and alum solution was put on fire and boiled for 45 minutes. At the end of 45 minutes, the fabric was removed from the pot and allowed to cool and dry.

Extraction of dye from insulina leaves: 150g of fresh and tender insulina leaves were cut in pieces, wrapped in cellophane bag, fermented for three (3) days and boiled for 15minutes. This process resulted to the extraction of light yellow liquid which is the dye.

Fabric dyeing procedure and data collection**:** One and half yards of pre-mordanted fabric was sub-merged into the light yellow dye that resulted from the boiling of insulina leaves. The pot containing the dye extract and the cotton fabric was put on fire and boiled for fifteen minutes. The pre-mordanted fabric was then removed from the pot and aired for five minutes to allow for oxidation (reaction of the dye and oxygen). The dyed cotton fabric was rinsed and dried under a shade. The white cotton fabric at this stage turned to a light yellow colour as the extract from fermented boiled insulina leaves.

Determination of Colour Fastness of Insulina Dyed Cotton Fabric: Three samples of dyed fabric (A, B, and C) were subjected to three different treatments (A, washing, B, exposure to sunlight, and C, perspiration treatment). A fourth sample (D) served as control. After the treatments, data were collected and analyzed.

Treatment A- Washing with soap and water: Sample A was washed and dried under a shade three different times. After each washing and drying, data on fastness were collected.

Treatment A – Exposure to sunlight: Sample B was washed and dried under sunlight three different times. After each washing and drying appropriate data were collected.

Treatment C- Perspiration treatment: Sample C was put under the armpit researchers for 10 minutes. Then sample was rinsed in water and dried. The treatment was carried out three times. After each treatment appropriate data were collected.

Panelists: Five Textile and Clothing undergraduates of Michael Okpara University of Agriculture, (MOUA) Umudike served as the panel of assessors. They were appropriate trained for the assessment.

***Instrument*:** A- 3 point rating scale was developed and validated for data collection. The response options are "Light yellow/ No Change in Colour" (NCC) (3); "Slight Colour Change" (SCC) (2); and "Obvious Colour Change" (OCC) (1).

***Data Collection Method*:** The samples A, B and C were each rated at the end of the three replications of treatment, with sample D as control.

***Data Anlayisis Method*:** Date were analyzed using mean. Mean score of 2.0 was regarded as fairly-colour fast while > 2.0 was regarded as non-colour-fast.

Results

Table 1: Mean ($\bar{X}$) Scores of Colour Fastness of Insulina Dye Cotton Fabric to Washing.

Sample A	NW	CC	CAT	$\bar{X}$
1st wash	Once	-	LY	3.00
2nd wash	Twice	-	SCC	2.00
3rd wash	Thrice	-	OCC	1.00
D (control)	-	LY	-	-

NW= Number of washing; CC = Colour of control; CAT = Colour after treatment; LY = Light yellow; SCC = Slight clout change; OCC = Obvious colour change; $\bar{X}$= mean score.

Table 1 shows that there was no change in colour after the first washing ($\bar{X}$ = 3.00), there was slight change in colour on second washing ($\bar{X}$ = 2.00). Result of third washing shows obvious colour change ($\bar{X}$ = 1). This indicates that extracted insulina dye lost colour with repeated washing.

Table 2: Mean ($\bar{X}$) Scores of Colour Fastness of Insulina Dye Cotton Fabric to Exposure to Sunlight

Sample B	NE	CC	CAT	$\bar{X}$
1st exposure	Once	-	LY	3.00
2nd exposure	Twice	-	SCC	2.00
3rd exposure	Thrice	-	OCC	1.00
D (control)	-	LY	-	-

NW= Number of exposure; CC = Colour of control; CAT = Colour after treatment; LY = Light yellow; SCC = Slight clout change; OCC = Obvious colour change; $\bar{X}$= mean score.

Table 2 reveals that dye extracted from insulina leaves did not fade when the dyed fabric was exposed to sunlight the first time ($\bar{X}$ = 3.00). Second exposure of the same dyed fabric showed slight change in colour ($\bar{X}$ = 2.00), while the third showed obvious change ($\bar{X}$ = 1.0). These indicate that insulin a dye is not fast to const exposure to sunlight.

Table 3: **Fastness of Insulina Dye to Perspiration.**

Sample C	NE	CC	CAT	$\bar{X}$
1st PT	Once	-	SCC	2.00
2nd PT	Twice	-	OCC	1.0
3rd PT	Thrice	-	VOCC	.50
D (control)	-	LY	-	-

PT = Perspiration treatment; NW= Number of exposure; CC = Colour of control; CAT = Colour after treatment; SCC = Slight clout change; OCC = Obvious colour change; Very obvious change in colou; $\bar{X}$*= mean score.*

Table 3 reveals that there was slight fading of colour ($\bar{X}$ = 2.00) the first time the dyed fabric was removed from the armpit that is given perspiration treatmen. The second treatment obtained fastness score of $\bar{X}$ = 1.0. The third treatment revealed obvious change in colour of $\bar{X}$ = 0.5. This indicates that the extracted insulina dye was not fast to perspiration.

Discussion

Dye was extracted from insulina leaves which was fermented for three (3 days and boiled for 45 minutes. A light yellow solution of insulina leaves dye extract resulted after fermentation and boiling. This implies that dye can be extracted from Insulina leaves by fermentation and boiling. High temperature helps to draw dye pigments from Insulina leaves. Kannanmarking, Uma and Rajathinam, (2015) stated that temperature is the main factor which affect the extraction efficiency of dye from natural plant.

The light yellow colour that emanated from the fermented and boiled insulina leaves was able to dye the while cotton fabric showing the dye affinity to alum mordanted fabric. Mordants are chemical agents which allows a reaction to occur between the dye and the fabric thereby fixing the colour to the fabric. Wipperlinger, (2004), noted that mordants fix the dye to a substrate by combining with the dye pigment to form an insoluble compound. (Earth Guild, 2016), pointed out that a mordant join with the fabric and the dye to set the colour permanently. It enters deep into the fibre grains and when the dye is added they combine to form a good colour.

The result shows that there was no change in colour of the dyed cotton fabric after washing for the first time $\bar{X}$ = 3.00) and when spread and removed from the sun. this is consistent with the report of Mormardaslan, (2018), that colour fastness is usually rated either by loss of depth of colour in original sample or expressed by staining scale. Washing of the dyed fabric twice and trice revealed change in the colour of the dyed fabric indicating that repeated washing and exposure to sunlight of fabric dyed with insulina dye fades. Fading of colour when naturally dyed fabric is repeatedly washed and exposed to sunlight may be attributed to constant friction and agitation during washing. Byjus (2023) pointed out that the friction from agitation during washing causes the dye to come loose from the clothes. This result aligns with the statement of (Mazharul, 2022) that colour fast of natural dyes to washing and light are generally inferior to well selected and applied synthetic dyes and tend to fad easily.This is contrary to the assertion of (Christine D'Cruz, 2020) that stated that natural dyed fabrics have good dyeing and wasf fastness. Running of the colour of the fabric into the wash water will mean that the dye is not fast but when there is no change in the colour of the original dyed fabric, it means that the colour is fast. Ezema, (1996) wrote that the best way to assess the fastness of a fabric to laundry is to launder a sample piece of the fabric. 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 a slight change in colour of the dyed fabric when subjected to perspiration ($\bar{X}$ = 2.0, $\bar{X}$ = 1.0, and $\bar{X}$ = 0.5), respectively for the first, second and third treatments) The change in colour may be attributed to the reaction between the dye and the product of perspiration which may be alkaline or acidic in nature. The findings are consistent with those of Helmestine (2019).

Helmenstine (2019) pointed out that perspiration consists of water, minerals, lactate and urea. Also, the finding by Laundry Chef (2017) aligns with observation of that some dyes will exhibit a colour change when exposed to an acidic or alkaline substance.

Conclusion

This study has shown that light yellow natural dye can be extracted from fermented insulina leaves. This process of extraction is eco-friendly. The light yellow colour obtained from Insulina leaves has the ability to dye textiles (fabrics). The utilization of mordant on the fabric helped in improving the colour fixation. It follows that insulina leaves are good source of dye extraction for fabric dyeing. Dye from insulin leaves was found to be fast to initial washing but sparingly fast on subsequent washing and exposure to sunlight. There was also a slight change in colour due to perspiration. It is therefore concluded that dye extracted from insulina leaves could be used for dyeing items which should not be constantly washed or exposed to sunlight since these activitiest change the colour slightly.

Recommendations

The following recommendations for further actions.

- ❖ Fabric dyed with insulina leaves should be washed many more number of times to further determine its fastness.
- ❖ Insulina dyed fabric should be washed using different synthetic detergents to discover their effects on colour fastness.
- ❖ Insulina dye should applied to different fabric types or blends to ascertain their fastness to washing, light and perspiration.
- ❖ Fermentation period of insulina leaves should be varied to see the shades of colours to be obtained.
- ❖ Clothing and textiles lecturers and students should engage in more studies on dye extraction plants in their local environment.

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